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Digital Technology for Digital Supply Chain – Overview

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Abstract:

Purpose: *Discussion of identified digital technologies used in digital supply chains.*
Design/Methodology/Approach: *The presented research results were developed on the basis of the text mining method and cluster analysis.*
Findings: *The article presents the features and technological components to build the conceptual framework of the Digitized Supply Chain. They were developed on the basis of existing literature.*
Practical Implications: *Digitalization in supply chains implies the need for use Digital Technology. This does not describe how items are delivered, but defines the way how to react to problems within supply chains.*
Originality/Value: *The article indicates the directions of works on digital technologies and digitization in the coming years in Digital Supply Chains. The next stage of the research will try to answer the following question: In which direction should include the further transformation of Digital Supply Chain go as a result of the current energy crisis?*

Keywords: *Digital transformation, digitization, digital supply chain technologies, digital technology assets.*

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1. Introduction

Global changes such as pandemic, environmental crises, social crises, cyberattacks, and geopolitical tensions are causing a serious external shock. Over the next three years, we are expected to experience various types of economic turbulence, supply chain disruptions, and unforeseen events. It is clear that neither resilience nor governance will be possible without reliable and advanced digital technologies.

The use of digital technologies in supply chains will be essential to ensure even and faster global recovery. In the near future, digitization will play an even greater role in the operation of supply chains. It will increase the information transparency of supply chains and increase the resilience of supply chains. The article indicates the directions of research and works on digital technologies and digitization in the coming years in Digital Supply Chains.

Digitalization has touched almost each and every aspect of human life all over the world, greatly affecting supply chain processes. According to market forecasts (www), 76% of global population have now access to internet. Moreover, nine out of ten internet users make online purchases, 43% of companies make use of sophisticated big data analytics. Cloud storage is projected to hold about 37% of all generated data by 2020. The transformation towards Industry 4.0 and the use of Digital Technology for Digital Supply Chain in the economy is a long-term process that is still evolving.

The DSC has set supply chains and the logistics industry into a rapid change and a novel innovation path. In today's emerging digital model, data centers replace physical warehouses, bits replace the physical boxes, bandwidth replaces the physical trucks. There are shifts in channel management from conventional distribution centers to retailer services to broadband providers, to online, and directly to the customers (Büyüközkan and Göçer, 2018).

The publication is focused on the issue of technological support for the Digital Supply Chain (DSC). The conducted study and the presented paper feature two main research goals: (1) to indicate Digital Technology for Digital Supply Chain; (2) to discussion of them. Goals are of cognitive and conceptual character. The structure of the work is as follows: section 2 presents the literature review. The subsequent part of the article discussed the research methods. Section 4 focuses on and comments results of the research.

2. Literature Review

Based on the bibliometric analysis using the method of the systematic literature review and cluster analysis performed with genetic algorithms, identified 14 global and theoretical trends in supply chains. One of the key trends is the digitized supply chain (Grzybowska, 2021).

The digital supply chain support Industry 4.0. The shift from a traditional supply chain to a digital supply chain appears as a necessity. The digital supply chain can be defined as the development of information systems and the adoption of innovative technologies, strengthening the integration and the agility of the supply chain. A new wave of factory automation (Industry 4.0) will be supported by the next generation of low-cost robotics.

Digital Supply Chain becoming more and more popular in last year, which has resulted in different definitions of DSC. The popular definition of DSC is (Büyüközkan and Göçer, 2018): "DSC (…) is an intelligent best-fit technological system that is based on the capability of massive data disposal and excellent cooperation and communication for digital hardware, software, and networks to support and synchronize interaction between organizations by making services more valuable, accessible and affordable with consistent, agile and effective outcomes".

The different definition is (Tavana *et al.,* 2021): "Digital supply chains (DSCs) are collaborative digital systems designed to quickly and efficiently move information, products, and services through global supply chains". According to Boyson et al. (2022) a DSC can be defined as the ultimate expression of IoT (Internet of Things) development.

