The Effect of Digitalization on Logistics Performance in Logistics Companies

Work In Progress

Tamar Çırak

Abstract

In an increasingly global competitive environment, businesses need to follow new technological trends and keep up with innovations and transformations in order to continue their activities. Significant developments in information and communication technologies have initiated the digitalization era called Industry 4.0 and led to a serious transformation in all business processes. Along with the commercial activities affected by these important transformations, the logistics sector within the supply chain management has also undergone some changes. Digital technologies affect and support a wide range of logistics activities in the logistics industry, such as warehouse management systems and autonomous distribution systems. The adaptation of digital technologies brought by Industry 4.0 in logistics is called Logistics 4.0. With Logistics 4.0, optimization of resource use, minimization of costs, increase in personnel efficiency, increase in business efficiency and optimization of the supply chain are achieved.

It is possible for businesses to evaluate and improve their activities and determine their success or failure by evaluating their performance. Businesses in the logistics service sector, whose importance has increased with the innovations and changes brought by Logistics 4.0, have started to use digital technologies in their fields of activity in order to increase their performance.

In this context, the main research question of this study is to examine the effect of digitalization on logistics performance in logistics companies. The focus of the study is to investigate the effect of effective implementation of smart applications within the scope of Logistics 4.0 on the logistics performance of logistics companies. It is planned to use a survey method in the research, and the first part will include demographic characteristics, the second part will include the digitalization scale, and the third part will include the logistics performance scale. In this context, it is planned to include managers of businesses in the logistics sector as the population of the study.

As a result of the study, it is planned to find a significant and positive relationship between digitalization and logistics performance in logistics companies. It is also predicted that there is a connection between companies' use of digital technologies, the level of digitalization

and logistics performance, and the way to increase logistics performance is directly related to digitalization.
Keywords: Digitalization, Logistics 4.0, Logistics Performance

INTRODUCTION

Globalization and developments in information technologies in the 21st century have led companies to invest heavily in innovative and data-supported technologies in recent years. (Tsai and Tang, 2012). The process of using digital technologies started with the fourth industrial revolution called Industry 4.0. The main idea of Industry 4.0 emerged as using the Internet of Things (IoT) and emerging information technologies to implement its services (Kayıkçı, 2018). The focus of Industry 4.0 is based on the deep integration of business processes with engineering to increase the flexibility and efficiency of production processes in order to provide high-quality products and services at lower costs (Wang et al., 2016). Digitalization of production processes in terms of Industry 4.0 requires interconnection and integration to ensure superior value creation (Prause and Atari, 2017; Alibekova et al., 2020). For this reason, logistics in particular attracts great attention because it has a cross-cutting function and therefore affects all business units related and dependent on the process (Lai et al., 2008).

Logistics is one of the most important functions in the value chain for all supply chain actors (suppliers, manufacturers and retailers), because they cannot compete in the market without having the right products at the right time and place. It becomes increasingly difficult to meet these requirements as logistics networks become uncertain and variable (Nitsche and Straube, 2020). As the complexity of logistics networks increases, companies need new methods, technologies and services.

With the current digitalization trend in line with Industry 4.0 principles, logistics businesses need to transform their processes with logistics 4.0 roots in order to gain a share in the current market. The aim of the logistics 4.0 initiative is to facilitate decision-making with full visibility and optimization for logistics businesses that try to deliver products to customers on time and completely, under the right conditions and at the most affordable price, and to manage their operational processes more accurately and easily. We can also define digitalization of logistics activities as the application of information technologies to improve the performance of logistics activities (Ngai, Lai, Cheng, 2008). Logistics 4.0 applications allow processes to occur faster and error-free in operations, resulting in increased efficiency and reduced costs. With digitalization, logistics companies make their business models more innovative, allowing them to respond more flexibly and quickly to the variety of services requested.

In this context, the article focuses on the impact of the implementation level of activities on logistics performance under the influence of digitalization. First of all, the literature on "Logistics 4.0" and "Logistics Performance" has been reviewed. The focus of the study is to investigate the effect of effective implementation of smart applications on the logistics performance of logistics businesses. The rest of the article is organized as follows from the collected data: a literature review on digitalization, smart logistics applications is presented. Then, the proposed model and hypothesis are explained. The research methodology and

experimental results are then presented. It summarizes the analysis and discussion, followed by the conclusion.

