SILESIAN UNIVERSITY OF TECHNOLOGY PUBLISHING HOUSE

SCIENTIFIC PAPERS OF SILESIAN UNIVERSITY OF TECHNOLOGY 2023
ORGANIZATION AND MANAGEMENT SERIES NO. 170

TECHNOLOGICAL CONDITIONS FOR LOGISTICS 4.0 DEVELOPMENT

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Purpose: The publication presents the results of an analysis of the popularity of technologies used in logistics based on published technical literature. The aim of the work was to determine the participation of individual types of technologies in the development of Logistics 4.0. In the Industry 4.0 policy implemented in highly developed countries, logistics development is referred to as "Logistics 4.0".
Methodology: The work is based on the analysis of empirical data describing the topics of the application of the latest information technology and other technologies related to the fourth industrial revolution. The scope of the analysis covers technologies developed between 2014-2022.
Findings: Based on the investigation, the major technological subfields of Big Data, Cloud computing and networking, Business Intelligence and other, Internet of Things, and Hardware have been proposed as the core utility categories of technologies in Logistics 4.0.
Originality/value: The analysis can be useful for practical aims, e.g., while planning logistics 4.0 trainings, enterprising technical investments, but also for scientific and educational objectives.

Keywords: Industry 4.0, Logistics 4.0, IoT, Big Data, Cloud computing, ICT.

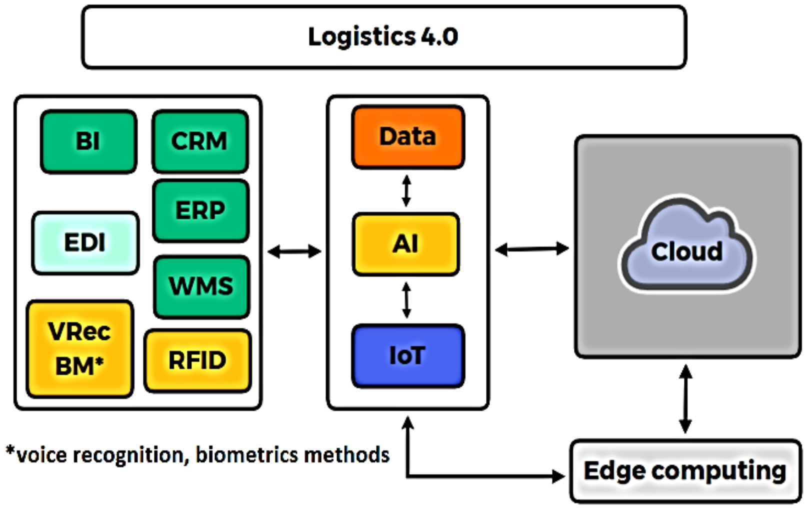
Category of the paper: Case study, literature review.

1. Introduction

Contemporary logistics is a highly intricate process. The one cause of that, among others, is the large number of commodity streams (raw materials, parts, semi-finished goods, and final products) and information streams that cross and complement one another. In order to optimal driving of products and information flow, enterprises implement the Fourth Industrial Revolution's strategy to improve the process. The new Industry 4.0 technologies complement existing information and communication technologies (ICT) used to support supply chain management (SCM) procedures. The concept of Industry 4.0 was born in Germany in 2011 as a proposal to Germany's economic in accordance with strategy: "High-Tech Strategy 2020 Action Plan" (Kagermann et al., 2013; Martin, 2015; Mosconi, 2015). The concept of Industry 4.0 is based on key technologies of the Fourth Industrial Revolution that are developing automation of activities, based on artificial intelligence (AI) algorithms, including machine learning (ML), have access to the Internet of Things (IoT) that allows machines to communicate with each other (M2M) (Hermann et al., 2016; Cooper, James, 2009). The Smart Factory fits Industry 4.0 perfectly. The concept of Smart Factory refers to an environment integrated by computers and information technology where reality is supported by virtual computer models. Smart Factory is also a place where data will be obtained, collected, and processed for use, e.g., at the stage of creating production plans, supply plans, types of distribution, etc. (Caggiano et al., 2015). Smart factories for internal and external logistics use machine-to-machine connectivity technology, such as the Industrial Internet of Things (IIoT). Some of the data coming from the sensors of these machines, or generated by users, is processed in real time using edge computing architecture, and huge data sets (Big Data) are stored and processed in cloud computing. Logistics, as well as manufacturing, uses artificial intelligence. Intelligent robots, cobots, autonomous vehicles perform many warehouse operations and activities to customize products (according to order specifications), such as cutting products, painting, picking, etc. The technologies mentioned in this publication, namely AI, Big Data, and IoT, are regarded as critical in Logistics 4.0. The term Logistics 4.0 refers to the application of Fourth Industrial Revolution technologies to internal and external logistics processes (Szymonik, Chudzik, 2020). Industry 4.0 technologies are expanding beyond enterprises (manufacturers), increasingly illustrating the level of competitiveness of the entire supply chain, which is known as the Smart Supply Chain when it is outfitted with contemporary technologies like AI, Big Data, IoT, and others (Dembińska et al., 2018).

