

Katarzyna Nowicka

SGH Warsaw School of Economics

e-mail: Katarzyna.Nowicka@sgh.waw.pl

ORCID: 0000-0001-7830-7457

DIGITAL INNOVATION IN SUPPLY CHAIN MANAGEMENT

CYFROWE INNOWACJE W ZARZĄDZANIU ŁAŃCUCHEM DOSTAW

DOI: 10.15611/pn.2019.8.16

JEL Classification: O33

Summary: Digital innovations result from the implemented digital technologies and a combination of their properties. They can form the basis for building digital supply chains (networks) that are a new stage in their evolution. The article explains the concept of digital innovation and highlights the place of technology in supply chain management. The goal of the article is to present the results of research carried out using the CATI method among supply chain managers using digital technologies. The most important changes resulting from the application of these technologies include not only the increase in the level of process automation, but also the extension of distribution with a new sales channel, as well as the possibility of simultaneous communication with several partners and access to information related to logistics activities, i.e. free space in warehouses and planned freight routes. Such effects give the potential to improve the competitive position and constitute a premise for the further development of the digital transformation of supply chains. In this process, however, not only are the costs of the implemented technologies important (indicated as the main barrier to their implementation), but also the competences enabling the identification of digital innovations that best respond to the needs of supply chain management.

Keywords: digital innovation, digital supply chain, digital transformation of supply chains.

Streszczenie: Innowacje cyfrowe wynikają z wdrożonych technologii cyfrowych i kombinacji ich właściwości. Mogą stanowić podstawę budowy cyfrowych łańcuchów dostaw (sieci) stanowiących nowy etap w ich ewolucji. W artykule wyjaśniono koncepcję innowacji cyfrowych i podkreślono miejsce technologii w zarządzaniu łańcuchem dostaw. Celem tekstu jest prezentacja wyników badań przeprowadzonych metodą CATI wśród menedżerów łańcucha dostaw korzystających z technologii cyfrowych. Najważniejsze zmiany wynikające z zastosowania tych technologii to wzrost poziomu automatyzacji procesów i rozszerzenie dystrybucji o nowy kanał sprzedaży, a także możliwość jednoczesnej komunikacji z kilkoma partnerami oraz dostęp do informacji związanych z działaniami logistycznymi, tj. wolnej przestrzeni w magazynach i planowanych trasach towarowych. Takie efekty dają potencjał do poprawy pozycji konkurencyjnej i stanowią przesłankę dalszego rozwoju cyfrowej transformacji łań-

cuchów dostaw. W tym procesie ważne są nie tylko koszty wdrożonych technologii (będące główną barierą w ich implementacji), ale także kompetencje umożliwiające identyfikację innowacji cyfrowych najlepiej odpowiadających potrzebom zarządzania łańcuchem dostaw.

Słowa kluczowe: innowacje cyfrowe, cyfrowy łańcuch dostaw, cyfrowa transformacja łańcuchów dostaw.

1. Introduction

As a result of the implementation and dissemination of digital technologies, enterprises can introduce innovative solutions of a diverse nature, significantly improving the effects achieved so far (in terms of cost, time and quality). Supply chain management has been supported by information and communication technologies for decades, and nowadays digital technologies are the most important reference point for the development of competitive supply chains (networks).

The purpose of the article is to indicate the scope of the changes occurring in supply chains as a result of the use of digital technologies recognized today as a driving force of innovation in organization management. The following sections outline the essence of digital innovation as well as its impact on supply networks, as a result of which independent digital supply chains can be built. The approach to the model digital supply chain was compared with the results of a study conducted among supply chain managers using digital technologies. The last part of the article indicates the most important technologies, the reasons for their use, their benefits and implementation barriers. The survey was conducted on a sample of 120 respondents at the turn of November and December 2018 using the CATI method.

2. Digital innovation

One of the main driving forces of changes in the modern economy are digital technologies, and in principle their properties [Goliński 2018]. Digital technologies are treated as a combination of information, processing, communication and technology [Olszak 2015]. The key digital technologies, whose application became widespread around 2010, include those that are part of the so-called SMAC, i.e. social media (Social Media), mobile technologies (Mobile), big data analytics (Big Data Analytics) and cloud computing (Cloud Computing). Nowadays, there is increasing discussion about the practical and widespread use of another group of new technologies, which include: blockchain, Artificial Intelligence, 4D Printing (4D Printing), the Internet of Things, and the Internet of Everything). Thanks to interoperability, networking and the relatively low cost of access to almost any level of computing power needed in real time anywhere, these technologies have enabled work efficiency to be achieved at a level that was previously impossible to achieve while reducing costs.