LITERATURE REVIEW

1.Digitalization in logistics and Logistics 4.0

Over the last decade, the use and development of Information and Communication Technologies (ICT) in industry has become inevitable, mainly because it is vital for increasing organizational efficiency and competitiveness (Heuser et al., 2008). In order to create a digital representation that can be electronically processed or stored, an analogue signal must first be captured and then converted into digital form, a process known as digitization (Ornig,2016). Digitization makes information and communication available anywhere, anytime, within any context, and for any user using any device and type of access.

The Fourth Industrial Revolution is called digital transformation, made possible by the application of numerous innovative digital technologies in the manufacturing sector. Industry 4.0 is therefore characterized by progressive connectivity, new assistance systems and decentralized decision-making (Muhuri et al., 2019). The digital technologies included in Industry 4.0 not only increase the ability to respond to fluctuations in demand, but also increase flexibility regarding limited capacities. The main idea of Industry 4.0 is based on the deep integration of business processes with engineering processes to increase the flexibility of production processes in order to deliver high-quality products and services at lower costs (Wang et al., 2016).

However, digitalization of production processes in terms of Industry 4.0 requires the interconnection and integration of adjacent internal and external procedural environments in order to ensure efficient value creation. In this context, logistics in particular attracts great attention because it has a cross-cutting function and therefore affects all business units related and dependent on the process (Lai et al., 2010). Logistics is one of the most important functions in the value chain for all supply chain actors consisting of suppliers, manufacturers and retailers; Because there is no competition in the market without having the right products at the right time and place. As logistics networks become uncertain and variable, companies need new methods, technologies and services to meet the requirements. (Nitsche and Straube, 2020).

For this reason, digitalization of transportation and logistics processes arouses great interest within the scope of Industry 4.0. The concept of Industry 4.0, its application in logistics processes, is called Logistics 4.0. Additionally, Logistics 4.0 is seen as the outcome and next step of Industry 4.0. Logistics 4.0 involves the planning and control of the movement of goods and related information flows from source to final destination. Logistics 4.0 mainly uses technologies such as the Internet of Things (IoT), Cyber Physical Systems (CPS), big data analytics and cloud computing (Winkelhausand Grosse,2020).

1.1 Logistics 4.0 Components

The concepts developed by Industry 4.0 and the use of these concepts in logistics processes are explained in detail below.

1.1.1. Internet of Things (IoT)

IoT refers to a system that allows sensors embedded in objects in the physical world to connect to the internet via wireless or wired connections (Banger, 2016).

The use of IoT in logistics processes enables objects connected to the Internet to communicate both with each other and with control centers, thanks to the industrial internet network. In addition, the use of IOT allows the traceability of the process, real-time monitoring of deliveries, and the possibility of data accuracy to increase in a flow where technologies that carry out transportation, handling, production and packaging can be aware of each other (Tadejko, 2015).

1.1.2. Cyber Physical Systems

Cyber-physical systems are physical, biological and engineering systems in which operations are integrated, monitored and/or controlled with the help of a computational core (Loukas, 2015). In cyber-physical systems, sensors, actuators and hardware constitute the physical part, while software modules constitute the cyber part. In cyber-physical systems, information about physical processes is collected in real time with the help of sensors and actuators, and intelligent controls can be made on physical systems to adapt to changing conditions and environment (Tu, Lim and Yang, 2018).

Cyber-Physical Systems provide a new dimension for the full transparency of the supply chain's material flow. Thus, cyber-physical system technologies can be used to monitor products, provide security for all chain elements, access a data communication common platform, provide information about demand, stock and sales, and predict anomalies during production (Frazzon et al., 2015).

1.1.3. Big Data

Big data refers to complex and unstructured data that is difficult to analyze and use with traditional applications and analytics. Monitoring and sensor devices widely used in big data, logistics and supply chain management come from various sources related to mobile devices, internet of things and radio frequency identification (RFID) technology (Papadopoulos, Gunasekaran, Dubey and Balta, 2017).

The main benefit of using Big Data in logistics is the optimized use of resources and quality improvements through better data quality. The data collected and analyzed benefit the use of resources by increased transparency and an enhanced resource consumption.