The ability to effectively use information and telecommunications technologies and integrate them with the technical environment of the organization in the supply chain is currently one of the key factors in the development of logistics. The Fourth Industrial Revolution's technologies enable supply chains' essential logistics processes and functions to work closely together and be fully integrated. As a result, more and more businesses are making efforts to put Logistics 4.0 into practice.

This article presents the key technologies of Logistics 4.0 (AI, Big Data, IoT, Cloud Computing), along with Customer Relationship Management (CRM), Enterprise Resource Planning (ERP), and Warehouse Management System (WMS), that support Supply Chain Management. The structure of the interrelationships among the technologies discussed is shown in a figure (Figure 1). The paper is divided into a descriptive and an empirical section. The descriptive section is based on a critical analysis of the literature on the topic, while the research section is based on reports from Packt Publishing. The publishing house belongs to international publishers and provides the market audience with knowledge about key ICT technologies and innovative techniques and methods of Industry 4.0. The analysis' methodology includes a review of the Fourth Industrial Revolution's technological concepts and the extraction of the most important ones for the creation of Logistics 4.0. The key technologies identified were then analyzed in terms of their potential impact on logistics processes and their adoption level in the industry. The findings of the analysis provide insights into the future direction of logistics and supply chain management. In terms of knowledge resources about the use and ubiquity of technology, available publications in the form of books and video presentations have been subjected to quantitative analysis. The analysis made it possible to answer questions: What is the market demand for knowledge about the key technologies of Logistics 4.0? How, in the era of today's technological revolution, knowledge about them is popularized in publications?



Legend: BI – Business Intelligence, CRM – Customer Relationship Management, ERP – Enterprise Resource Planning, WMS – Warehouse Management System, EDI – Electronic Data Interchange, RFID – Radio-frequency identification, AI – Artificial Intelligence, IoT – Internet of Things.

Figure 1. Systems and information technology in Logistics 4.0.

Source: own research.

If companies do not want to fall behind, they must be ahead of their potential competitors. For this purpose, they implement Industry 4.0 technologies in their enterprises and throughout their supply chains, so they have to be the initiators of change. Therefore, a crucial part of logistics development must be learning new things and training cadres—not just in programming, but especially in analytical skills. These specialists will be able to adjust to changes and integrate the new technologies of Logistics 4.0 into supply chains and businesses. By investing in the education and training of logistics professionals, businesses can ensure that they are well-equipped to handle the challenges of an increasingly digital and automated supply chain. This will not only improve efficiency and reduce costs but also help organizations stay competitive in a rapidly evolving marketplace.

2. Information Systems and Technologies of the Fourth Industrial Revolution in Logistics 4.0

Whole supply chains are supported by logistics systems in a broad sense. The use of ICT technologies like Big Data, AI, IoT, Cloud Computing, Edge Computing in supply chain management, and other developments, determines how modern digital businesses operate, (Szymonik, Chudzik, 2020) as shown in the figure (Figure 1). The centralized storage and real-time processing of data in the Cloud faces growing technical and analytical challenges as IoT devices are used more and more in business and daily life, producing an increasing amount of data. An edge architecture could be used as a solution. Edge Computing, also known as fog computing, can move data control to edge servers while keeping the fundamental benefits of Cloud Computing. However, the increasing dispersion of data is causing a data security problem. In this context, discussions about the potential of Blockchain technology are growing. Blockchain technology can provide a secure and decentralized solution to data management, while edge computing can enhance the speed and efficiency of data processing. Therefore, the integration of blockchain and edge computing has the potential to address the challenges of data security and privacy in a more effective way (Luo et al., 2020).

Logistic process management systems are integrated (Integrated Logistics Information Systems (ILIS)). Information systems are modularly organized, e.g., procurement module, order module, complaints module, etc. Logistics information systems are part of Integrated Management Information Systems (IMIS). Within enterprises, IT systems support all areas of business activity, from marketing, planning, and procurement through technical production preparation, production process management, distribution, sales, repair economy, financial and accounting work, and human resource management (Gunia, 2019; Adamczewski, 2014; Banaszak et al., 2016).

The key software used in enterprise logistics is ERP (Enterpirise Resource Planning), which was created on the structure of the Materials Requirement Planning (MRP) system (Radziejowska, 2001). Integrated ERP management systems consist of sales planning, supply management, and warehouse management. They are comprehensive systems, encompassing practically all production and distribution processes. Through the integration of supply chain cells, they improve the flow of information critical to its functioning and allow the participants in the supply chains to respond quickly to changes in demand. By operating on the basis of web resources, these systems enable the creation of web services dedicated to the chain, such as those for customers, cooperatives, and suppliers (Bentyn, 2017). The function of ERP systems has evolved in recent years from basic process support to a superior service platform in the form of data aggregation and exchange between various systems dedicated to different business areas and functions. These systems serve as both a data source for Logistics 4.0 solutions and a hub for data collection, processing, and optimization of logistics operations (Lech, 2003).