Deep and extensive changes in the management of business entities caused by the implementation of digital technologies are the starting point for the introduction of the concept of digital innovation. According to O. Henfridsson et al. digital innovation refers to the use of digital technology in a product that has never been used before [Henfridsson, Yoo, Svahn 2009]. Y. Yoo and others understand digital innovation as an innovation introduced through the use of digital technologies and leading to new forms of digital transformation [Yoo et al. 2010]. M. Akesson defines digital innovation in a similar way, understanding it as a solution stimulated by digital technologies, supplementing this definition with the aspect of new ICT products [Akesson 2009]. In the narrower sense, digital innovation is therefore understood as the implementation of a new or significantly improved ICT product (solution). However, in a broader sense (based on the definition of innovation indicated in the Oslo Manual), it also refers to the use of ICT in the implementation of a new or significantly improved product or process, a new marketing method, or an organizational method in business practice or external relations – thus it is an innovation stimulated by technology [Reimsbach-Kounatze 2016].

It can therefore be assumed that digital innovation is the creation (and resulting changes) of market offers, business processes or models that are the result of the use of digital technologies [Nowicka 2019a]. A feature of digital innovation is therefore that digital technologies and related digital transformation processes are an immanent part of a new idea, its development, diffusion or assimilation [Nambisan et al. 2017]. The adoption of such a definition therefore covers three aspects characterizing digital innovation:

- they cover a number of innovations, such as new products, platforms and services, processes, as well as new customer experiences and other ways of delivering value resulting from the use of digital technologies, while the effects (results) of these innovations do not have to be in digital form,
- they arise from the use of a wide range of digital tools and infrastructure (e.g. cloud computing, blockchain, 3D printing, data analytics, mobile data processing, etc.) to introduce innovations,
- the effects of digital innovations can be disseminated, adopted or adapted to specific applications, e.g. digital platforms.

Therefore the diffusion of digital innovations may concern individual solutions or complex elements of a business model (i.e. a way of creating value). This is connected with the process of digital business transformation involving the use of digital technologies to change the business model and provides new opportunities bringing income and value. This is the process of migrating the business model to the digital enterprise model [www.gartner.com/it-glossary/digitalization], which includes in the scope of this activity things that become an important subject of cooperation.

Digitization is a continuous process of convergence of the real and virtual world, becoming the main driver of innovation and change in most sectors of the economy

[Pieriegud 2016]. The source of digital transformation are digital technologies, and the result is innovation and a new nature of organizational innovation [Kowalczyk 2017].

3. Supply chain digital transformation

J. Witkowski defines the supply chain as mining, production, commercial, service companies and their clients cooperating in various functional areas, between which flow products, information and financial flows [Witkowski 2003]. According to M. Christopher, the supply chain is a network of organizations involved, through links with suppliers and recipients, in the implementation of various processes and activities that create value in the form of goods and services provided to consumers [Christopher 2016].

The economic network is described as a modern form of organization, a new style of management or a form of organizing relations between various institutions. In the network, the boundaries between its elements are blurred, which is the result of both attaching less importance to formal restrictions, and giving meaning to the temporary relationships between entities – network elements – and within them. Usually there is both cooperation and competition at the same time – without this kind of relationship, networks could not function properly [FORESIGHT 2011]. The network's dynamic growth is due to the development of information technologies. "Each of the two processes – a network-based increase in productivity and network-based globalization – is driven by a specific industry: the information technology industry, increasingly organized around the Internet, as a source of new technologies and specialized management knowledge for of the whole economy" [Castells 2007]. As a result of the convergence of devices enabling freedom in communication and the exchange of knowledge, there is potential for the emergence of new sectors (platforms) based on geographically dispersed competences and built for the implementation of individual projects. In addition, the convergence of software, hardware and communication technologies leads to an increase in automation (e.g. through robots and 3D printing), and thus to a higher level of operational efficiency. Modern networks are therefore based on digital technologies and using their ecosystems to build networked enterprises and digital business models [Łobejko et al. 2018], as well as competing with supply chains integrated through the flow of information (and the goods and funds following them) [Nowicka, Nowicka, Szpringer 2019].

Technology and innovation are one of the main factors influencing the evolution of the supply chain [MacCarthy et al. 2016]. The processes occurring within the organization, the offered products, the communication channels and all the other key aspects related to supply chain management are going through an accelerated digital transformation process [Geisberger, Broy 2012].