1.1.4. Cloud Computing

Cloud computing is a term in computing that is used to store, maintain data in a secured manner (Vinitha, D., & Duela, J 2014).

In general, logistics providers handle a variety of transactions between various parties using various transport management systems and cloud-based warehouse applications. By presenting a single integrated image, the entire supply chain can be coordinated, akin to a

control tower, and businesses can receive accurate information about shipping locations, stock status, and assets worldwide. (Çiçekli, 2018)

1.1.5. Additive Manufacturing and 3D Printers

With the introduction of industrial automation technologies, a faster production process has started. The most important aspect of accelerating this process is to develop a rapid supply of systems and parts before finalizing the product. It is possible to talk about this situation as a prototype (Gibson et al., 2010). The purpose of additive manufacturing is to turn digital prototypes into physical prototypes. As a result, at this point, it is necessary to develop a product that includes both software and appropriate hardware. It is stated that the additive manufacturing process consists of the layered integration of the obtained materials. The use of 3D printing equipment provides the transition of the layers of the model from the digital to the real world (Soylu, 2018).

1.1.6. Augmented Reality

The environment created by computers through imitation is called virtual reality. Augmented reality is; It is an image formed as a result of virtualization of the environment we live in the real world with data such as computer-assisted image, sound, video, GPS, and it is actually an application that combines the virtual and real world.

Augmented reality has provided a new perspective to the logistics industry in the stages of logistics planning and logistics activities. Augmented reality-based systems have started to be used in warehousing operations, transportation optimization, last kilometer delivery and enhanced value-added services in the logistics industry (Glockner, Jannek, Mahn and Theis, 2014).

1.1.7. Autonomous Robots

Autonomous robots are devices that lack human intervention and interaction and are programmed to perform tasks. In increasingly complex workspaces, activities are carried out by new sensor systems, artificial intelligence methods and very flexible and cognitively strong robots with the necessary computer performance for these systems (Hohenstein and Wagner, 2017).

Autonomous robots have the ability to achieve more consistent levels of quality and productivity, and to perform tasks that humans cannot, shouldn't, or don't want to do. Autonomous robots can test, select, pack, sort, set up, inspect or transport materials of different sizes and weights more quickly and efficiently than humans (Fitzgerald and Quasney, 2017). With these features, autonomous robots will be frequently encountered in basic logistics activities such as transportation, storage, labeling, packaging and handling in the near future.

2. Logistics Performance

The main factor for businesses and companies to achieve organizational success is the valid and reliable performance measurement of their activities (Fawcett and Cooper, 1998). For this reason, performance measurements and revealing the variables that affect performance shed light on the decisions companies will make and increase the accuracy of the decision.

While logistics performance is expressed by Piriyakul (2011) as the performance of management, transportation and storage of products and materials; Green Jr. et al. (2008) is

defined as the ability of a company to deliver its products and services in a certain time and quantity requested by customers.

When measuring logistics performance, Andersson et al. (1989) believe that a comprehensive measurement strategy is necessary for the successful planning, execution and control of the different activities that make up the logistics function of the enterprise.

When we look at traditional logistics measurements, we encounter an approach that focuses on the logistics and distribution success of companies (Bowersox et al., 1996); this approach is based on 5 categories (conventional transport performance) (Bowersox et al., 1989; Fawcett and Cooper, 1998). These; asset management, costs, customer service, productivity, quality.

3.Logistics Performance and Digitalization

In a variety of logistics operations, the adoption and effective implementation of digital technology enables the achievement of competitive advantages (Bhandari, 2014; Choy et al., 2014). Information and data security is becoming more and more important as digital technologies impact and assist the logistics sector in a variety of ways, from intelligent transportation systems to optimised resource planning and warehouse management systems (Barreto et al., 2017; Kayikci, 2018).