IT-computer systems in logistics processes, in addition to supporting inventory planning, are also used to analyze customer behavior and preferences, which helps wholesalers personalize their offerings and improve customer satisfaction (CRM systems). CRM software consists of three basic components for logistics support: operational, communication, and analytical. In modern logistics (Logistics 4.0) in CRM solutions, wholesalers take data segments such as customer data, transactions, products, contact forms, etc. as of particular importance (Lotko, 2003; Szymonik, Nowak, 2018).

At various points in the material demand and warehouse sales cycle, modern warehouses require the application of RFID technology, image analysis and recognition, or augmented reality. RFID, or electronic product recognition, enables the supply chain to identify all items and specific products (Bentyn, 2013; Sarma, 2008). The data exchange systems EDI (Electronic Data Interchange) and VMI (Vendor Managed Inventory) in use throughout the supply chain are of particular significance. When referring to an organization's internal systems, the WMS (Warehouse Management System) should be mentioned as a system that enables more effective operation of warehouses, including full utilization of their capacity, control of the course of warehouse turnover, and the potential for automating specific operations (Bentyn, 2017).

These systems, in conjunction with physical objects and technologies, are interconnected and can communicate with each other in real time via a global network. According to the idea of the IIoT, unlimited communication improves and automates decision-making and the transfer of data and information between connected devices. Modern technologies are based on machine learning (ML) algorithms and real-time decision-making systems (Atzori et al., 2010; Baurer et al., 2014; Hribernik et al., 2010).

The most important element of logistics solutions is the integration of procurement processes. In this area, properly used modern technologies allow for the best results: reduced costs and improved logistics. Maintaining the enterprise's competitive position requires proper use of the potential of new technologies (Gunia, 2019). Supply chains are becoming more self-sufficient and automated. The supply chain management system's full autonomy is the culmination of the logistics process and the computerization of individual supply chain links. Such a chain is characterized by the ability to self-configure, self-repair, self-optimize, and automatically protect processes (Schanne et al., 2003; Bentyn, 2017; Szymczak, 2015). Information sharing in supply chains addresses the idea of the Internet of Things, which potentially improves search, data updates, and identification of materials and resources in the supply chain. Logistics 4.0 seeks to build autonomous and fully automated chains to optimize processes. After Logistics 4.0, another concept of "Smart Logistics" is proposed by the scientific and business communities. In the next concept of logistics development, attention is paid to the importance of the human factor and the sustainability of supply chains. The change is due to the emergence of the "Industry 5.0" concept. The concept of "Industry 5.0" was introduced in 2015. Michael Rada. An attribute of Industry 5.0 is the interaction between human and machine (robot), including in logistics.

Industry 5.0 reflects the growing need to individualize production, which is a result of increasingly individualized customer demand. In the cooperation between human and machine in the personalized production model, the element of human creativity is important. On the basis of Industry 5.0, Logistics 5.0 is expected to emerge (Dembińska et al., 2018).

3. Key Technologies of Logistics 4.0 analysis

This publication recognizes IoT, Big Data, AI as the triad of technological advances in the development of Logistics 4.0.

Active Learning & Learning Strategies ranks second on the World Economic Forum's (WEF) list of top competencies for the future, published in 2020. It should be noted that the first five skills on the list include several soft competencies. WEF experts estimate that up to 50% of the workforce will also require retraining by 2025. In the case of ICT skills, enterprises are constantly struggling to find new employees while also looking for efficient ways to train those who are already employed.

Studying the number of publications, courses in a given field, and area of use can provide added value for logistics. Tracking technological trends and preparing reports in this area shows in which direction the market is developing and can also determine the potential direction of enterprise development. Key activities not only concern the new IT infrastructure itself but also properly trained personnel. The analysis was carried out for the development of logistics processes by studying the usefulness of key IT technologies and Logistics 4.0 technologies.

The conclusions are based on data from publications available at https://www.packtpub.com/. The site used has the character of a library, bookstore, or "training center". The site used is a case study in this publication because it is one of many sites that assist developers and non-developers alike in staying current with the technologies embedded in the Fourth Industrial Revolution. Through various learning formats and a growing ecosystem of ICT resources and products, the site covers both emerging and contemporary tools and trends. Its goal is to provide professionals with effective education and information services in the form of the practical knowledge they need, whether it is specific learning about a new technology or optimizing key skills in more established tools. The data used in the analysis is publicly available.

The scope of the analysis covered four general categories of the latest ICT technologies promoting the development of Logistics 4.0, which were classified in the following categories on the website https://www.packtpub.com/: Data, Cloud&Networking, IoT&Hardware, Business&Other (Figure 2).