As a result of the changes caused by the conditions of the digital economy, supply chain managers are increasingly expected to be innovative and creative in how to achieve competitive advantages. Traditional supply chain strategies were geared towards incremental changes, risk avoidance and cost containment skills to improve efficiency. According to Gartner, contemporary supply chain strategies are expected to have a different approach to how to win the competitive struggle. This should give the possibility of two-fold actions in supply chain management. The first of them assumes a linear approach to changes, emphasizing: the importance of predictability, accuracy, reliability and stability. The second talks about non-linearity, failure, learning through iteration. Agility and speed are important, and the ability to deal with uncertainty is key. Due to the difficulty in building supply chains that meet the assumptions of the second approach, most managers focus on the first approach to managing the supply chain, remaining in a kind of ‘comfort zone’ in relation to the type of decisions taken and basing them primarily on experience. Non-vulnerability of changes requires, however, taking the risk of ‘non-criminal’ decisions. As a result, hybrid solutions appear in supply chain management, i.e. using both the resources used so far – constituting a kind of foundations for them, and introducing new, innovative solutions, including speed, risk and readiness to act – as in the case of start-ups [Griswold 2017]. Digital technologies implemented in supply chain management are such a new solution. As a result of their implementation, supply chains are undergoing a digital transformation. The digital transformation of the supply chain is the transformation of its business model into one that provides new value based on digital technologies in order to achieve higher efficiency as part of achieving the strategic goals set for supply chains [Nowicka 2019b]. The digital transformation of the supply chain is the process and result of the digital transformation strategy adopted first by the company. Subsequently an operational model and a supply chain management model are developed; planning of integrated activities within the sourcing, production and distribution functions takes place; measures and indicators of expected results for individual functions are defined, and the infrastructure of the technology ecosystem is built, enabling the implementation of strategic goals of both the enterprise (digital chain leader) and the supply chain [Raab, Griffin-Cryan 2011].

4. Digital supply chain – the concept and the practice

Digital transformation creates digital supply chains, understood as a new supply chain business model based on the properties of digital technologies, which aims to provide values higher than currently [Nowicka 2019b]. An example of a digital supply chain (referred there to as the ‘self-thinking supply chain’) can be the model developed by A. Calatayud, J. Mangan, M. Christopher [2018], which is fully based on digital technologies and their properties.

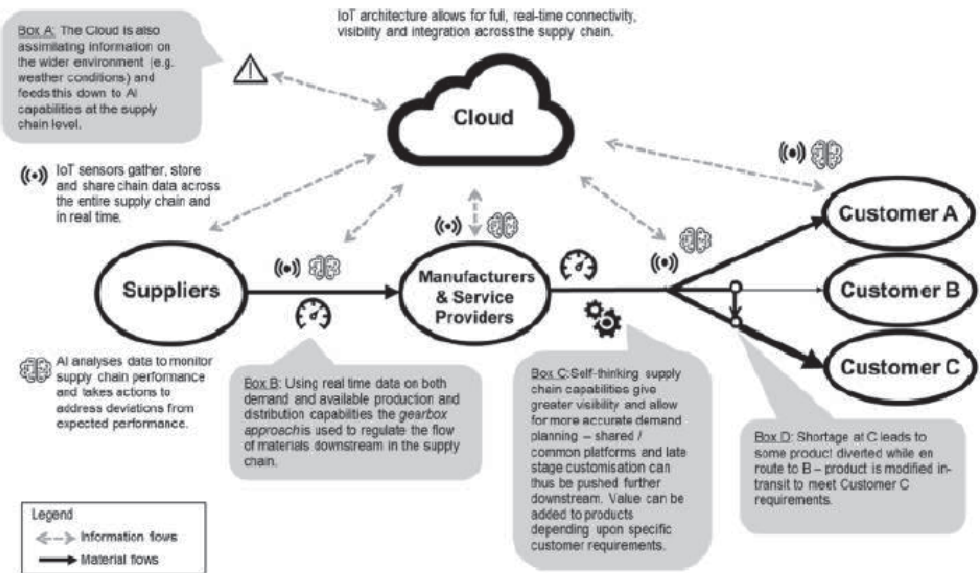


Fig. 1. Example of a digital supply chain model

Source: [Calatayud, Mangan, Christopher, 2018, p. 10].