Number of articles about DCS in last few year show growing interest in this topic. In the 2015-2021 year, 70% papers related to DSC topic were published in 2020-2021, while on 2015-2017 it was 5% (Farajpour *et al.,* 2022). Farajpour *et al.* (2022) classified DCS articles for four categories: (1) papers describing the DSC concept (37%), 2) papers on DSC management (14%), 3) papers focusing on DSC implementation (31%), 4) DSC Frameworks and models (18%).

Digitalization of supply chain is not a simple think, because of many aspects which should be included. Farajpour *et al.* (2022) present the thematic map for the DSC. 12 main themes among DSC were defined based on thematic analysis: (1) DSC network, (2) DSC flows, (3) process, (4) management & leadership, (5) DSC features, (6) digital infrastructure, (7) customer, (8) people, (9) partnership, (10) strategies, (11) DSC value chain, (12) data analytics & management). For every theme few concepts have been distinguished.

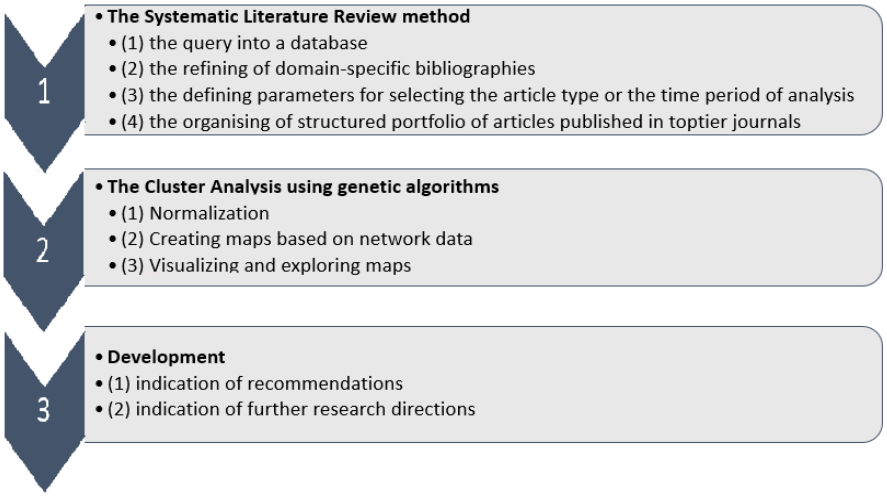
Yang *et al.* (2021) in their article describe drivers, process and impact of adoption of digital technologies in supply chains. Example of distinguished digital technology adoption by Yang *et al.* (2021): (1) the real-time data collected through IoT devices; (2) using big data analysis for forecast margins for different supplier and optimalization the selection of supplier (3) using digital technology to diagnostics and prognostics equipment, the location of equipment can be tracking by IoT technology; (4) the digital retailer platform as a new business model.

Yang *et al*. (2021) presented in their article guidance for practitioners for adopting digital technologies for supply chain. Moreover, the tips for business strategies at different digitalization levels are shown.

3. Research Methodology

The conducted study considers research methodology based on the systematic literature review and knowledge visualization. The overall research plan was divided into three stages (Figure 1). A detailed discussion of the research method is described in the article Grzybowska and Cyplik (2022).

Figure 1. *Research steps to carry out the study; (Grzybowska and Cyplik, 2022)*



Source: *Own study.*

As a result of research, a network was created based on keywords. As a result, 3569 keywords were listed that describe the scientific papers identified in the local database over the years 01.2000–12.2021 (Grzybowska and Cyplik, 2022). Table 1 presents the concept clusters identified based on the semantic map with the identified Digital Technology. Figure 1 shows the identified digital technologies for the Digital Supply Chain.