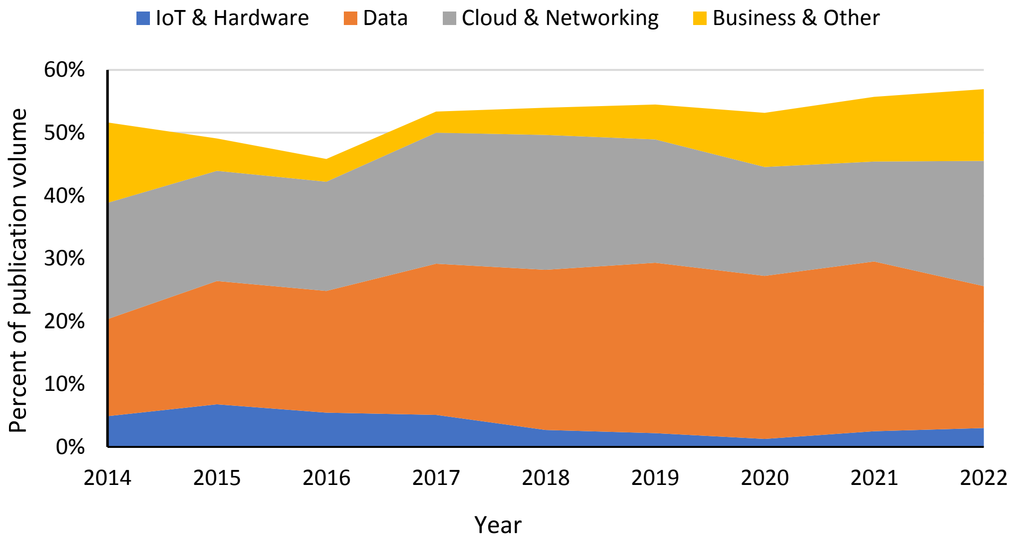


Figure 2. An overview of technologies closely linked to Logistics 4.0.

Source: own research.

In the total number of analyzed publications, the most popular were IT technologies and tools related to data collection, processing, and analysis, which is the category used in the figure as Data. The cloud solutions for storing large amounts of data in the Cloud & Networking category, as well as those that perform other functions like updating device IT software and other functions like system security, device navigation, network administration and management, etc., were ranked second in this report. This indicates that there is a growing demand for cloud-based solutions that offer a wide range of functions and capabilities beyond just data storage. It also suggests that businesses are increasingly looking for comprehensive solutions that can help them manage their IT infrastructure more efficiently. These two technologies would not have developed so rapidly in recent years without IoT and the appropriate IT and hardware software (IoT&Hardware) to support logistics processes. Furthermore, it is noted that the fourth category listed as Business&Other includes the development of logistics systems such as ERP and Business Management as well as additional systems, e.g., design support of logistic processes using digital twins and soft skills solutions. In current IT skills training, increasing importance is given to building soft skills, including critical and analytical thinking, teamwork, interpersonal communication, stress management, etc. (Dean, East, 2019).

Based on the technologies shown in the figure (Figure 2), a detailed analysis was made. In each general category, the techniques used within each concept are listed. Each of the main categories has been color-coded as shown in the figure (Figure 2): orange for Data, gray for Colud&Networking, blue for IoT&Hardware and green for Business&other. The analyzed subcategories within the main category maintain the adopted color scheme, and each subcategory is presented in the charts according to the time range from 2014-2022. Each row represents 100% of the publications over the years in the subject of the main category.

To present the results, heat maps were used, drawn up in R. The intensity of the color represents the number of publications; the more intense (darker) the color, the higher the number. Each of the heat maps also included technologies that had single indications in the tested database and were recorded in one group called "other".

The research methodology is shown in the figure (Figure 3).

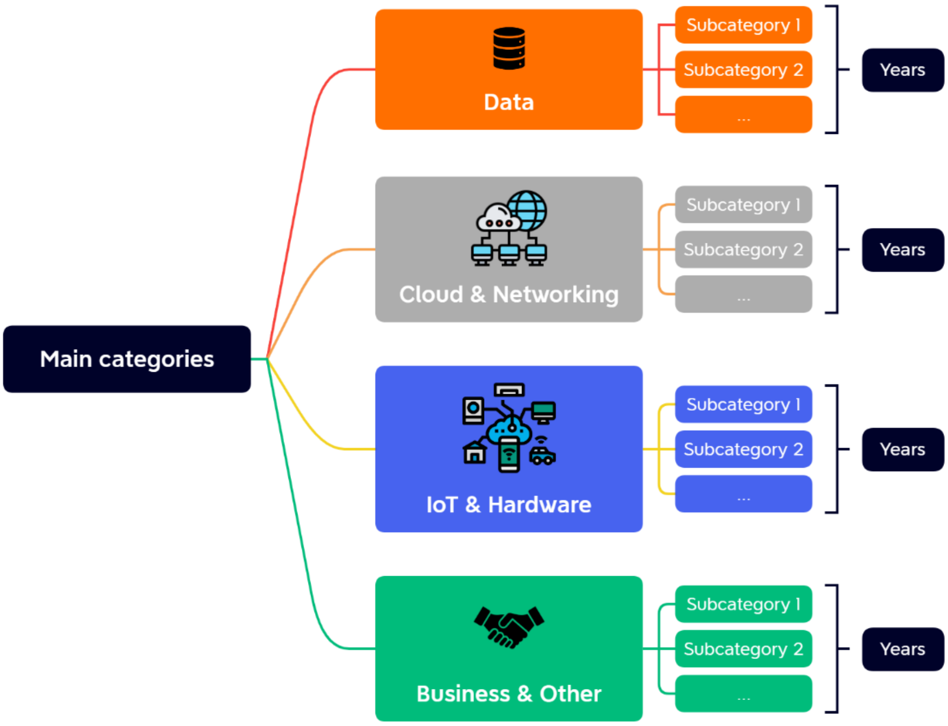


Figure 3. The research methodology.

