REVIEW OF INTELLIGENT SOLUTIONS TO OPTIMISE LOGISTICS PROCESSES AND IMPROVE EFFICIENCY

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Abstract

Constantly changing business conditions force companies to apply ever more intelligent solutions aimed at optimizing logistics processes and improving efficiency. In the era of globalization of supply chains, focus on digitalization, automation of logistic processes, solutions combining optimization activities with activities influencing the profitability of their implementation play an increasingly important role. The sharing economy in supply chains is as important an initiative as the application of IoT in transport processes or the application of the physical internet.

In this paper, the authors focused on conducting a review of available modern and intelligent solutions that not only optimize logistics processes but also improve the competitive position of enterprises in supply chains. The review was conducted both in the research aspect, by verifying knowledge on the subject in the scientific literature available on the Web of Science and Scopus databases (based on sciencedirect.com), but also in the practical aspect, by analyzing trends in the use of particular solutions in business practice.

The analyses will be complemented by expert verification of the degree of importance of individual intelligent solutions in business practice. The research carried out in this area is the result of cooperation between Poznan School of Logistics and Lukasiewicz Research Network - Institute of Logistics and Warehousing. The research was conducted in the first half of 2021 among Polish logistic companies.

Key words: innovation in logistics, supply chain efficiency, supply chain digitalization

1. INTRODUCTION

Megatrends are global, long-term changes that affect business, the economy, and culture at both societal and individual levels. They are multi-component in nature and their characteristic is that they do not change direction easily. Among the biggest megatrends having an indirect but significant impact on the changing business environment are the rapidly growing world population and the increasingly important and large middle classes in China and India. As a consequence of this phenomenon and the changing geopolitical configuration, the focus of the global economy is shifting eastward. Globalization, fragmentation of production and accelerating technology development are other factors that have a strong impact on business. These megatrends are compounded by the global problem of climate change and the resulting increase in the urban population. The megatrends described above affect the development trends of many industries, including logistics.

Megatrends are indirect causes of trends or directions of development of various social and economic areas. They have a recognizable path of development usually can be verified by quantitative data. Current trends are the result of historical dependence on the development path, which we believe will continue in the future. From the megatrends described above, there are a number of implications for logistics that take the form of trends. The main objective of the research work was to compare whether all of the analysed intelligent solutions are analysed with similar intensity in terms of science and business practice. According to the authors, only the synergy of these two environments gives a chance for further development of logistics using intelligent solutions. Only a few of them are listed below.

The rise of the middle class in emerging markets means increased exports and larger flows of goods to countries like China and India. Aging populations in western countries will increase the importance of automation and robotics in logistics. Shrinking resources will cause industry to relocate due to access to resources and thus create a demand for new logistics strategies. Climate change is already influencing environmentally friendly behavior, such as the increased use of electric vehicles, the growing importance of ecological solutions in warehouse construction and intralogistics, or the increasing popularity of business models based on sharing.

Fragmentation and globalization of production favors the introduction of solutions based on the concept of the "Physical Internet". The shift in the focus of the global economy to the East increases the importance of competing on quality of service. The growing urban population in turn generates demand for optimized logistics solutions related to the mobility of goods and people within cities.

In addition to the megatrends described above and the resulting trends in the development of global supply chains and intelligent solutions in logistics, we are also dealing with so-called "change drivers" that can affect changes in individual organizations, industries or the entire economy. A classic and very current example of such a change driver is the pandemic caused by the Covid-19 virus. Another change driver is the synergy effect achieved through mutually driving development of such technology areas as artificial intelligence, machine learning, robotics, nanotechnology, 3D printing or sensory systems. Together, these dynamically

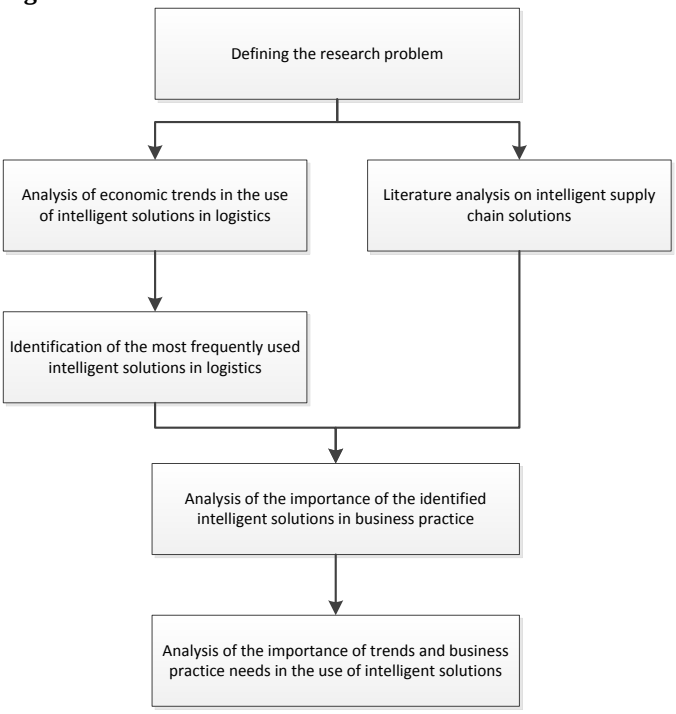
developing technologies mean that we can more and more boldly speak of the fourth industrial revolution taking place before our eyes under the banner of Industry 4.0.