The most important changes resulting from the implementation of digital technologies in supply chains include [Lei et al. 2010; Agrawal, Narain 2018]:

- redesigning business process models (including their digitization, standardization and improvement);
- process automation and improvement based on a new way of accessing information;
- cooperation in the supply chain, including data exchange, connectivity, partnership;
- supply chain integration;
- process and product innovations;
- greater transparency leading to better decisions;
- reduction of inventory levels due to an increase in the use of just-in-time deliveries;
- better visibility (level) of resources resulting from full integration of systems throughout the entire value chain;
- greater decentralization of storage to reduce costs associated with deliveries;
- better understanding of customer needs and the ability to improve customer relationships;
- the ability to react quickly to changes in demand;
- access to current sales information;
- increase in sales, higher margins;

- a wider range of choices in the decision-making process in the field of supply chain management,
- increase or maintenance of competitive advantage.

As part of the diagnosis of the changes occurring in supply chains resulting from the use of digital technologies, a CATI survey was conducted among supply chain managers in Poland. The quantitative survey was conducted in November and December 2018 using standardized questionnaire interviews. The sample was random, and the sampling frame were micro, small, medium and large enterprises (respectively: employment: up to 9 employees, 10-49, 50-249, 250+) from the manufacturing, service, production and service sector located in the Bisnode Poland database. Contact was established with 1397 enterprises, and 120 full interviews were carried out.