Source: own research.

The figure (Figure 4) shows that the Machine Learnig (ML) concept, which in Logistics 4.0 is a new form of machine communication, is the most widely discussed concept in scientific publications between 2017 and 2022 (intensive orange color). Machine Learning in logistics is applied to demand forecasting and inventory management, transport routes optimization, machine, and equipment preventive maintenance, and is also used in warehouses such as mobile robots, in voice picking devices for order completion (Uczenie…, 2021).

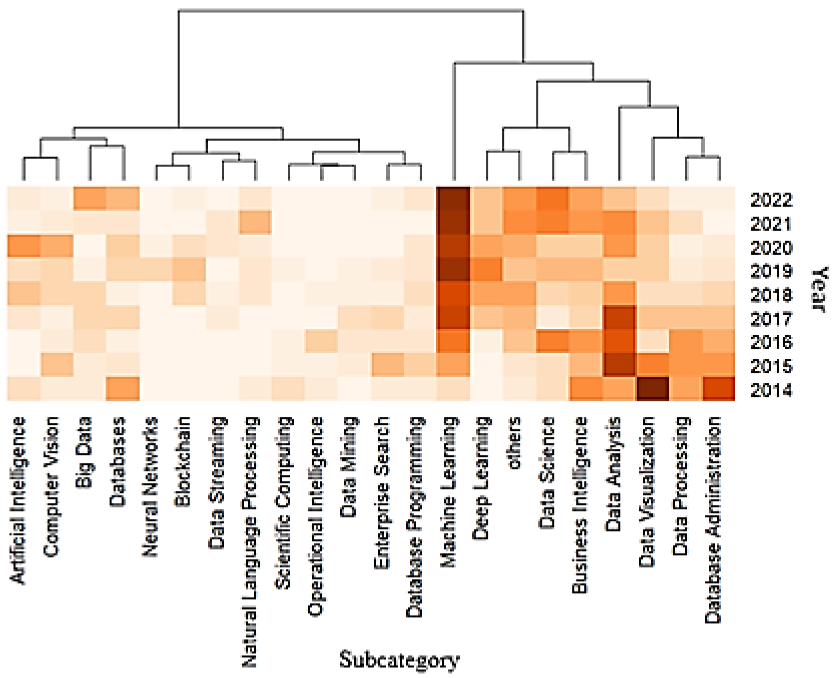


Figure 4. Heatmap for Data category (by row).

Source: own research.

ML, along with deep learning (DL) and neural networks (NN), natural language processing (NLP), and computer vision (CompV), is part of Artificial Intelligence (AI). Relationships between these areas are shown in the Venna diagram (Figure 5).

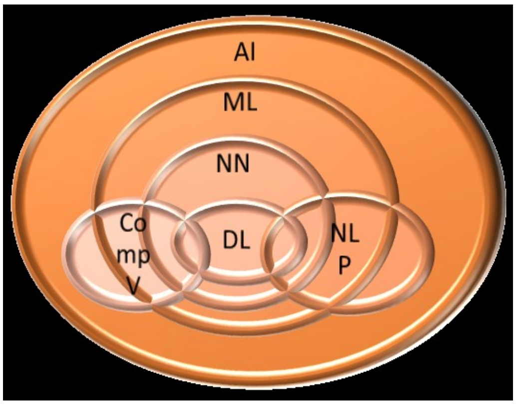


Figure 5. AI and its components.

Source: own research.

NLP and CompV are also increasingly used in logistics. NLP algorithms are used, for example, in creating chatbots to assist customers in logistic processes, as well as other solutions to limit the use of information flow in paper form. CompV helps in locating logistic facilities (goods, vehicles, and people) through QR (Quick Response) codes, barcodes, and optical character recognition (OCR). Codes used in goods control processes using IT-computer algorithms serve to optimize logistics and, in the case of people, to identify persons entitled to monitor processes.

Blockchain (BC), which is linked to Logistics 4.0, gained popularity in 2017-2019. However, it can be assumed that with the popularization of the Industry 5.0 (January 2021) concept of the European Commission (EC) (Industry 5.0: Towards a more sustainable, resilient, and human-centric industry, 2021), the popularity of BC in the life cycle analysis (LCA) aspect will grow, including among all product users.