Generally, digital technologies that are considered as accelerators or facilitators for the digital transformation or Industry 4.0 in the manufacturing sector are labelled as enabling technologies. Therefore, present research efforts aim to identify new technologies that are expected to most effectively support the digital change particularly with related to the logistics industry. For instance, Harris et al. (2015) emphasize that the improvement of multimodal transportation increasingly depends on the smart application of enabling technologies such as cloud computing, wireless/mobile communication technologies and IoT. Similar findings were gathered by the study of Ardito et al. (2019), who aimed to identify enabling technologies pertaining to the fourth industrial revolution that can be considered as most relevant for an effective supply chain integration of firms – here: Industrial IoT, cloud computing, big data analytics, etc. To counter this, Strange et al. (2017) evaluated the potential effects on the organization of activities within global value chains of the widespread adoption of digital enabling technologies, such as IoT, big data analytics, robotics, etc. More broadly, the possibilities presented by Industry 4.0 were examined in the context of logistics management by Hofmann and Rüsch (2017). The authors emphasized that products and services must be flexibly connected via the Internet or other network applications such as blockchain technology, which allows decentralized control of value networks. They show that digital connectivity enables automated and self-optimized production of goods and services, including delivery without human intervention – that is, self-adaptive production systems based on transparency and predictive analytics. According to Witkowski (2017), the integration of comparable solutions generates operational information on the location and condition of items, which highlights the importance of IoT for the logistics and transport sector. By using this information, expenses may be decreased as a consequence of shortened logistical procedures by improving services and, consequently, customer happiness.

Digitization of logistics operations refers to the application of IT to improve logistics efficiency (Ngai, Lai, & Cheng, 2008). Many previous studies on IT implementation in logistics

management have been limited to examining the performance of a single IT application in a specific logistics function, such as a warehouse management system; for recording operations and electronic data interchange (EDI) to share information (Hill and Scudder, 2002). Previous studies have shown that investments in digitized logistics operations can lead to the commitment of partner companies to collaborate in managing logistics operations (Kent and Mentzer, 2003) and subsequently improve the costs and services of the parties. The digitization of logistics management would enable the development of external relations of partner companies (Bowersox and Daugherty, 1995) and encourage the development of long-term partnership relationships. From this perspective, the integration of digitized logistics functions helps to reduce logistics costs through better information sharing for logistics coordination and improves logistics services by improving the responsiveness of the organization to customer needs (Lai and Cheng, 2006; Wu and Cheng, 2008). The first is related to logistics management costs such as inventory management and storage, order processing, which reflects efficiency-related logistics (Whicker, Bernon, Templar, & Mena, 2006), while the latter refers to performance-related logistics, which concerns the responsiveness and reliability of firms in managing their logistics operations (Lai, Ngai, & Cheng, 2002). Digitization would increase the effectiveness and efficiency of company logistics in managing internal and external logistics operations of organizations. Companies find the timely and cost-effective coordination of logistics a difficult challenge in logistics management, while digitalization of logistics operations benefits logistics through improved information sharing.

METHODOLOGY (Lai vd., 2010)

1. Purpose and Importance of the Research

In this research, it is planned to investigate the digitalization capabilities of logistics service companies and how these variables affect logistics performance. It is noteworthy that the number of studies on these variables in the literature is limited. In this context, it will be useful to understand the logistics performance and digitalization abilities of the managers of companies providing logistics services.

2. Research Questions

Main Research Question

• Does the digitalization of processes in companies providing logistics services have an impact on logistics performance?

Sub-Research Question

- What are the latest technologies in logistics regarding the implementation of digitalization?
- Do the latest technologies in logistics regarding the implementation of digitalization have an impact on logistics performance?

3. Research Model

- There is a positive relationship between digitalization and logistics performance in companies providing logistics services.

Population and Sample

The universe of the research was determined as the companies providing logistics services. As a first step, the number of companies providing logistics services will be determined.

There are many opinions about sample size in the literature. Some opinions in the literature are given below.

Guilford (1954) stated that the sample size was more than 200.

Macallum (1995) requires a minimum of 10 participants for each question.

Hutcheson and Sofroniou (1999) stated that the minimum number of participants should be between 150 and 300.