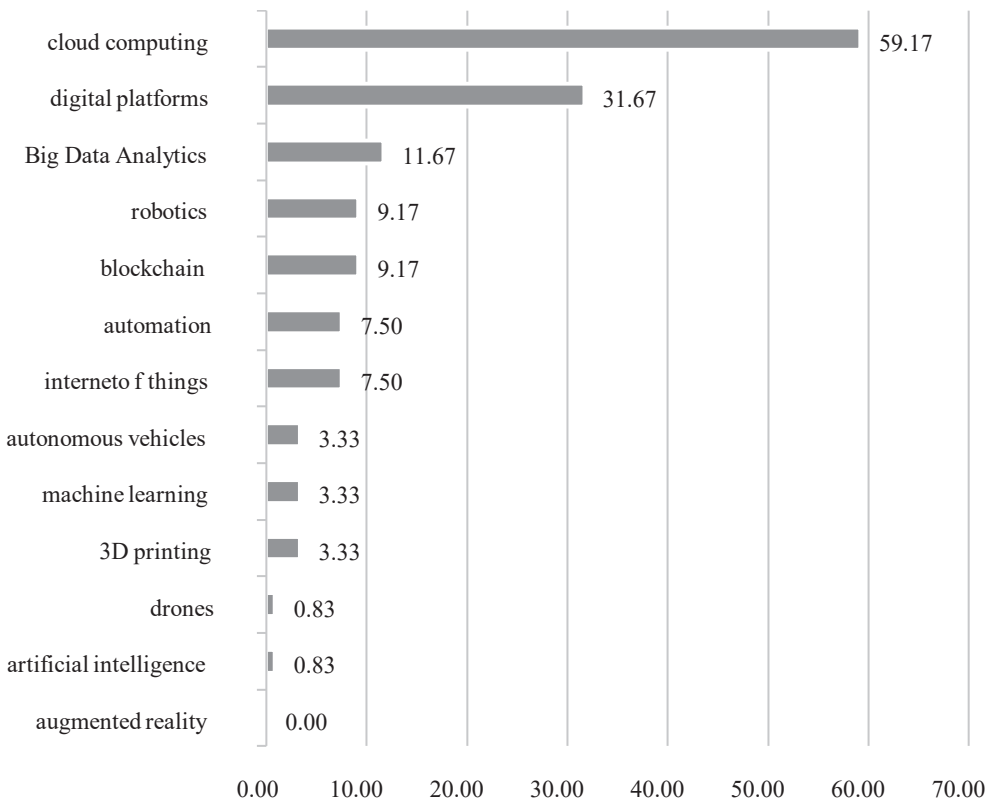


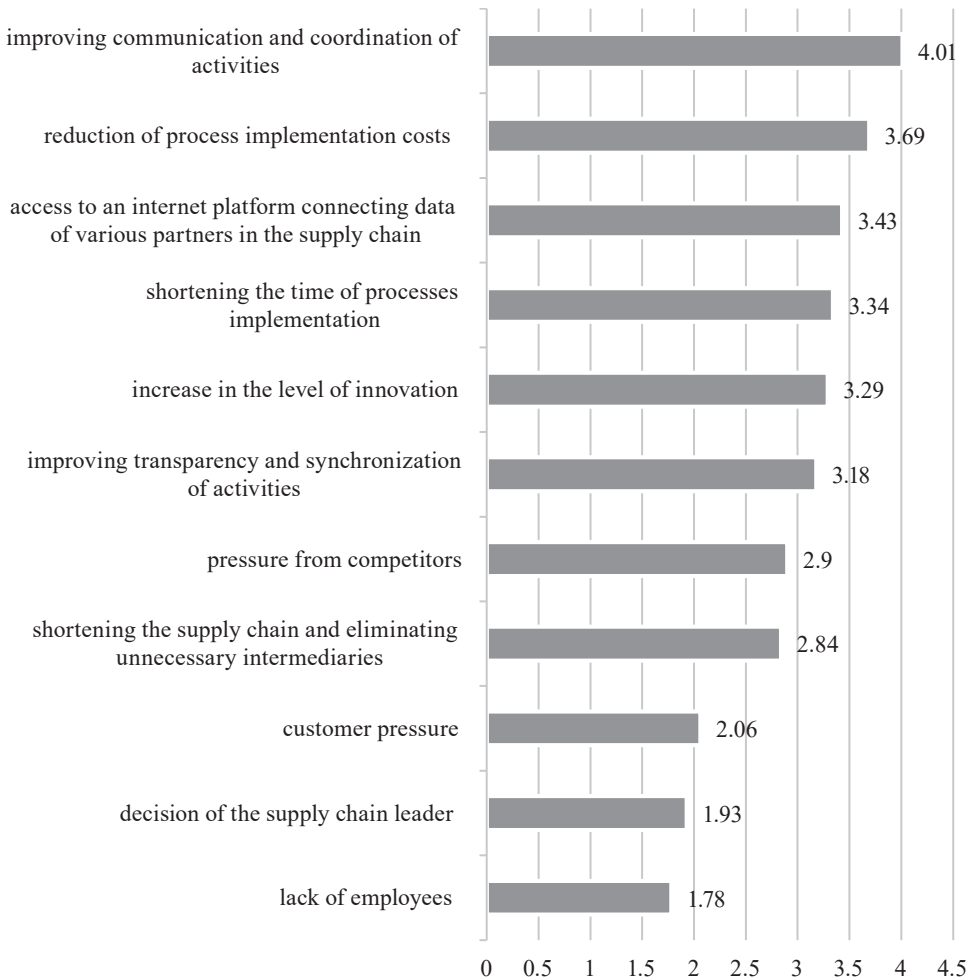
Fig. 2. Digital technologies used in supply chain management (%)

Source: own study based on the CATI survey results.

This part of the study focuses on identifying the most important digital technologies used in supporting supply chain management, the reasons for their use

and the changes resulting from their use in this area of organization management. The most important barriers to the implementation of digital technologies in supply chain processes were also identified.

Cloud computing and digital platforms (also based on solutions available in the cloud computing model) are the most commonly used technologies in supply chain management, while the lowest application rate applies to drones, machine learning, autonomous vehicles, 3D printing, AI and augmented reality. The degree of use of individual technologies is illustrated in Figure 2.