Data Analysis (DA), Data Visualization (DV), Database Administration (DBA), Databases (Db) preceded the popularity of ML occurring with the greatest intensity in 2014-2017, which is a natural stage in the development of these technologies, because first sensors generate data, which after accumulation are the basis for building ML algorithms. Until 2014 only two publications about ML were created. In contrast, in 2014 in the area of AI, DL, and NN topics there was no publication in the analyzed database. Popularity of these solutions grew after 2014. ML used in logistics processes and other organizations contributes to (Gajdzik, 2014):

- demand forecasting,
- preventive maintenance of machinery and equipment,
- optimization of transport routes,
- reverse logistics in the case of waste and returns of goods,
- recognizing the voice of employees in warehouses entitled to operate the given technology,
- mobile robots for the identification of goods,
- control of inventory levels and minimizing inventory management risks (quick response),
- other functions of the WMS.

The next phase of the analysis was the Cloud&Networking area, which through the collection, transfer, and transfer of data (Big Data), contributes to improving the efficiency of entire supply chains by reducing the logistics costs associated with the rationalization of the bases of participants in the supply chain as well as products and services. The cloud IT systems market includes, in addition to hardware infrastructure, many dedicated IT system classes. The dedicated systems can relate to the service of specific areas of the enterprise, such as warehouses or transportation processes, or to the business service as a whole (Malinowska, Rzerzycki, 2016). Dedicated to logistics processes, computer clouds have been called Cloud Logistics.

Referring to a figure (Figure 2), Cloud&Networking are constantly developing technologies and are strongly popularized in the logistics community. Compared to other technologies used for data management, the share of Cloud Computing (CC) is the highest in the surveyed years 2014-2022, as noted in the heat map by the increasing gray color in a figure (Figure 6). In addition to CC, other important technologies include System Administration, IT Certification (training), and DevOps. The listed technologies do not exhaust all solutions used in process logistics for data management and are closely related to CC. Containerization, Virtualization, Cloud Native are also emerging in the logistics of the future. The new solutions are strongly linked to modern work methods classified as agility (L'Hermitte et al., 2015).

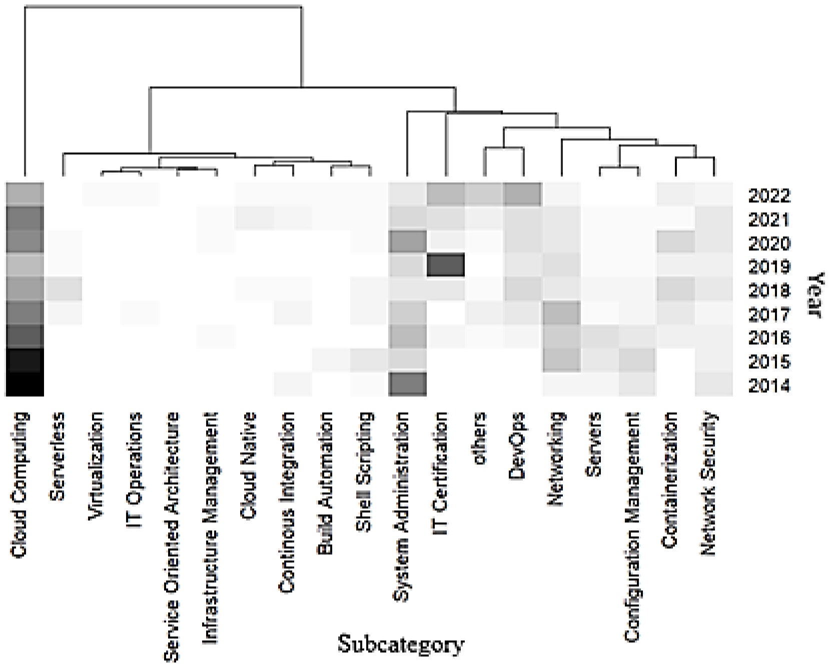


Figure 6. Heatmap for Cloud&Networking category.

Source: own research.

Based on the figure (Figure 7), the following technology areas relevant to logistics development were analyzed: Robotics, IoT Development, Embedded Systems, Microcontroller, Industrial Internet of Things and Security, Single board computers and others. The listed technologies in the analyzed publications are classified under IoT & Hardware. The largest number of publications in the period under review were related to Robotics, Embedded systems, Single Board Computers and IoT development. These technologies are used in modern warehouses. The majority of warehouse and related processes, such as distribution, shipping, and picking, are automated in today's warehouses and transportation hubs, either entirely or to a high degree. In addition, Internet applications, embedded systems, and the use of microcontrollers are used to track goods and monitor their status during transport. Businesses must also accommodate customers' growing interest in tracking the status of their orders.