Table 1. *Clusters with the identified Digital Technology for Digital Supply Chain*

Clusters	Items	Digital Technology
Cluster 1	267	-
Cluster 2	233	Assistive technology Communication technology Information technology Educational technology
Cluster 3	118	Digital technology
Cluster 4	82	Blockchain technology

		Distributed ledger technology
Cluster 5	31	
Cluster 6	8	Emerging technology

Source: *Own study.*

4. The Digital Technology Overview

4.1 Assistive Technology

The combination of increasing life spans and low birth rates is accelerating the pace at which the share of older adults in the population worldwide is rising. As people age, their autonomy tends to decrease which leads frequently to the need to use support equipment to perform their daily living activities (de Armas *et al.,* 2021).

Recent studies from United Nations show a demographic change due to an increase in elderly people in front of a decreasing amount of births (World Population Prospects, 2019). Global demographic changes have resulted in a growing technological demand to meet the arisen social needs. In particular, the increasingly ageing population requires assistive technologies to stay at home for longer independently while receiving continuous healthcare (Martinez-Martin and Costa, 2021).

Global aging is expected to significantly impact the need for solutions, Assistive Products (APs), and Assistive Technologies (ATs) that support the participation and independence of people with disabilities or the elderly.

Assistive Technology (AT) is defined as "any product whose primary purpose is to maintain or improve an individual's functioning and independence and thereby promote their wellbeing" (WHO). Assistive technology enables participation in the labor market and civic life of persons with disability, aging populations, and people with non-communicable diseases.

They allow people to live healthy and productive, independent lives and participate in education, the labor market, and civic life. It is any item, piece of equipment, software program, or product system that is used to increase, maintain, or improve the functional capabilities of persons with disabilities, for example, Text to Speech, Reading Pens, Voice Recognition, Digital Recorders, iPads, and Tablets, Electronic Spell Checkers, Word Prediction Software, Visual Search Engines.

Assistive technologies support activities in the supply chain and individual enterprises. For example, mobile device applications, such as digital magnifiers, gesture to voice, and memory aid apps, can improve functioning across vision, hearing, communication, and cognition, respectively (Danemayer *et al.,* 2021).

Assistive technology use can enable academic engagement and social participation and be transformative from a psychological perspective (McNicholl and Casey, 2021). Despite the need for assistive technologies, and a wealth of innovative, afford-able, and accessible products, a low rate of assistive technology uptake is globally maintained (Ran *et al.*, 2022).

4.2 Communication Technology

The success of global supply chain management often rests on the information sharing capabilities of trading partners in the global business network (Hokey, 2021). Communication Technology (CT) has been on the rise since the 1980s. It stimulates the growth of the economy. The CTs in an operational aspect is a generator of a more efficient and collaborative coordination between the members of the organization and its suppliers and in an aspect of implementation that if not carefully evaluated It will produce high costs to the company (Duche-Pérez *et al.*, 2022).

With the advent of technological revolutions (Industry 4.0), it has been recognized that communication technology contributes to global economic growth (Afroz *et al.*, 2020; Chatterjee, 2020; Tripathi and Inani, 2020). Information Communication Technology (ICT) is changing the way we work, socialize, create and share information. Companies can monitor costs and incorporate customers' feedback into product innovation and streamline product research using ICT in its Supply Chain Management activities (Amukanga and Otuya, 2021).

A study done by Cheng-Min and Chien-Yun (2006) showed that applying ICTs on logistics management has already had an impact and provided significant benefits to SCM functions.

The Internet is widely viewed as likely to significantly impact inventories through improved supply-chain management (He, 2020). Companies are increasingly using the Internet to work together for better forecasting and restocking, using Collaborative Planning Forecasting Replenishment (CPFR). Home depot uses IT and the web throughout its supply chain to largely bypassing the warehouse: 85% of its merchandise moves directly from the manufacturer to the storefront (Stein and Sweat, 1998).

Communication Technology can also help share information, reduce the need for physical presence and mobility by adopting virtual flows (videoconferencing, work at home, online shopping) (Zhang and Wei, 2022).