Companies must respond by introducing increasingly intelligent solutions to optimize logistics processes and improve their competitive position in supply chains. In the context of the above mentioned megatrends, trends and "change drivers" (Change Drivers, 2016) an analysis of the emerging trends related to the application of intelligent solutions in logistics will be presented. The analysis is based firstly on the academic literature and secondly on a review of commercially available studies considered to be authoritative sources of information, such as DHL Trend Radar, PWC Trend Book and studies by the Word Economic Forum and OECD.

2. RESEARCH METHODOLOGY

The methodology provided for conducting parallel literature research and business practice research. The research was carried out both as part of the research work of the Institute of Logistics and Warehousing, as well as research work carried out as part of the statutory activity of the Poznan School of Logistics, carried out in 2020-2021.Figure 1 shows the methodology of the research work carried out.

Figure 1. Process of conducted research works



Source: own study

Due to the issues discussed, two theoretical scopes related to:

- a literature review on the use of innovations in logistics, indicating the popularity of particular solutions, in terms of the number of scientific publications on the subject,
- analysis of secondary sources, in the form of reports prepared by leading research institutes and logistics companies.

This division of research methods was used to compare whether all of the reviewed intelligent solutions are analysed with similar intensity in terms of science and business practice. While in scientific terms the number of publications on a given topic in leading scientific databases is a sufficient indicator for verification, in the case of business practice analysis a quantitative and qualitative analysis of the degree of use of the solutions in question was necessary.

The theoretical research was supported by the identification of the needs of business practice, which was carried out as part of the research work of Lukasiewicz Research Network - Institute of Logistics and Warehousing. The structure of this chapter corresponds to the logic of research work, consistent with the developed methodology.

3. RESEARCH OF INTELLIGENT SOLUTIONS IN SCIENTIFIC LITERATURE

Market globalization is causing a concentration of business activity on the level of customer service, which has become a key factor affecting the competitiveness of companies. Customer service is seen as the ability or capacity to satisfy customer requirements and expectations, mainly regarding the time and place of ordered supplies, using all available forms of logistics activity, including transportation, warehousing, inventory management, information and packaging (Leuschner, Charvet, Rogers, 2013). Lead time forces continuous improvement of material flow through the entire logistics supply chain. For this reason, concepts for logistical target customer service are continuously sought and improved. When analyzing customer requirements for the execution of logistics processes in dynamically changing supply chains, it can be observed, a constant search for both conceptual and technological solutions to improve supply chain efficiency (Osmolski et al. 2019; Witkowski, 2017). Therefore, the application of new technologies and innovations mainly in logistics processes has a key role in gaining competitive advantage in the market.

The application of intelligent solutions in logistics is widely discussed in the scientific literature. The number of publications on specific intelligent solutions is practically impossible to present in a literature review. However, it is worth noting the basic scopes of analyses conducted in this area:

- publications cover both strictly theoretical aspects in the form of literature reviews (Domanski, Adamczak, Cyplik, 2018; Mangiaracina, 2019; Custodio, Machado, 2020; Batarlienė, Meleniakas, 2021; Nilsson, Göransson, 2021), conceptual process modeling (Cyplik et al, 2019;

Taniguchi, Thompson, Qureshi, 2020; Dedík, Čechovič, Gašparík, 2020; Machado, et al, 2021), simulation capabilities of their potential application (Natalicchio, Petruzzelli, Garavelli, 2017; Brendel et al, 2018; Klavsuts, 2020), as well as analysis of practical application in various business industries (Ulrich, 2011; Slabinac, 2015; Kostrzewski, Kosacka-Olejnik, Werner-Lewandowska, 2019; Szczepaniak, Trojanowska, 2019; Stachowiak et al, 2019; Nechaev, Schupletsov, 2021),

- the substantive scope of the publications deals with the specificities of transportation (Sliwczynski, Hajdul, Golinska, 2012; Balm et al, 2014; Schodl et al, 2018; Pietrzak, Pietrzak, Montwiłł, 2021), production (Araújo et al, 2018; Trojanowska et al, 2019), storage (Gamberini et al, 2008; Guérin et al, 2016; Żuchowski, 2016; Limeira et al, 2019), supply chain (Dujak, Sajter, 2019; Shen et al, 2021), but also city logistics (Quak et al, 2012; Mazzarino, Rubini, 2019; Dalla Chiara, Musso, Ottomanelli, 2019; Sliwczynksi, 2020),
- in another perspective, the conducted analyses of the application of intelligent solutions concern the scope of information systems (Kadłubek, 2015; Domanski, Filipiak 2019), digitalization (Pan, 2021; Luo, Tian, Kong, 2021), but also ecological aspects (Golinska-Dawson, 2020; Werner-Lewandowska, Golinska-Dawson, 2021).