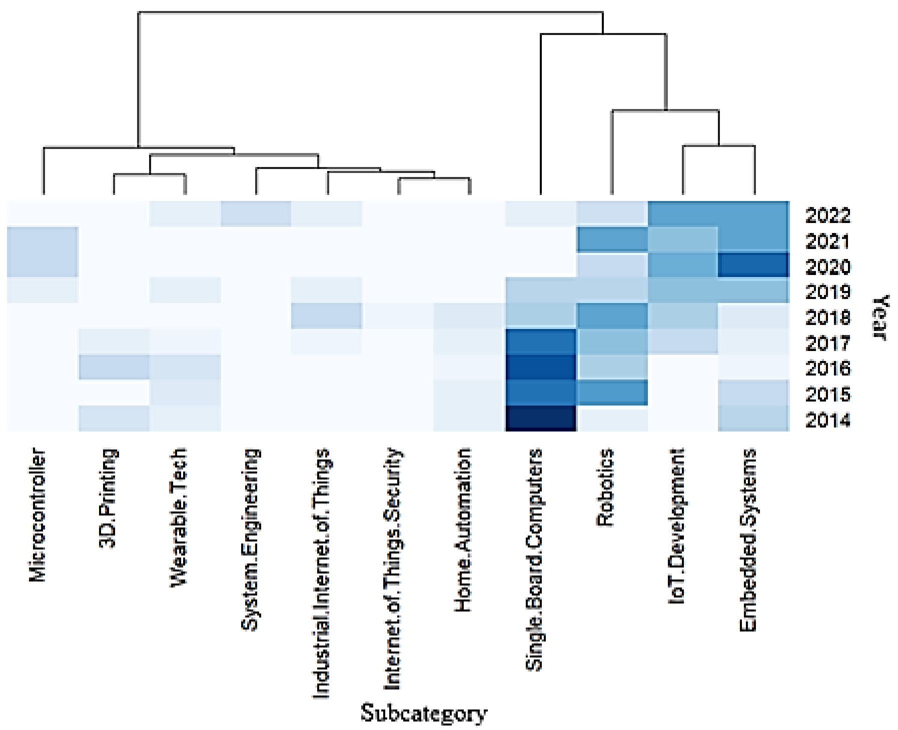


Figure 7. Heatmap for IoT & Hardware category.

Source: own research.

An analysis of the final category, Business & other, is given in a figure (Figure 8). This category includes solutions that support management, administrative, and design processes. During the time period from 2014 to 2022, the greatest scientific and research popularity has been in Project Management (PM) and ERP, where the ratio of the number of publications to the total number of publications in a given category during the study period was 15% and 16%, respectively. Due to the advancement of digital technologies, computer modeling of planned logistics processes within digital twins, simulation, and other factors, PM has a significant presence in scientific publications (Agalianosa et al., 2020).

In addition to technologies that support management-administration processes in logistics, techniques written in the agile subcategory related to PM are becoming increasingly popular. This was particularly highlighted in 2021, as the number of publications in the surveyed category related to PM accounted for 30% and the number of publications related to Agile accounted for 21% of the total number of publications in Bussines & other field. The enterprise environment is changing at an unprecedented pace and scope. As a result, in recent years, more and more companies are using management by projects to achieve their goals. To this end, companies are streamlining their work by creating project teams. Project management takes care of developing specific project goals, assigning roles, and managing budgets. Companies need to offer higher and higher quality products while adapting quickly to new circumstances. (Dryl, 2019). Agile work methods are often the answer to these needs. However, they require a change in thinking about how to manage the business, the product, and the people. Moreover, since agile methods focus more on interactions between people (employees, stakeholders) and less on processes, more publications may also confirm the importance of collaboration between new technologies and humans and the importance of human creativity.

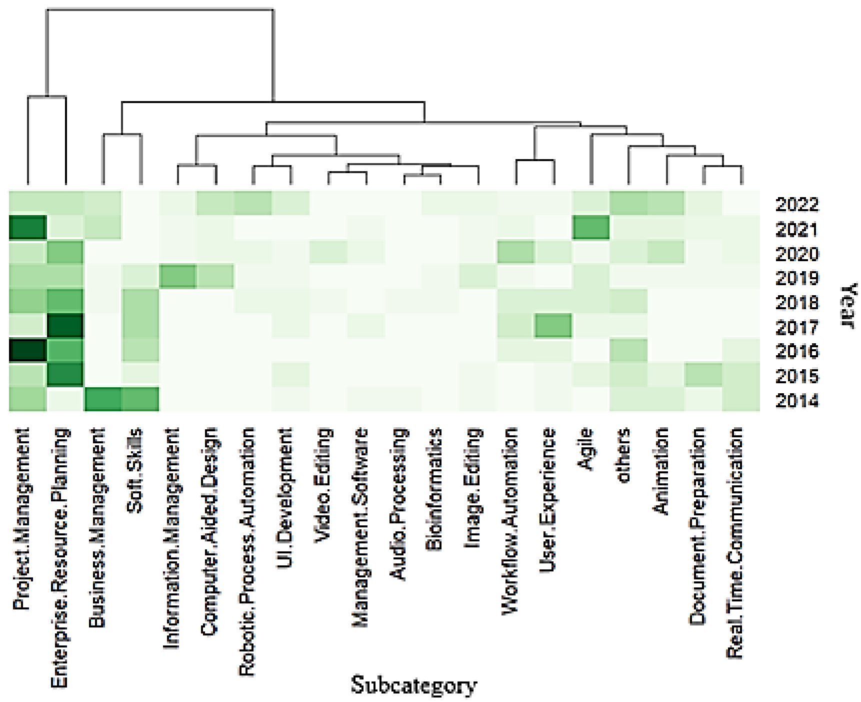


Figure 8. Heatmap for Business & other category.