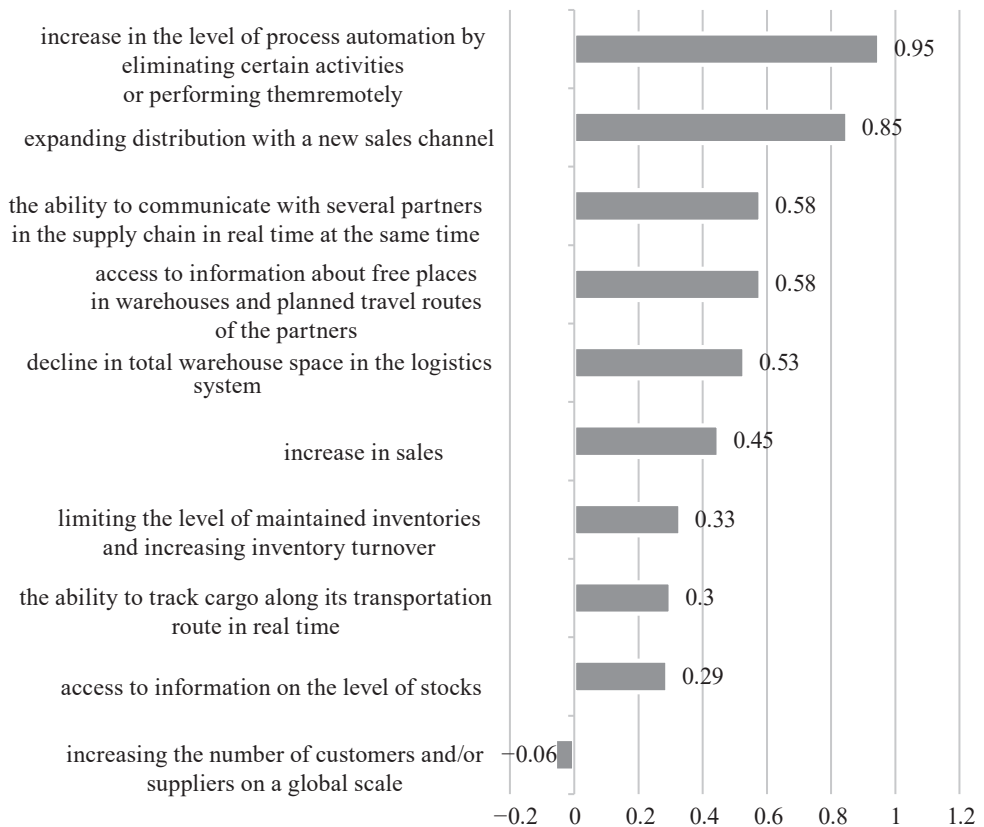


Scale: 5-0, where 5 – priority; 4 – very important; 3 – significant; 2 – not very significant; 1 – invalid; 0 – not taken into account.

Fig. 3. Reasons for using digital technologies

Source: own study based on the CATI survey results.

The main reasons for using digital technologies in supply chain management, according to the respondents, were the improvement of communication and coordination of activities, the reduction of the costs of implementing the supply chain processes and the possibility of access to a platform connecting data of various partners. In addition, it was also important to shorten the time needed to process and increase the level of innovation (Figure 3). Improving communication and reducing costs are areas that harmonize with the strategic goals of supply chain management indicated earlier. Further development and an increase in the use of technologies such as blockchain and the Internet of Things will be able to further support the implementation of strategic goals in this area of management [Nowicka 2019b].



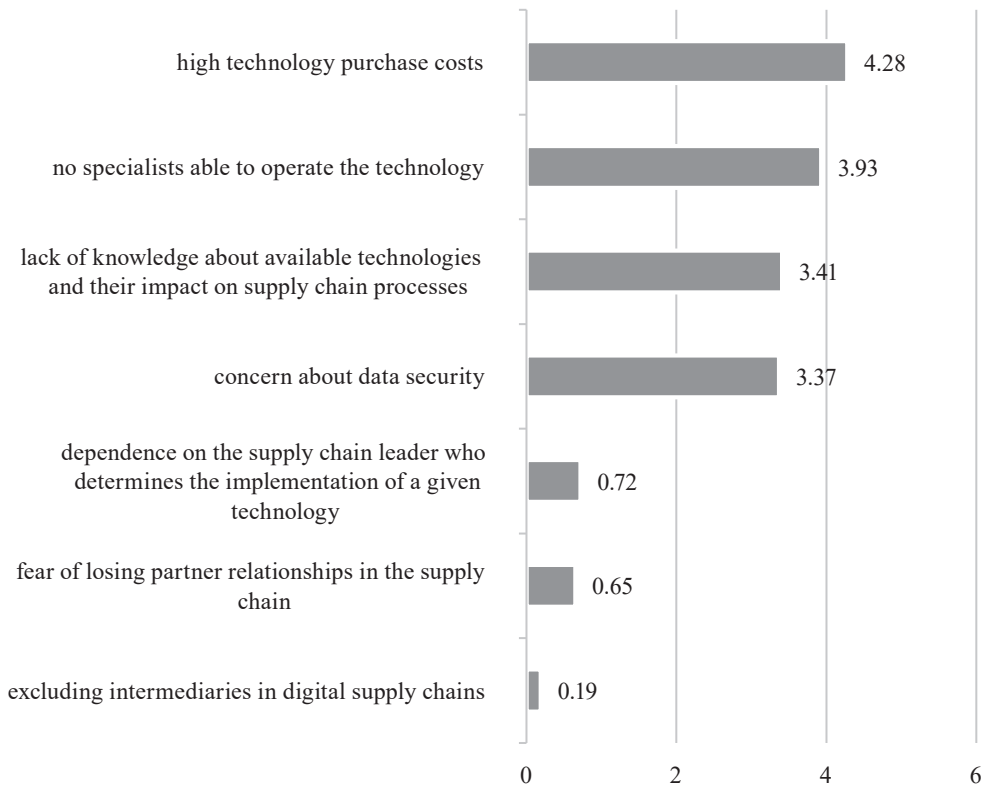
Scale: -1-1, where: -1 – I do not agree; 0 – I don't know; 1 – I agree.