The number of solutions offered in business practice does not allow for a comprehensive analysis of scientific publications in every field. In this paper it has been decided to concentrate the analysis on intelligent solutions that, from the business point of view, are ready for practical use . Taking into account the results of business practice research, further literature analysis was focused on intelligent solutions with a high degree of functional development and application in business:

- Blockchain DLT solutions,
- Inteligent Transport Systems (ITS) – PWC 14,
- Robotic Processes Automation (RPA),
- IoT,
- Big Data Analitics,
- Cloud &API's.

The research conducted in the remainder of the paper was aimed at quantitatively verifying the degree of interest in each of these solutions from the scientific community. In the literature verification, Web of Science and Scopus databases were used, based on the sciencedirect.com portal. The selection of publications qualified for the compilation included the assumption of application of a given solution in logistics. Table 1 presents the quantitative interest in particular innovations in logistics, in terms of the last 5 years. It is worth mentioning that the verification of the number of publications on a given innovative solution takes into account only the first half of 2021 - the result for 2021 will undoubtedly change.

Table 1. Literature analysis on the application of intelligent solutions in logistics (June 2021)

Innovative solution	2017	2018	2019	2020	2021
Blockchain in logistics	13	76	229	422	451
Intelligent Transport Systems (ITS)	3358	3582	4266	5197	3925
Robotic Processes Automation	2327	2751	3221	4130	2601
IoT in logistics	232	377	656	881	675
Big Data Analytics	1639	1892	2476	2845	2218
Cloud &API's	1266	1387	1562	1887	1308

Source: own research

The number of scientific publications in the field of particular intelligent solutions is increasing every year. The greatest growth trend is generated by scientific publications on the application of blockchain in logistics. The thematic scope of blockchain application in the scientific literature on logistics is very wide. It includes, among others, port logistics (Ahmad et al, 2021; Wang et al, 2021), city logistics (Hribernik et al, 2020; Mora et al, 2021) or aspects of information systems integration and digitalization (Harish et. al, 2021; Li et al, 2020; Issaoui et al, 2019).

Analyzing the popularity of scientific publications of other intelligent solutions, it should be stated both very extensive literature in this area, indicating a growing trend, however, not as dynamic as in the case of Blockchain. This is due to the fact that the other areas have been known in the environment for a long time, and the tests of practical solutions are well advanced, which gives the prospects for full implementation in business practice in a relatively short time. This is also confirmed by the fact that in the last 5 years there have been (at least) 57850 scientific publications on the subject of intelligent solutions in logistics, presenting both the concept of using these solutions, as well as tests of their practical application in various sectors of business activity.

4. ANALYSIS OF TRENDS IN THE APPLICATION OF INTELLIGENT SOLUTIONS IN BUSINESS PRACTICE

Analysis of trends in the application of intelligent solutions in business practice depending on maturity of these solutions. The subject of the description will be developed innovations which according to trend analysis will be the fastest developing ones in the next five years like: Intelligent Transport Systems, Internet of Things, predictive maintenance, blockchain solutions, Robotic Process Automation, Cloud and API's and big data solutions. In case each of this intelligent solutions it's description will encompass innovation definition, possible applications in logistics, examples of successful applications and finally key success factors of implementations.

4.1. Intelligent Transport Systems

Intelligent Transport Systems (ITS) are defined as systems and technologies integrating different elements of transport infrastructure, vehicles and software to improve safety and efficiency of transportation networks (PWC, 2019).

Talking about the most common applications of ITS are traffic management systems functioning in different geographically restricted environments like centers of the cities but also for example in see ports. Advantage of these systems is increase of traffic efficiency better visibility of shared information

Another example of ITS application are tools collection systems. Significant savings are possible through automation of tools collection. Third application of ITS are freight management systems - solutions allowing to control and optimize efficiency and real time situation of company's fleet. All these above mentioned applications of ITS are possible thanks to the usage of big data analytics of traffic. Another large group of ITS applications are solutions devoted to improvement of mobility of people like public transportation systems and parking slots management solutions.

One of the most advanced cities in implementation of ITS solutions is Barcelona. Famous La Ramblas is equipped with traffic management system with function of car plates recognition. Solution allow to monitor traffic of cars in these very congested place.

Smartport – the intelligent control systems used by the Hamburg Port Authority rely on interaction between sensor technology and analysis, forecasting and information systems delivers huge efficiency improvements in the port area (HPA, 2020).

City of Lyon is developing data warehouse to enable creation of practical mobility services resulting in increase of intermodality, preventing of traffic congestion and better road sharing (MCT, 2020).

Key success factors in further development of ITS applications are the introduction of cooperative, connected, and automated mobility (CCAM) programs and the establishment of an Intelligent Transportation System infrastructure which involves the integration of various heterogeneous devices that are likely to create compatibility issues quite often. The synchronization of these heterogeneous devices needs standardization and the lack of a standard ITS infrastructure is also an issue (MRR, 2020).

4.2 Internet of Things

Internet of Things (IoT) is described as the networked connection of physical objects. Recently the definition of IoT is often expanded to the Internet of Everything (IoE). IoE includes different variations of connected objects: machine-to-machine (M2M); machine-to-person (M2P); or person-to-person (P2P). Internet of Everything is the name of technological trend which added links between people, process, and data.