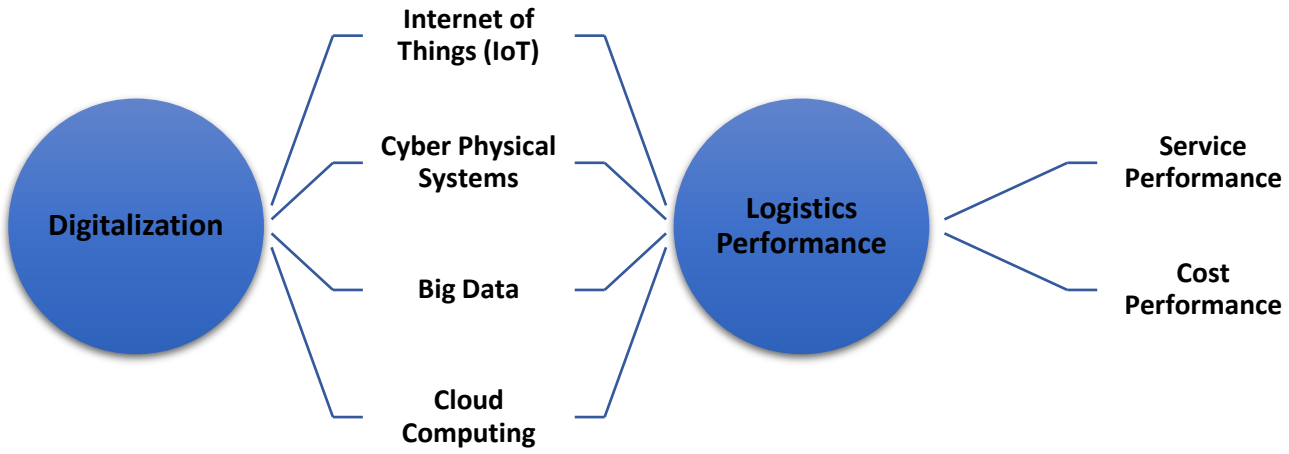
Hatcher (1994) and Hair (2010) require a minimum of 5 people to answer each question.

In this context, the number of samples will be determined after the scales to be used in the research are decided.

Data Collection Method and Analysis

Since it is planned to use quantitative research methods during the thesis study, it is planned to apply the survey technique as a data collection method. It is possible to create an online survey via Google forms. The data to be collected in the research will be analyzed with the help of the SPPS program.

Theoretical Framework



Expected Results

- Determining the effects of digitalization on logistics performance
- Finding the effect of digitalization processes in logistics companies
- Asses the willingness in the digitalization processes of logistics companies

REFERENCES

ALIBEKOVA, G., MEDENI, T., PANZABEKOVA, A., & MUSSAYEVA, D. (2020). Digital transformation enablers and barriers in the economy of kazakhstan. *The Journal of Asian Finance, Economics and Business*, *7*(7), 565–575. https://doi.org/10.13106/JAFEB.2020.VOL7.NO7.565

Andersson, P., Aronsson, H., & Storhagen, N. G. (1989). Measuring logistics performance. *Engineering Costs and Production Economics*, *17*(1–4), 253–262. https://doi.org/10.1016/0167-188X(89)90074-8

Ardito, L., Petruzzelli, A. M., Panniello, U., & Garavelli, A. C. (2019). Towards Industry 4.0: Mapping digital technologies for supply chain management-marketing integration. *Business Process Management Journal*, *25*(2), 323–346. https://doi.org/10.1108/BPMJ-04-2017-0088

Banger, G. (2016). *Endüstri 4.0 ve Akıllı İşletme* (Vol. 540). Dorlion Yayınları.

Barreto, L., Amaral, A., & Pereira, T. (2017). Industry 4.0 implications in logistics: An overview. *Procedia Manufacturing*, *13*, 1245–1252. https://doi.org/10.1016/j.promfg.2017.09.045

Bhandari, R. (2014). Impact of technology on logistics and supply chain management. *IOSR Journal of Business and Management*, *2*(17), 19--24.

Bowersox, D. J., Daugherty, P. J., Droge, C. L., Rogers, D. S., & Wardlow, D. L. (1989). Leading edge logistics: Competitive positioning for the 1990s, council of logistics. Management, Oak Brook, IL.

Bowersox, Donald J and Daugherty, Patricia J. (1995). Logistics paradigms: The impact of information technology. *Journal of Business Logistics*, *16*(1), 65.

