European Research Studies Journal
Volume XXVII, Issue Specail 2, 2024

pp. 999-1018

Smart Technologies Integration and Challenges in the Context of Logistics Companies

Submitted 25/09/24, 1st revision 21/10/24, 2nd revision 11/11/24, accepted 30/11/24

Jurgita Paužuolienė[1], Ieva Kaveckė[2], Mariusz Pyra[3]

Abstract:

Purpose: *The purpose of the article is to investigate how smart technologies can help logistics companies in their day-to-day operations and identify the benefits and main challenges faced by logistics organizations when implementing smart technologies.*
Design/Methodology/Approach: *A quantitative study was conducted in which representatives of Lithuanian logistics companies participated.*
Findings: *Recent studies across the EU highlight the growing adoption of smart technologies in logistics, aligned with goals of efficiency, sustainability, and resilience. Digital transformation is emphasized for both operational improvements and environmental objectives. In Lithuania, logistics companies widely use route optimization programs and real-time cargo tracking, boosting efficiency and ensuring timely deliveries. Document digitization is another emerging trend. Key drivers for adopting smart technologies include cost reduction, enhanced efficiency, and improved service quality. However, challenges like high implementation costs, the need for skilled personnel, and system integration complexity hinder progress. Addressing these barriers is crucial for broader adoption, especially for SMEs, to enhance competitiveness in a dynamic market.*
Practical Implications: *The conclusions of this study provide real insights not only for the stakeholders of the Lithuanian logistics sector. By overcoming financial and skilled labour challenges, SMEs can better compete with larger companies by using smart technologies, offering high-quality services, and adapting to market needs. Overall, solving smart technological challenges can fully utilize digital tools in the logistics sector, increasing productivity, improving service quality, and strengthening the industry's global competitiveness.*
Originality value: *The study makes a meaningful contribution to both academic research and practical applications in logistics and digital transformation. The study deepens academic understanding of how logistics companies are adopting technologies like route optimization, real-time cargo tracking, and document digitization. It sheds light on the*

[1]*Higher Education Institution/Klaipėdos valstybinė kolegija, Faculty of Business, Department of Business Administration, Lithuania. ORCID 0000-0002-1034-2296. e-mail: j.pauzuoliene@kvk.lt;*
[2]*The same as in 1, ORCID 0000-0001-7919-6197. e-mail: i.kavecke@kvk.lt;*
[3]*University John Paul II in Biala Podlaska, Faculty of Economic Sciences, Department of Economics, Poland. ORCID 0000-0001-8246-851X. e-mail: m.pyra@dyd.akademiabialska.pl;*

factors driving adoption, such as cost efficiency and improved service quality, while also exploring the barriers to implementation. By systematically identifying benefits, challenges, and trends in smart technology adoption, the study creates a framework that can be replicated or expanded upon in other regions or industries.

Keywords: *Smart logistics, transport, technology.*

JEL Classification: *N70, Q55.*

Paper type: *Research article.*

1. Introduction

In recent years, various studies across the European Union have focused on the adoption and impact of smart technologies in the logistics sector, with a particular emphasis on enhancing operational efficiency, sustainability, and resilience in line with EU policies. One significant area of research has been Smart Grid standardization within EU-funded Horizon 2020 projects. Researchers from multiple countries, including Latvia, Ireland, the Netherlands, and Cyprus, have explored the role of standardization in improving the interoperability, compatibility, and efficiency of smart technologies in energy and logistics.

This initiative supports the European Green Deal's objectives of achieving a sustainable, low-carbon economy by addressing key challenges related to renewable energy integration and energy efficiency in logistics and transportation systems (Mutule *et al.,* 2024). Based on research conducted in various countries, the implementation of smart technologies in the logistics sector is rapidly growing and driving operational efficiency and transparency (Kadlubek *et al.,* 2022a; 2022b).

In Europe, a study by Burinskienė and Daškevič (2024) examined the integration of digital technologies, such as artificial intelligence and IoT, in logistics processes to enhance competitiveness and supply chain transparency. This study emphasized that digital technologies can improve productivity by up to 20% and increase companies' competitiveness.