In the world of logistic applications of IoT there is enormous number of solutions based on IoT. Advantages of this technology can be found across whole value chain and are defined as increase of operational efficiency, safety and security,

better customer experience, and are ask the source of new business models. Innovations based on interconnected objects are present in warehousing operations, freight transportation, and last-mile delivery. IoT allows real time monitoring of flow of people and objects. Such functionality leads to automation business processes and improvement of their quality and efficiency.

One of the most promising application of the Internet of Things is predictive or even prescriptive maintenance. Traditional maintenance is reactive and responding to failures in equipment or devices after the fact. Predictive maintenance allows to carry out continuous maintenance. Intelligent software working together with interconnected devices (but also embedded sensors, controllers enable, business logic, algorithms and Big Data analytics) enable fast diagnosis and proactive maintenance. Predictive analytics discovers potential future failures. The most advanced approach is prescriptive maintenance which taking into account knowledge of is going to happen and adjust according to that maintenance strategy. Applications of predictive maintenance can be divided into two main groups – diagnosis of events before they happen and dynamic case management for predictive or prescriptive maintenance. Both groups create the chance for disruptive innovations both in manufacturing and aftermarket services (Khoshafian & Rostetter, 2015).

Good practices of applying IoT in logistics include such fields as traffic and fleet management (for example Seul City Transportation Information Center), connected production floor (ABB, Bosch, GE and Rockwell Automation), equipment and employee monitoring (for example Dundee Precious Metals – DPM), smart warehousing operations (for example Swisslog SmartLIFT Technology), smart sensors in freight transportation (Agheera real-time tracking portal, DHL Resilence 360), last mile delivery (Postybell Smart Mailbox, DHL Paketkasten)

In IoT success factors are related to clear and standardized approach for the use of 'tags' on a global scale. Another important factors are smooth interoperability for exchanging sensor information and creation of trust concerning data ownership (DHL, 2015). The usage of the full potential of the Internet of Things relay also on change in business mindset what leads to new innovative business models.

4.3 Robotic Processes Automation

The definition of robots used for process automation in logistics is different from the dictionary one which defines a robot as "a machine capable of carrying out a complex series of actions automatically, especially one programmable by a computer" (Oxford, 2009). More accurate definition for a logistics robot was proposed in DHL report: "A robot with one or more grippers to pick up and move items within a logistics operation such as a warehouse, sorting center or last-mile" (DHL, 2016). High value of robots usage in logistics is connected with such their features as accurate and low-cost perception, precise manipulation and collaboration, high mobility and computational power.

According to the recent researches just 5% of current warehouses are automated. These automated warehouses are usually highly mechanized environments that still employ people in key functions however we can observe increasing warehousing

robotic processes automation which includes stationery and mobile piece picking robots and usage of robots in co-packaging and manipulation.

Stationery piece picking robots save labor by reducing the time spent walking. Mobile piece picking robots are moving around warehouse picking items. Co-packaging and customization includes automation of such activities like opening a box of products, taking out the items, doing something simple to them like putting on a sticker, and then packing the items back into the box. The key feature of such robot is flexibility of changing packing parameters. It is not easy to achieve so today still co-packing is done manually.

Example of stationery piece picking robot is the one built by Kiva company and used in Amazon warehouses. Solution represents so-called goods-to-picker concept. Another one is Swisslog´s CarryPick mobile system allowing to save 50% of warehouse picking labor through the elimination of walking.

Mobile piece picking robots are developed for example by IAM Robotics - small company based in the United. Robot is equipped with an arm on top and a camera system that can navigate an existing warehouse and pick items from shelves and place them into an order tote. Baxter from Rethink Robotics is an example of co-packaging and customization robot designed to work safely around people. One key goal for Baxter's design team was to create a robot that an average person could train just by grabbing one of the robot's arms and leading it through a simple task. In theory, Baxter should be perfect for co-packing since it was originally designed for end-of-production-line packing applications (DHL, 2016).

Success factors of robotic processes automation development in logistics are connected on the one hand with the development of such complementary technologies as low-cost sensors, kinematics solutions, powerful batteries and artificial intelligence and on the other hand with inevitable changes on labor marked which will lead to shortages in many industries.

4.4 Blockchain

Blockchain is defined as a "distributed ledger technology that can record transactions between parties in a secure and permanent way" (DHL, 2018). It is widely recognized by its original application in digital currencies and especially bitcoin. Thanks to the blockchain notion of trust in business has gain the new meaning. Third parties which usually were needed in order to verify transactions are no longer needed.

One of the most important applications of blockchain technology in logistics is tracking of goods along the supply chain. Traceability of goods brings the whole set of advantages including increase of logistics processes efficiency as well as visibility and predictability of logistics operations. All these advantages can contribute to cost savings and elimination of errors in logistics processes. Application of blockchain in logistics gives opportunity to create new services and business models.

There are several worth mentioning good practices describing use of blockchain in logistics. The first one is project TradeLens - cooperation of Maersk and IBM in delivery of global blockchain-based system used for tracking shipments. Visibility of shipments encompass such data like custom documents and bills of lading. Another good illustration of the use of blockchain technology in logistics is food tracking

project IBM Food Trust in Wal-Mart supply chains. Third example of blockchain application in logistics industry is application of smart contracts leading to improve of invoice accuracy. Test application of blockchain in operations between exporters and importers was developed by Bank of America Meryll Lynch, HSBC and the Infocomm Development Authority of Singapore.