4.3 Information Technology

Information technology (IT) continues to be an essential enabler for the effective supply chain management. The use of information technology (IT) through

information, innovation in business practices, automation, and transformation is widely observed. Information technology, such as an industrial Internet platform, allows you to effectively deal with disruptions in the supply chain. It has revolutionized supply chains. It has helped achieve the benefits of better coordination, increased efficiency, faster response, and increased competitive advantage. Information technology allows companies and entire supply chains to disseminate information efficiently; connects suppliers and customers, which facilitates information processing and will enable you to quickly deal with uncertainty in supply chains (Calatayud *et al.,* 2019).

Information and communication technology (ICT) is expected to stimulate economic growth and mitigate adverse environmental effects. However, studies of ICT's effects on the economy and environment have shown inconsistent results.

4.4 Educational Technology

Education presents an area of great interest in incorporating new technologies, thus technology acceptance and adoption theories and models are often used to inform research in educational context (Granić, 2022). Educational technology is concerned with the use of technology in order to improve education. With various tools and applications, technology provided significant support and facilitation to teaching and learning. Educational technology is an essential adjunct to education and works in the current time.

Education technology is undergoing significant changes due to computers' increasing pervasiveness (Collins and Halverson, 2010). Educational systems have integrated numerous technologies such as computers, smartphones, tablets, and cloud-based services, each modifying instructional strategies and teaching methods (Schulze, 2014). Educational technology and learning technology are broad, overlapping concepts encompassing a range of digital learning modalities (Oliver, 2000). In the past two decades, e-learning mobile learning and game-based learning have continuously evolved (Lu, 2022; Rodrigues *et al.,* 2019; Yukselturk *et al.,* 2018; Huizenga *et al.,* 2017).

It is essential for communication, storing and transferring information, audio-visual media use and production, and sharing. Technology has invaded and made life better in many ways (Mitroff, 2019).

Since 2000, areas such as Game-Based Learning and the Technology Acceptance Model have started to gain popularity; later, Blended Learning and M-Learning have begun to gain popularity. MOOCs, Social Media, and Learning Analytics began to gain attention in 2010, and Flipped learning began in 2015. The development of the Educational technology keywords has remained relatively stable, with slight positive.

E-learning being currently the most prevalent form of learning technology (Kavitha and Lohani, 2019). Utilization of mobile technologies in educational contexts has been growing steadily; mobile applications provide substantial advantages to users such as low cost, portability, and accessibility (Criollo-C *et al.,* 2021). Zeng *et al.* (2020) report the prevalence of educational games in education explain how games can influence interest and engagement and can impact learners' "high-level abilities".

4.5 Digital Technology

Digital supply chains and digital twins play an increasingly important role in supply chain (Queiroz *et al.,* 2019). In particular, Digital Supply Chain twins (Ivanov and Dolgui, 2020) – i.e., the computerized Supply Chain models that represent the network state for any given moment in real-time – take on meaning. One of the substantive areas of data analytics and digital twin applications is Supply Chain disruption risks (Choi *et al.,* 2017). A digital twin represents the physical supply chain based on actual transportation, inventory, demand, and capacity data and can therefore be used for planning and real-time control decisions (Battarra *et al.,* 2018).

A digital twin is a digital counterpart of the physical systems based on a simulation that deals with design systems and optimizes them for improved efficiency (Guo *et al.,* 2019). A "digital twin" as consisting of three components – a physical product, a virtual representation of this product, and bidirectional data connections that feed data from the physical to the virtual representation, as well as information and processes from the virtual representation to the physical (Grieves, 2014).

This basic concept of a digital twin provides a system that connects physical entities with virtual counterparts, taking advantage of both the virtual and physical environment to take advantage of the entire system (Grieves and Vickers, 2016). Simchenko et al. recommended using digital twins to map activities across the whole supply chain (Simchenko *et al.,* 2021).