Another area of focus has been blockchain technology within the EU's logistics and energy sectors. Gholizadeh (2024) conducted a study on blockchain's potential to streamline and secure transactions across borders, providing transparency and efficiency in logistics and energy management (Tyagi *et al.,* 2023).

By ensuring compliance with EU data protection and cybersecurity standards, blockchain technology is seen as a key tool for modernizing infrastructure and enhancing the security of logistics operations across Europe.

Digitalization and knowledge management have also been prominent in logistics studies within Poland. Salek and Wisniewska-Salek (2024) examined the use of digital freight exchanges, which facilitate real-time information exchange between carriers and cargo owners, thus reducing the incidence of empty trips and optimizing transport efficiency. This approach has proven especially beneficial for small and medium-sized enterprises (SMEs), enabling them to remain competitive against larger players by improving operational effectiveness through digital platforms.

In Croatia, Klarić (2024) analyzed smart digitalization in public sector logistics, particularly in the context of sustainable development goals. By implementing digital tools such as artificial intelligence (AI) and the Internet of Things (IoT) in public administration, Croatia aims to enhance logistical efficiency in public services. This digital transformation aligns with the EU's broader efforts to facilitate a green transition across member states, showcasing how digital technologies can support environmental objectives while improving public service delivery.

Another critical study examined the resilience of logistics systems in the EU and Ukraine amid the Russo-Ukrainian war. This research emphasized the role of digital solutions in bolstering logistical resilience, particularly through advanced route planning, infrastructure modernization, and cross-border coordination.

The findings highlighted how digital platforms and intergovernmental cooperation contribute to supply chain stability during periods of disruption, showcasing the necessity of resilience-building in the logistics sector (Bajor *et al.*, 2024; Lebedeva and Shkuropadska, 2024). A comprehensive analysis of the EU logistics sector's adaptation to technological advancements by Bajor *et al.* (2024) illustrated the increasing integration of digital tools and automation into logistics operations.

This study revealed a trend toward more data-driven, efficient, and environmentally sustainable logistics management practices across the EU. By addressing operational costs and aligning with environmental targets set by EU regulations, digitalization is positioning the EU logistics sector to meet the challenges of a rapidly evolving industry. We raise the problematic questions: What are the essential motives for logistics organizations to use smart technologies and what challenges do they face?

This aim of the article is to investigate how smart technologies can help logistics companies in their day-to-day operations and identify the benefits and main challenges faced by logistics organizations when implementing smart technologies. We use comparative analysis of scientific literature, synthesis, quantitative research, questionnaire survey, data processing with SPSS software package.

2. The Challenges of Smart Logistics

In modern logistics, the integration of smart technologies such as the Internet of Things (IoT), blockchain, smart contracts, and 5G connectivity has become essential

for implementing green logistics and reducing the carbon footprint (Ravi et al., 2023). These technologies enable real-time cargo tracking, optimization of transport routes, and more efficient use of energy resources (Khatib and Barco, 2021).

For example, blockchain technology enhances transparency within the supply chain and helps prevent information tampering, which is a crucial advantage for environmentally sensitive industries (Rahman *et al.*, 2024). The Internet of Things has enabling communication not only between people and smart devices but also directly among these intelligent devices themselves.

This connectivity aims to ensure constant and universal communication—anytime, anywhere, using all types of information mediums, involving all entities (not just people), and ideally across any network with all available services (Dembińska, 2018). Despite the benefits of these technologies, their implementation in logistics faces challenges, including high initial investments and compatibility with existing systems (Oladele, 2024). Additionally, a lack of qualified personnel and resistance to change can hinder the adoption of advanced solutions (Sumets, 2023).

According to Kalenyuk *et al.* (2024), smart technologies such as artificial intelligence (AI), the Internet of Things (IoT), and blockchain require substantial investments in infrastructure, software, and hardware, creating significant financial challenges, especially for small and medium-sized enterprises (SMEs) that may struggle to secure necessary funding for technology adoption.