Key success factor for blockchain implementation is improvement of it scalability limited now by such factors as high latency, energy consumption and computing power requirements. Another this time not technological obstacle is gaining interest of industry because only vast interest of stakeholders can ensure success of blockchain implementation. This leads attention to another success factor – collaborative mindset of companies which depends on specific local culture. In case of above mentioned Trade Lens project it seems to work properly. At the end of 2020 it's ecosystem included 175 organizations (more than 600 ports and terminals) and the total numbers exceeded 1,6 billion transport records, 14 millions of documents and 34 million of TEU. In IBM Food Trust project Walmart and IBM built till the end of 2020 ecosystem of 280 members. (Lacity & Van Hoek, 2021).

4.5 Data processing in logistics - Big Data analytics, Cloud and API's

Huge quantity of available data created another important trend in different businesses named big data analytics. The term describes examination of large amounts of data in order to find hidden patterns, correlations and other insights. Present technology makes it possible to analyze data very efficient and get answers almost immediately. Typical advantages resulting from application of big data analytics are costs savings, faster and better decision making and possibility to create new products and services.

In logistics there is a lot of potential applications of the big data analytics. Stakeholders of the logistic market work with vast data volumes consisting information about shipments, origin destination, content and location across supply chains. Applications of big data analytics can be related to for example precise forecasting of market demand, radical customization of services, and creation of entirely new business models. Among concrete fields of the use of big data are last mile optimization, predictive network and capacity planning and supply chain risk management (DHL, 2014). One of the concrete examples of big data use in logistics is aggregation and analytics of big data in Amazon in automation of warehouses and the supply chain, UPS optimizing last mile delivery processes, DHL Smart Truck using data from sensors to enhance possibilities of route planning or TIBA from Spain using data from sensors to monitor temperature of transported goods (Datumize, 2020). Among success factors of big data analytics implementations the most important one is the quality of data, overcoming of privacy issues and use of appropriate technology.

Another important trend in the area of data processing in logistics is usage of the cloud based services and so called application programming interfaces (APIs). Application programming interfaces (APIs) are software protocols allowing applications to communicate and exchange information. Centralized cloud-based platforms are the basis for the future supply chain management solutions. Good

designed APIs are key element for providing shipment tracking, full landed cost calculations, rate sourcing, and other logistics services anywhere on the web and via mobile apps (DHL, 2020). According to 5th edition of DHL Logistic Trend Radar application of cloud these solutions can be found in modular cloud logistic platform integrated via API's with existing data infrastructure and systems (for example – digital freight network Convoy helps shippers with real time pricing technology). Another application is cloud-enabled management dashboard developed by DHL together with Microsoft;'s Azure IoT cloud service and Blue Yonder digital fulfillment platform. Success factors for cloud and APIs solutions implementations are interoperability of existing legacy systems with new platforms, mitigation of supply chain risk given economic and trade uncertainty, guaranteeing security of platforms with the use of external clouds.

In this paper authors focused only on innovations which, according to different research and speculations, will be fast developing ones in the next 5 years. Beside them there is worth mentioning whole group of emerging innovations such like artificial intelligence, innovative packaging or omnichannel logistics. Another group is built by future speculated intelligent solutions like self-driving vehicles, Digital Twins, bionic enhancements, supergird logistics and smart containerization. All above mentioned innovations can play significant role in the logistics of the future.

5. IMPORTANCE ANALYSIS OF THE IDENTIFIED INNOVATIONS IN LOGISTICS

The final stage of the research work carried out was to conduct a survey of business practice regarding the degree of importance of particular innovations used in logistics. The survey was conducted in the second quarter of 2021 among 43 enterprises doing business in Poland. The analysis carried out by the author allows to state that assuming the maximum error of 15% and the confidence level of 95%, the research sample of 43 enterprises should be considered representative (Domanski and Kolinski, 2020). Therefore, it should be concluded that not only the obtained statistical sample is representative, but also allows deducing conclusions on a European scale. This is due to the fact that Polish logistics and industrial enterprises are very strongly developed, compared to other EU countries. Poland is an interesting market for a study in logistics sector. According to the data from the Eurostat, Polish logistics sector has got a very high share in tonne-kilometers terms in freight transport in European Union (16, 4% of total EU)(EuroStat, 2019).

Basic information on the surveyed companies is provided in Table 2.