Çiçekli, S. (2018). Sanayi 4.0'ın Lojistik Sektörüne Etkileri. T.C. Bilim, Sanayi ve Teknoloji Bakanlığı, Verimlilik Genel Müdürlüğü, Anahtar Dergisi, Nisan 2018

Fawcett, S. E., & Cooper, M. B. (1998). Logistics performance measurement and customer success. *Industrial Marketing Management*, *27*(4), 341–357. https://doi.org/10.1016/S0019-8501(97)00078-3

Fitzgerald, Joseph, and Evan Quasney. 2017. "Using Autonomous Robots to Drive Supply Chain Innovation."

Frazzon, E. M., Silva, L. S., & Hurtado, P. A. (2015). Synchronizing and improving supply chains through the application of cyber- physical systems. *IFAC-PapersOnLine*, *48*(3), 2059–2064. https://doi.org/10.1016/j.ifacol.2015.06.392

Gibson, I., Rosen, D. W., & Stucker, B. (2010). *Additive manufacturing technologies: Rapid prototyping to direct digital manufacturing*. Springer.

Glockner, Holger, Kai Jannek, Johannes Mahn and Björn Theis (2014) Augmented Reality in Logistics, DHL Customer Solutions & Innovation Research Report, Troisdorf.

Green, K. W., Whitten, D., & Inman, R. A. (2008). The impact of logistics performance on organizational performance in a supply chain context. *Supply Chain Management: An International Journal*, *13*(4), 317–327. https://doi.org/10.1108/13598540810882206

Harris, I., Wang, Y., & Wang, H. (2015). ICT in multimodal transport and technological trends: Unleashing potential for the future. *International Journal of Production Economics*, *159*, 88–103. https://doi.org/10.1016/j.ijpe.2014.09.005

Hill, C. A., & Scudder, G. D. (2002). The use of electronic data interchange for supply chain coordination in the food industry. *Journal of Operations Management*, *20*(4), 375–387. https://doi.org/10.1016/S0272-6963(02)00017-7

Hofmann, E., & Rüsch, M. (2017). Industry 4.0 and the current status as well as future prospects on logistics. *Computers in Industry*, *89*, 23–34. https://doi.org/10.1016/j.compind.2017.04.002

Hohenstein, Frank and Ole Wagner (2017) Robots in Picking Logistics, Miebach Consulting Research Report, München.

https://www2.deloitte.com/content/dam/Deloitte/us/Documents/manufacturing/usmanufacturing-autonomous-robots-supply-chain-innovation.pdf.

Kayikci, Y. (2018). Sustainability impact of digitization in logistics. *Procedia Manufacturing*, *21*, 782–789. https://doi.org/10.1016/j.promfg.2018.02.184

Kent, J. L., & Mentzer, J. T. (2003). The effect of investment in interorganizational information technology in a retail supply chain. *Journal of Business Logistics*, *24*(2), 155–175. https://doi.org/10.1002/j.2158-1592.2003.tb00050.x

L. Heuser, Z. Nochta, N.C. Trunk, ICT shaping the world: A scientific view. ETSI, Wiley Publication, London, 2008.

Lai, K., Wong, C. W. Y., & Cheng, T. C. E. (2006). Institutional isomorphism and the adoption of information technology for supply chain management. *Computers in Industry*, *57*(1), 93–98. https://doi.org/10.1016/j.compind.2005.05.002

Lai, K., Wong, C. W. Y., & Cheng, T. C. E. (2010). Bundling digitized logistics activities and its performance implications. *Industrial Marketing Management*, *39*(2), 273–286. https://doi.org/10.1016/j.indmarman.2008.08.002

Lai, K.-H., Wong, C. W. Y., & Cheng, T. C. E. (2008). A coordination-theoretic investigation of the impact of electronic integration on logistics performance. *Information & Management*, *45*(1), 10–20. https://doi.org/10.1016/j.im.2007.05.007

Loukas, G. (2015). *Cyber-physical attacks: A growing invisible threat*. Waltham, MA, USA : Elsevier/BH, Butterworth-Heinemann is an imprint of Elsevier.