Source: own research.

Two other factors should be mentioned: Robotic Process Automation (RPA) software and Computer Aided Design (CAD), which in 2022 achieved the same results as PM and ERP. At the same time, in this ranking, these are new solutions, as the first publications appeared for RPA in 2018 and for CAD in 2019. RPA software is a technology for creating digital robots supporting the implementation of business processes, including logistics processes. CAD has been known since the sixties of the last century, however, in recent years, due to technological progress, new tools and applications of computer-aided design have emerged. These tools can be used in both logistic process modeling, systems, creation of virtual warehouses (Plinta et al., 2019).

4. Conclusions

The results were presented according to the category studied:

1. Data.

In Logistics 4.0, Big Data is the typical name for Data, as in modern ICT and AI there are no small data sets. Big Data appeared just in 2013, which was associated with the strong popularization of the pillars of Industry 4.0. This shift towards the name Big Data reflects the increasing importance of data in all areas of business and industry and highlights the need for companies to effectively manage and utilize their data resources in order to remain competitive. As such, the term Big Data will likely continue to evolve alongside advances in technology and data analytics. In line with Industry 4.0 and Logistics 4.0, it is predicted that databases, along with the increasing demand for data stored in the cloud, will gain popularity, according to the researched publications.

As logistics procedures are created to comply with Industry 4.0 specifications, they seek to be optimized using the most recent ICT technologies (AI, IoT, and CC). The process approach has long been applied in the enterprise but has been limited to the internal enterprise, and in Logistics 4.0, it goes beyond the company, e.g., the collection of data from social media, public rankings, reports, exchanges, auctions, etc.

2. Cloud&Networking.

Cloud & Networking, because of their past use and improvement, are the basis for building IT infrastructure on a macro, mezo, and micro scale. Cloud & Networking technologies are considered a necessity in the global economy and in a digital society. Due to process linkages between participants in logistics processes (internal and external logistics), customization is growing in importance. The customer participates in the design of the product, service and follows the logistics process, determining its agility. Networking was and still is important in logistics, as concurrent technologies, integrated processes, customization, and reverse logistics, as well as the popularization of the green concept, provide opportunities for its growth. Networking is not only the Internet but also internal networks and external networks.

3. IoT&Hardware.

Of the four categories listed, the IoT&Hardware category is the most recent. The total number of publications in the period under review represents 95% of all publications since the founding of the publishing house in 2004. At the same time, it should be noted that logistics is an area that IoT will affect tremendously. The development of chips and microcontroller sensors makes it possible to track vehicles, goods, and containers in real time (not only location but also other relevant parameters such as temperature, humidity, etc.). The data collected and processed by IoT devices allows efficient management and monitoring of logistics processes, responding to emerging problems and faults in real time. In addition, there is a continuous development of automation and robotization in warehouses and distribution centers.

4. Business&Other.

The last category was organizational and management support systems. In this category, special attention was paid to the importance of ERP and Project Management in the development of logistics processes. With the development of modeling and simulation, the importance of virtualizing PM processes under test is growing. On the basis of already well-known ERP systems, other systems are being developed. The realization of the idea of an integrated organization became possible due to the modular design of the ERP system, which covered every aspect of management. When the idea of an extended enterprise emerged, i.e., an enterprise open to the environment, to suppliers, business partners, and customers, the ERP system evolved into ERP II, the architecture of which became component-based (application-based). The development of e-business played a major role in this process. On the other hand, the boom of cloud technologies, mobile applications, and social networks contributed to the emergence of hybrid ERP systems, combining the functionality of several systems (e.g., ERP, CRM, BI). This type of system is becoming a universal platform for handling enterprise operations. Business processes, which were previously internal processes of the enterprise, can be extended in various directions outside the enterprise. These processes then become extended business processes, multi-application processes, or, in other words, megaprocesses (Missbach, Anderson, 2016; Lenart, 2019).

5. Summary

The analysis's conclusion includes a list of recent technological innovations that can take into account future advancements in logistics and more. According to the analysis, it was found that the development of Industry 4.0's key technologies is the foundation for Logistics 4.0. Previous ICT solutions have received strong support from Data, Cloud and IoT, creating new business solutions in logistics processes (Buissiness & other). A detailed analysis showed that technologies such as AI with ML, general data analytics, CC, system administration, Networking, DevOps, IT certification, IIoT, embedded systems, robotics, single board computers, PM, ERP, and Agile have gained popularity in recent years.

The achievement of company goals should be the result of employee development initiatives. Employee development in an organization is responsible for a number of activities that help employees develop their skills, access the latest knowledge in this field, and improve motivation. This enhances their professional potential and enables them to perform current and future tasks more effectively. The research performed has a use value in training processes, and the technologies analyzed show their popularity through the number of publications in a given technological category that are used as training materials, among other things. The number of publications in a given area is a response to market demand. The analyzed technologies determine the directions of development of Logistics 4.0, which is characterized by digitalization, agility, smartness, and intelligence, and detail the application of Blockchain and Edge computing.

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