4.6 Blockchain Technology

Blockchain technology is most often mentioned and used in cryptocurrencies, but the extent of possible applications is significantly larger. Blockchain is a distributed book (ledger) with many potential applications. There are advantages of blockchain:

(1) it is anonymous; (2) it is free to join; (3) it has free access; (4) submitted data cannot be altered; (5) published data cannot be removed.

Since the blockchain is immutable, alteration of the hidden messages is virtually impossible, and the embedding of covert information is free to be fragile (Partala, 2018). One of the most investigated topics is a blockchain for product tracking and tracing (Bai and Sarkis, 2020; Tijan *et al.,* 2019; Li and Kassem, 2021; Ming *et al.,*

2021). Blockchain technology can prevent data fraud caused by data centralization in a traditional supply chain because it uses a distributed system that eliminates intermediaries (Azzi *et al.,* 2019).

Data sharing through blockchain technology can help upstream enterprises gain a deeper understanding of the needs of downstream customers (Longo *et al.,* 2019). Obtaining timely data can improve procurement management, production management, transportation management, inventory management, and many other links in a supply chain (Cole *et al.,* 2019).

4.7 Distributed Ledger Technology

Blockchain technology entered the public mindset when it first became a popular platform for cybercurrency such as Bitcoin (Zhu *et al.,* 2022). Blockchain technology is most often mentioned and used in cryptocurrencies, but the extent of possible applications is significantly larger. Blockchain is a distributed book (ledger) with many potential applications. There are advantages of blockchain: (1) it is anonymous; (2) it is free to join; (3) it has free access; (4) submitted data cannot be altered; (5) published data cannot be removed.

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4.8 Emerging Technology

Next-generation and emerging technologies (Internet of Things, Big Data, Cloud Computing) contribute to a more comprehensive way to optimize the supply chain and improve its operating mode to achieve better supply chain efficiency. Cloud Computing (CC) enhances supply chain efficiency by changing the method of sharing information (Cao *et al.,* 2017).

The Internet of Things (IoT) has provided immense business opportunities in industry, manufacturing, and service provision, restructuring the entire supply chain (Ben-Daya *et al.*, 2019). Internet of Things better predicts supply and demand and better matches the right resources (Manavalan and Jayakrishna, 2019). The Internet of Things (IoT) is one of the most promising information and communication technologies (ICT) (Zheng *et al.*, 2018).

The typical applications of IoT include logistics management with Radio-Frequency Identification (RFID) technology (Varriale *et al.*, 2021), the maritime industry (Efthymiou *et al.*, 2013), maritime shipping (Howson, 2020), agri-food (Kayikci *et al.*, 2020) and pharmaceuticals (Hastig and Sodhi, 2020). The IoT provides a foundation for developing sustainable products, reducing waste, and maximizing resource efficiency (Tseng *et al.*, 2018; Esmaeilian *et al.*, 2020; Irie and Yamada, 2020).

Big data analytics technology (Big Data Analytics; BDA) improves operational efficiency and sustainable supply chain performance by forecasting and analyzing big data collected from enterprises and supply chains (Bag *et al.*, 2020). Because the three technologies of big data, cloud computing, and the Internet of Things are intertwined and connected, they cannot be completely independent in practice (Zhang *et al.*, 2022).

Along with its rising importance in industry, Artificial Intelligence (AI) shows an in the scholarly discourse (Soni *et al.*, 2020) and business. Artificial intelligence and machine learning (ML) may save money and improve the efficiency of business processes in the supply chain (Canhoto and Clear, 2020), with SCM being recognized as one of the fields most likely to profit from AI applications (Toorajipour *et al.*, 2021).

5. Conclusion

The Digital Supply Chain is not only the trend recognized in research but also the practical approach promoted by organizations and authorities. A Digital Supply Chain is a smart and efficient process of business. DSC is about the way how supply chain processes are managed with a wide variety of innovative technologies.

The next stage of the research will try to answer the following question: In which direction should include the further transformation of Digital Supply Chain go as a result of the current energy crisis?

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