Table 2. Basic information about the surveyed companies

Characteristics	Answers (%)
1. Number of employees employed by the company:	
· less than 10 employees	4,65%
· 10 to 49 employees	11,63%
· from 50 to 250 employees	34,88%
- more than 250 employees	48,84%
2. time in business:	
- up to 1 year	0,00%
- from 1 to 3 years	4,65%
- from 4 to 7 years	9,30%
- between 8 and 15 years	4,65%
- more than 15 years	81,40%
3. capital of the company:	
- Polish enterprise (no foreign capital ties)	62,79%
- foreign company (ownership of foreign capital)	27,91%
- mixed enterprise (Polish and foreign capital)	9,30%
4) Market served	
- local (commune, district)	2,33%
- regional (up to 5 voivodeships)	0,00%
- national (6 voivodeships and more)	9,30%
- European (continent)	46,51%
- global (two continents and more)	41,86%

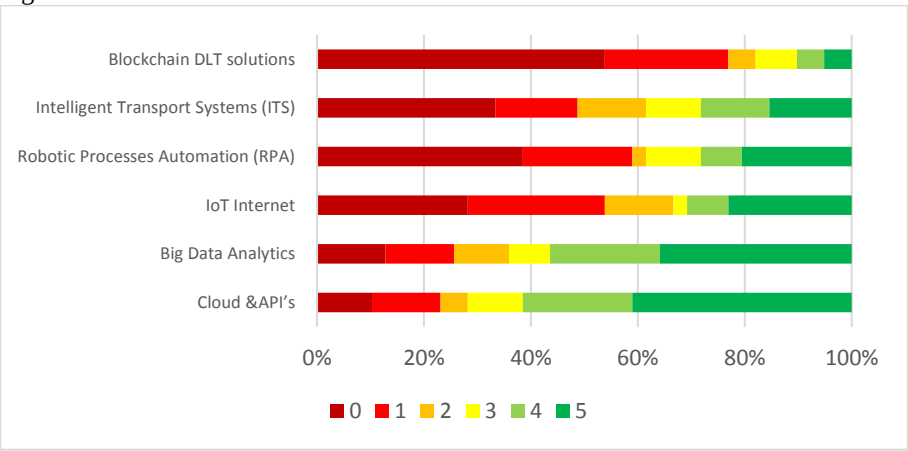
Source: own research

This distribution should be considered representative not only because it takes into account the statistical assumptions of the research sample, but also in terms of the distinguished characteristics of the companies involved in the study.

The research identified that more than 90% of the surveyed companies are implementing modern solutions to optimize logistics processes. This makes it possible to conduct in-depth research on the degree of use of particular solutions, which was subjected to literature analysis and trend analysis, described in earlier sections of this paper.

Figure 2 presents an analysis of the extent to which each innovative solution is used in business practice.

Figure 2. Analysis of the extent to which the identified innovations are used in logistics



Source: own research

As shown from the presented chart and the breakdown of detailed data in Table 3, most of the listed intelligent solutions are at the beginning of the road to successful implementation in business practice. Solutions based on Big Data and cloud solutions are used to the greatest extent.

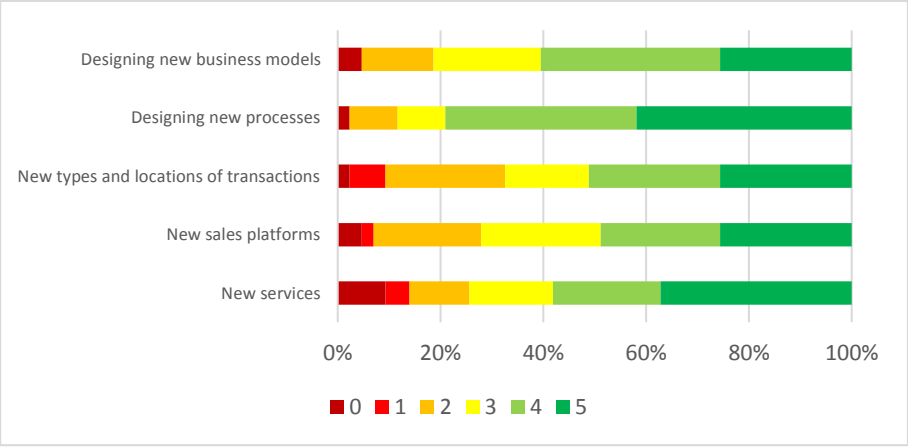
Table 3. Distribution of the results of the degree of use of identified innovations in logistics

Process	Utilization rate						Weighted average
	0	1	2	3	4	5	
Blockchain DLT solutions	21	9	2	3	2	2	1,03
Intelligent Transport Systems (ITS)	13	6	5	4	5	6	2,00
Robotic Processes Automation (RPA)	15	8	1	4	3	8	1,90
IoT Internet	11	10	5	1	3	9	2,05
Big Data Analytics	5	5	4	3	8	14	3,18
Cloud &API's	4	5	2	4	8	16	3,18

Source: own research

The next stage of the research was to analyze the market activities of the use of innovative trends in logistics, in terms of digitalization, international trade development prospects and process changes. Figure 3 shows the results of the analysis of the degree of impact of innovative activities on business needs for digitalization.

Figure 3. Analyzing the extent to which innovations affect business needs for digitization



Source: own research

As shown from the chart presented and the breakdown of detailed data in Table 4, all of the identified innovation activities largely meet business needs, with a particular focus on designing new processes.