Fig. 4. Changes in supply chain management resulting from the use of digital technologies

Source: own study based on the CATI survey results.

The essence of using technology in supply chain management is to indicate the changes and the achieved results resulting from their implementation. Among

the most important of them, the respondents included the increase in the level of process automation and the extension of distribution by a new sales channel. As a result of their application, the possibility of simultaneous communication with several partners and access to information related to logistics activities, i.e. free storage spaces and planned cargo routes, were also indicated. The indicated effects are a premise to state that technologies support the development in terms of the quality of implemented activities due to their greater precision in a situation when they are automated and in terms of the entire business due to the construction of a new distribution channel based on these technologies. The intensity of the indicators of the changes in supply chain management resulting from the implemented technologies is presented in Figure 4.



Scale: 5-0, where: 5 – priority; 4 – very important; 3 – significant; 2 – not very significant; 1 – invalid; 0 – completely unimportant.

Fig. 5. Barriers to the implementation of digital technologies in supply chain

Source: own study based on the CATI survey results.

In addition, in the study it was important to determine the types of barriers to the implementation of digital technologies in supply chain management and its processes. The high costs of technology purchase were considered the highest barrier by the respondents. The second very important barrier was the lack of specialists possessing adequate competencies to support new technologies in the supply chain management process. The lack of knowledge about available technologies and their impact on supply chain processes also proved to be a barrier. The fourth major barrier to technology implementations was the concern about data security. The intensity of barrier importance indicators for the implementation of digital technologies in supply chain processes is shown in Figure 5.

5. Conclusion

Digital technologies and their properties change the principles of competition in a modern organization. Their implementation stimulates the development of digital innovations that, when used in supply chain management, allow to improve the achieved results. As a result of their implementation, digital supply chains can be built that take over the implementation of a significant part of operational (as well as tactical) activities. Their development is dictated by the scale of benefits – the values provided – and barriers to the implementation of digital technologies. It is worth mentioning that digital innovations, which are a reference point for the development of digital supply chains, drive the digital transformation of supply chains as a process. This process tends to develop the next stage in the evolution of supply chains, but it is difficult to clearly define due to the changes taking place in the technologies themselves, their properties and the effects of the combination of their use.

The results of the survey of supply chain managers using digital technologies indicate that they can be a significant source of competitiveness improvement through the digital innovations implemented in this area of management. The wide range of their impact results from the versatility of the properties of selected technologies (mainly cloud computing) and is the aftermath of the significance of the reasons (needs) of their application (related to the need to reduce time, costs and improve the quality of activities). However, it should be emphasized that digital technologies are still treated as one of the resources in supply chain management, and managers indicate both the high costs of their implementation and the lack of specialists as the main barriers to the implementation of digital innovations. This last argument seems to be particularly important due to the fact that these specialists should in fact have the competence to combine knowledge of the properties of the technology itself or a combination of them, as well as the needs and strategic priorities of supply chain management that could be achieved thanks to digital innovations in supply chain management.