Management Association, I. R. (Ed.). (2018). *Operations and service management: Concepts, methodologies, tools, and applications*. IGI Global. https://doi.org/10.4018/978-1-5225-3909-4

Muhuri, P. K., Shukla, A. K., & Abraham, A. (2019). Industry 4.0: A bibliometric analysis and detailed overview. *Engineering Applications of Artificial Intelligence*, *78*, 218–235. https://doi.org/10.1016/j.engappai.2018.11.007

Ngai, E. W. T., Lai, K.-H., & Cheng, T. C. E. (2008). Logistics information systems: The Hong Kong experience. *International Journal of Production Economics*, *113*(1), 223–234. https://doi.org/10.1016/j.ijpe.2007.05.018

Nitsche, B., & Straube, F. (2020). Efficiently managing supply chain volatility – a management framework for the manufacturing industry. *Procedia Manufacturing*, *43*, 320–327. https://doi.org/10.1016/j.promfg.2020.02.166

Ornig, H. (2016). *Leading into the future: The 'so what? ' on exponential technology and leadership.* Balboa Press 2016.

Papadopoulos, Thanos, Angappa Gunasekaran, Rameshwar Dubey and Maria Balta (2017) "Big Data and RFID in Supply Chain and Logistics Management: A Review of the Literature and Applications for Data Driven Research", Chan et al. (eds) Supply Chain Management in the Big Data Era, IGI Global, Pennsylvania

Piriyakul, M. (2011). "A partial least squares model for SCM strategy, willingness for external collaboration, competitive performance and relative performance: Effects of marketing and logistics performance in the palm oil industry." African Journal of Business Management, Vol.5, No.4, 1431.

Prause, G., & Atari, S. (2017). On sustainable production networks for Industry 4.0. *Entrepreneurship and Sustainability Issues*, *4*(4), 421–431. https://doi.org/10.9770/jesi.2017.4.4(2)

Soylu, A. (2018). Endüstri 4.0 ve Girişimcilikte Yeni Yaklaşımlar. *Pamukkale University Journal of Social Sciences Institute*. https://doi.org/10.30794/pausbed.424955

Strange, R., & Zucchella, A. (2017). Industry 4.0, global value chains and international business. *Multinational Business Review*, *25*(3), 174–184. https://doi.org/10.1108/MBR-05-2017-0028

Tadejko, P. (2015). Application of Internet of Things in logistics–current challenges. Ekonomia i Zarządzanie, 7(4), 54-64.

Tsai, W.-C., & Tang, L.-L. (2012). A model of the adoption of radio frequency identification technology: The case of logistics service firms. *Journal of Engineering and Technology Management*, *29*(1), 131–151. https://doi.org/10.1016/j.jengtecman.2011.09.010

Tu, M., K. Lim, M., & Yang, M.-F. (2018). IoT-based production logistics and supply chain system – Part 2: IoT-based cyber-physical system: a framework and evaluation. *Industrial Management & Data Systems*, *118*(1), 96–125. https://doi.org/10.1108/IMDS-11-2016-0504

Vinitha, D. E. G., & Duela, J. S. (2014). A secured event log storage management system in cloud computing. *International Conference on Information Communication and Embedded Systems (ICICES2014)*, 1–5. https://doi.org/10.1109/ICICES.2014.7033872

Wang, S., Wan, J., Li, D., & Zhang, C. (2016). Implementing smart factory of industrie 4. 0: An outlook. *International Journal of Distributed Sensor Networks*, *12*(1), 3159805. https://doi.org/10.1155/2016/3159805

Whicker, L., Bernon, M., Templar, S., & Mena, C. (2009). Understanding the relationships between time and cost to improve supply chain performance. *International Journal of Production Economics*, *121*(2), 641–650. https://doi.org/10.1016/j.ijpe.2006.06.022

Winkelhaus, S., & Grosse, E. H. (2020). Logistics 4.0: A systematic review towards a new logistics system. *International Journal of Production Research*, *58*(1), 18–43. https://doi.org/10.1080/00207543.2019.1612964

Wu, Y. N., & Edwin Cheng, T. C. (2008). The impact of information sharing in a multiple-echelon supply chain. *International Journal of Production Economics*, *115*(1), 1–11. https://doi.org/10.1016/j.ijpe.2008.02.016

Yu, Y., Wang, X., Zhong, R. Y., & Huang, G. Q. (2016). E-commerce logistics in supply chain management: Practice perspective. *Procedia CIRP*, *52*, 179–185. https://doi.org/10.1016/j.procir.2016.08.002