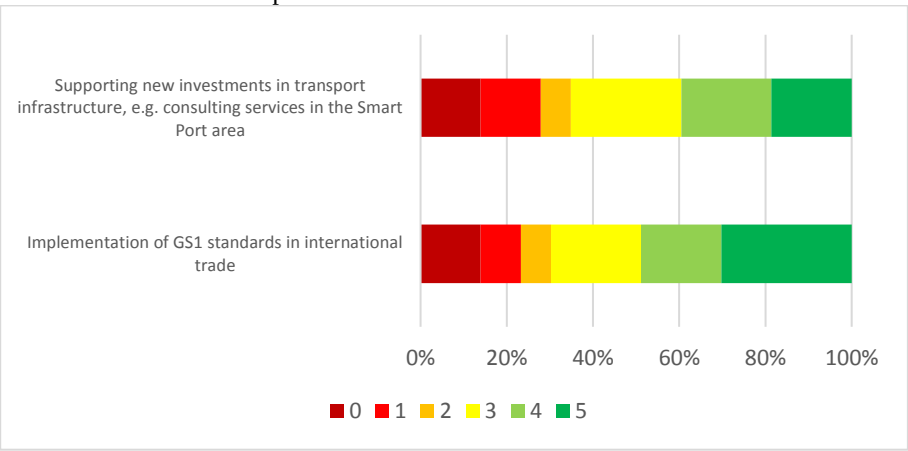
Table 4. Distribution of the results of the degree of impact of innovation on business needs for digitization

Innovative actions	Degree of impact						Weighted average
	0	1	2	3	4	5	
Designing new business models	2	0	6	9	15	11	3,58
Designing new processes	1	0	4	4	16	18	4,05
New types and locations of transactions	1	3	10	7	11	11	3,33
New sales platforms	2	1	9	10	10	11	3,35
New services	4	2	5	7	9	16	3,47

Source: own research

Figure 4 shows the results of the analysis of the degree of impact of innovative activities on business needs for international trade development.

Figure 4. Analyzing the extent to which innovation impacts on business needs for international trade development



Source: own research

As can be seen from the chart presented and the breakdown of detailed data in Table 5, both identified innovation activities meet business needs to a medium degree. Therefore, their further development should be expected in the nearest future.

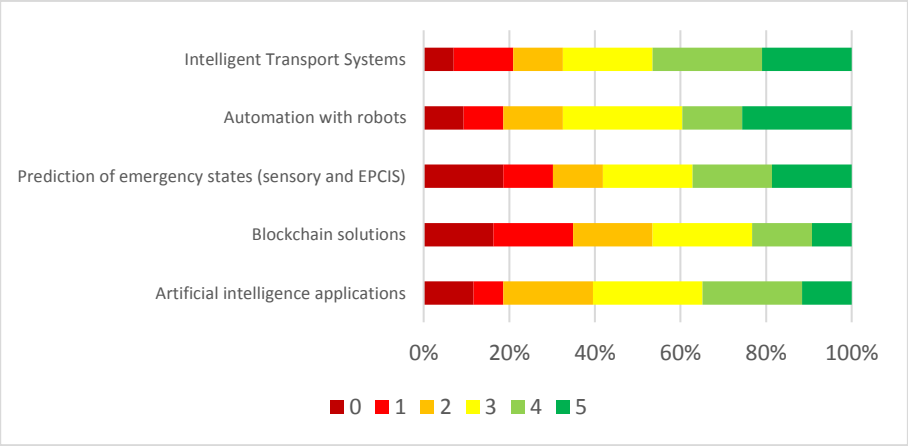
Table 5. Distribution of results of the degree of impact of innovation on business needs for international trade development

Innovative actions	Degree of impact						Weighted average
	0	1	2	3	4	5	
Supporting new investments in transport infrastructure, e.g. consulting services in the Smart Port area	6	6	3	11	9	8	2,81
Implementation of GS1 standards in international trade	6	4	3	9	8	13	3,12

Source: own research

Figure 5 shows the results of the analysis of the degree of impact of market innovations on business needs for software-driven process change.

Figure 5. Analyzing the extent to which innovations impact business needs for software-driven process change



Source: own research

As shown from the chart presented and the summary details in Table 6, both identified market innovations are meeting business needs to a medium extent. This research confirms the previous trend indicating a low degree of impact of blockchain-based solutions on the business needs of enterprises in logistics management.

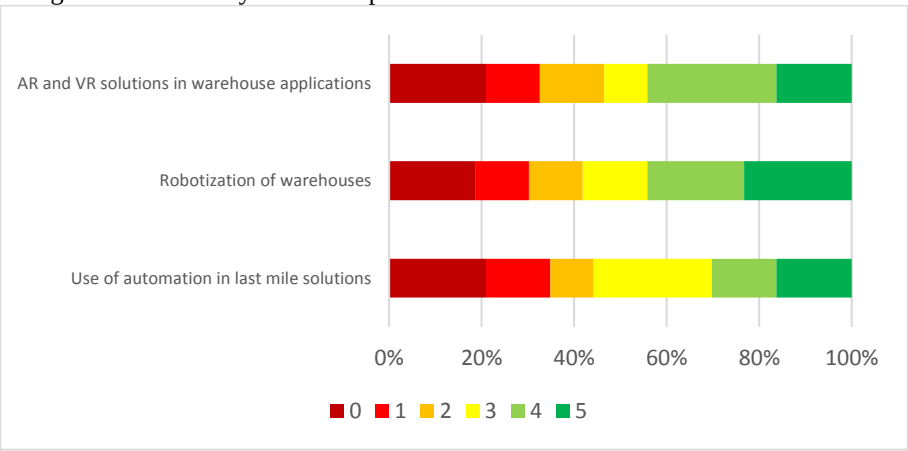
Table 6. Distribution of innovation degree scores on business needs for software-driven process change