Bibliography

- Agrawal P., Narain R., 2018, *Digital supply chain management: An overview*, Materials Science and Engineering, vol. 455, p. 5.
- Akesson M., 2009, *Digital innovation in the value networks of newspapers*, Gothenburg Studies in Informatics, Report 42, September.
- Calatayud A., Mangan J., Christopher M., 2018, *The self-thinking supply chain*, Supply Chain Management: An International Journal, p. 10.
- Castells A.M., 2007, *Spółeczeństwo w sieci*, Wydawnictwo Naukowe PWN, Warszawa.
- Christopher M., 2016, *Logistics and Supply Chain Management*, Pearson, London.
- FORESIGHT 2011, „*Sieci gospodarcze Wielkopolski*” – scenariusze transformacji wiedzy wspierające innowacyjną gospodarkę. Raport końcowy, M.K. Wyrwicka (ed.), Wydawnictwo Politechniki Poznańskiej, Poznań.
- Geisberger E., Broy M., 2012, *Agenda CPS – Integrierte Forschungsagenda Cyber-Physical Systems*, Springer, Berlin.
- Goliński M., 2018, *Gospodarka cyfrowa, gospodarka informacyjna, gospodarka oparta na wiedzy – różne określenia tych samych zjawisk czy podobne pojęcia określające różne zjawiska?*, Roczniki Kolegium Analiz Ekonomicznych, nr 49, p. 185.
- Griswold M., 2017, *Supply chain leaders must be prepared to transform in a disruptive world: A Gartner trend insight report*, Gartner, <https://www.gartner.com/doc/3664318> (20.10.2018).
- Henfridsson O., Yoo Y., Svahn S., 2009, *Path Creation in Digital Innovation: A Multi-Layered Dialectics Perspective*, Viktoria Institute, Sweden. Sprouts: Working Papers on Information Systems, 9(20), <http://sprouts.aisnet.org/9-20> (15.09.2018).
- Kowalczyk L., 2017, *Cyfryzacja w procesie postępu cywilizacyjnego i jej współczesna rola w innowacyjności*, [w:] *Innowacyjność to cyfryzacja i rozwój. Zarządzanie operacyjne w teorii i praktyce organizacji biznesowych, publicznych i pozarządowych*, L. Kowalczyk, F. Mroczo (eds.), Prace Naukowe Wyższej Szkoły Zarządzania i Przedsiębiorczości, t. 43(4).
- Lei Q., Yi S., Pan L., Song Y., 2010, *Research on the intelligent quality management system of Supply Chains based on Six Sigma theory*, Key Engineering Materials, pp. 646-651.
- Łobjeko S., Nowicka K., Szpringer W., 2018, *Biznes cyfrowy. Technologie, modele, regulacje*, Oficyna Wydawnicza SGH, Warszawa 2018.
- MacCarthy B.L., Blome C., Olhager J., Srari J.S., Zhao X., 2016, *Supply chain evolution – theory, concepts and science*, International Journal of Operations & Production Management, vol. 36, issue 12, pp. 1696-1718.
- Nambisan S., Lyytinen K., Majchrzak A., Song M., 2017, *Digital innovation management: Reinventing innovation management research in a digital world*, MIS Quarterly. Special Issue: IT and Innovation, vol. 41, no. 1, p. 224.
- Nowicka K., 2019a, *Biznes cyfrowy w optyce innowacji*, [in:] K. Nowicka (ed.), *Biznes cyfrowy. Perspektywa innowacji cyfrowych*, Oficyna Wydawnicza SGH, Warszawa.
- Nowicka K., 2019b, *Technologie cyfrowe jako determinanta transformacji łańcuchów dostaw*, Oficyna Wydawnicza SGH, Warszawa.
- Olszak C.M., 2015, *Cele i założenia strategii cyfrowej współczesnej organizacji*, [w:] *Informatyka 2 przyszłości. 30 lat Informatyki na Wydziale Zarządzania UW*, W. Chmielarz, J. Kisielnicki, T. Parys (eds.), Wydawnictwo Naukowe Wydziału Zarządzania Uniwersytetu Warszawskiego, Warszawa.
- Pieriegud J., 2016, *Cyfryzacja gospodarki i społeczeństwa – wymiar globalny, europejski i krajowy*, [w:] J. Gajewski, W. Paprocki, J. Pieriegud (ed.), *Cyfryzacja gospodarki i społeczeństwa – szanse i wyzwania dla sektorów infrastrukturalnych*, Publikacja Europejskiego Kongresu Finansowego, Instytut Badań nad Gospodarką Rynkową – Gdańska Akademia Bankowa, Gdańsk.

- Raab M., Griffin-Cryan B., 2011, *Digital transformation of supply chains. Creating value – when digital meets physical*, Capgemini.
- Reimsbach-Kounatze Ch., 2016, *Stimulating digital innovation for growth and inclusiveness. The role of policies for the successful diffusion of ICT*, OECD Digital Economy Policy Papers, OECD.
- Witkowski J., 2003, *Zarządzanie łańcuchem dostaw*, Polskie Wydawnictwo Ekonomiczne, Warszawa.
- www.gartner.com/it-glossary/digitalization (10.08.2018).
- Yoo Y., Lyytinen K., Thummadi V., Weiss A., 2010, *Unbounded innovation with digitalization: The case of the digital camera*, The Academy of Management Annual Meetin, January, p. 7, www.orgdna.net/wp-content/uploads/2011/10/AOM2010-Digital-Camera1.pdf (15.09.2018).