Innovative Actions	Degree of impact						Weighted average
	0	1	2	3	4	5	
Intelligent Transport Systems	3	6	5	9	11	9	3,07
Automation with robots	4	4	6	12	6	11	3,05
Prediction of emergency states (sensory and EPCIS)	8	5	5	9	8	8	2,65
Blockchain solutions	7	8	8	10	6	4	2,28
Artificial intelligence applications	5	3	9	11	10	5	2,77

Source: own research

Figure 6 presents the results of the analysis of the degree of impact of market innovations on business needs in terms of process changes conditioned by the development of machines and robots.

Figure 6. Analyzing the extent to which innovation business needs for process changes conditioned by the development of machines and robots



Source: own research

As shown from the chart presented and the summary details in Table 7, the identified market innovations poorly meet business needs. This may be due to the developmental stage of these innovations. The direction of further research should be to test the effectiveness of these solutions and an in-depth analysis of the literature in this area.

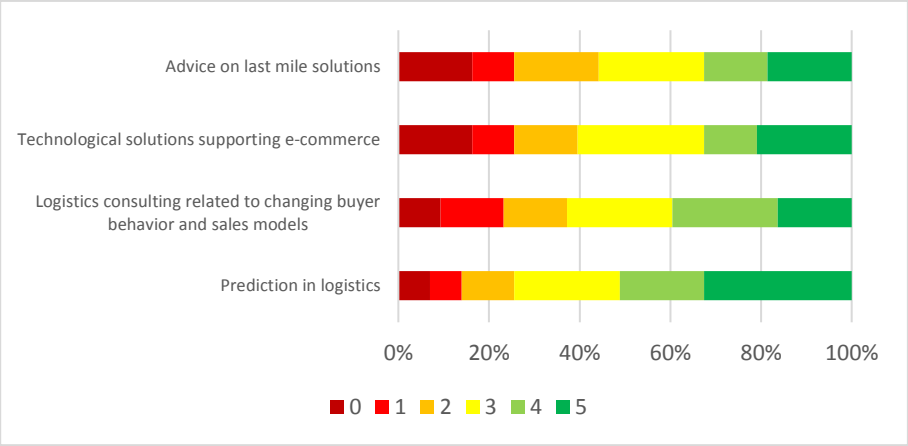
Table 7. Distribution of the results of the degree of impact of innovation on business needs for process changes conditioned by the development of machines and robots

Innovative actions	Degree of impact						Weighted average
	0	1	2	3	4	5	
AR and VR solutions in warehouse applications	9	5	6	4	12	7	2,60
Robotization of warehouses	8	5	5	6	9	10	2,77
Use of automation in last mile solutions	9	6	4	11	6	7	2,47

Source: own research

Figure 7 shows the results of the analysis of the degree of impact of market innovations on business needs for changes in internal markets.

Figure 7. Analyzing the extent to which innovations impact business needs for changes in internal markets



Source: own research

As can be seen from the chart presented and the breakdown of detailed data in Table 7, prediction meets business needs in the internal market to the greatest extent. This is a result of many local/regional project initiatives or implementation of R&D projects in this area, which directly translates into the degree of application in business practice.

Table 7. Distribution of the results of the degree of impact of innovation on business needs for changes in internal markets

Innovative actions	Degree of impact						Weighted average
	0	1	2	3	4	5	
Advice on last mile solutions	7	4	8	10	6	8	2,65
Technological solutions supporting e-commerce	7	4	6	12	5	9	2,72
Logistics consulting related to changing buyer behavior and sales models	4	6	6	10	10	7	2,86
Prediction in logistics	3	3	5	10	8	14	3,37

Source: own research

6. CONCLUSION

The application of intelligent solutions in logistics processes is a very difficult issue, both in terms of conceptualization and practical implementation of the assumptions of the indicated innovations and supporting technologies. It is worth emphasizing that despite the widely discussed issues in the scientific literature, the implementation of these concepts and technologies in business practice is not simple. This paper focuses only on those innovative technologies that are already

characterized by high technical readiness and are after the testing stage - ready for scalable business implementations.

One current example of research projects focused on the implementation of intelligent solutions is the PLANET project testing the test deployment of a sensor network and IoT to monitor containers in rail transportation along the New Silk Road.

The purpose of this paper was to conduct a literature review and analyze trends of change in the use of modern and intelligent solutions in logistics. Business practice studies indicate that the implementation of intelligent solutions is only in its infancy, while new concepts and solutions for optimizing logistics processes are already emerging. The direction of further research should be the identification of benefits and barriers to the implementation of these solutions in business practice, analysis of the scope of their use in logistics, and comparative analyses of currently used intelligent solutions, with emerging technologies. These objectives are also guiding the further work planned within the Living Lab 3 in PLANET project.

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