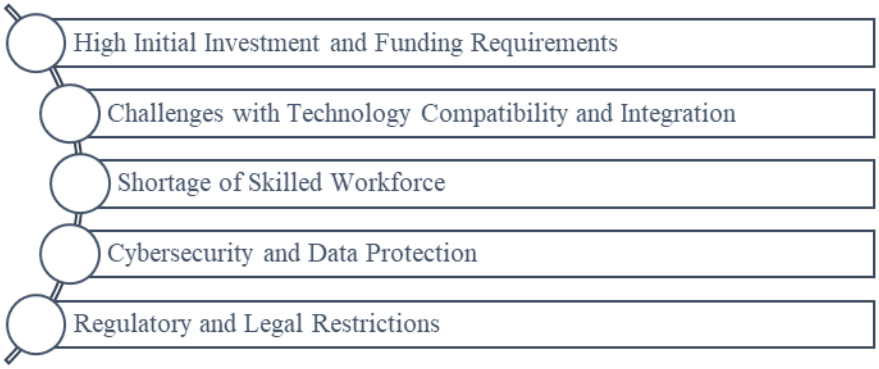
Additionally, as Oladele (2024) highlights, integrating these technologies into existing logistics systems presents compatibility issues. For instance, IoT systems must align with current transport and warehousing infrastructure to operate effectively. Without seamless integration, such systems can cause operational disruptions, hinder data exchanges, and reduce overall efficiency, thus posing a considerable challenge for logistics firms (Oyetoro, 2024; Ekhsonov, 2024).

Further complicating technology adoption is the shortage of skilled personnel, as Zemlyak, Nozdreva and Sivakova (2024) emphasize. Implementing technologies like AI in logistics requires a workforce skilled in managing and analyzing large volumes of data and operating complex systems. The scarcity of qualified personnel limits smooth integration and reduces the effective use of these smart technologies within logistics operations (Akkaya and Kaya, 2019).

Cybersecurity and data protection also represent critical challenges, as noted by Oyetoro (2024) and Andreas (2024). Real-time data exchanges through IoT and blockchain systems expose these platforms to cybersecurity risks, and inadequate data protection can lead to security breaches, eroding customer trust and potentially leading to legal issues (Zemlyak, Nozdreva, and Sivakova, 2024). Andreas (2024) points out that regulatory and legal restrictions, particularly for technologies like autonomous vehicles and drones, impose stringent compliance requirements that

vary by country. These legal constraints can obstruct the deployment of these technologies, requiring additional inspections and certifications to ensure adherence to local regulations (Adesoga *et al.*, 2024; Akkaya and Kaya, 2019). After summarizing the analysis in the first figure, we presented the essential challenges that logistics companies usually face when implementing smart technologies.

Figure 1. *Challenges to implement smart technologies*



Source: *Created by authors based on analysis.*

These challenges underscore the importance for logistics companies to not only invest in smart technologies but also prepare for comprehensive change management, ongoing training, and robust security protocols to effectively address potential integration and security concerns.

3. Benefits of Smart Technologies

Implementing smart technologies in logistics companies brings numerous advantages, enhancing efficiency, transparency, and sustainability in supply chains. According to Zemlyak, Nozdreva, and Sivakova (2024), artificial intelligence (AI) and big data analytics optimize route planning and demand forecasting, improving overall supply chain responsiveness and reducing operational costs. One of the factors driving companies to invest in smart technologies is the desire to reduce risks (Wang *et al.*, 2019).

For instance, IoT devices enable real-time tracking and monitoring of goods, enhancing visibility and traceability, which is essential for effective logistics management (Ravi *et al.*, 2023). Blockchain technology, with its decentralized ledger, ensures secure, tamper-proof transactions, which are particularly valuable for supply chain transparency and trust among stakeholders (Oladele, 2024).

Blockchain technology also plays a pivotal role, as highlighted by Ekhsonov (2024), enabling secure and transparent transactions, which are essential for building trust among stakeholders. This transparency reduces fraud and errors in logistics operations, as blockchain's decentralized ledger provides an immutable record of

each transaction. Similarly, Liu and Zhao (2024) emphasize the integration of the Internet of Things (IoT), which allows for real-time tracking and monitoring of goods, further enhancing supply chain visibility and allowing companies to make proactive adjustments as necessary.

Sandoval (2021) notes that, like other forms of business automation, warehouse automation can improve productivity and reduce costs. The author noted that in both retail and manufacturing, internet-driven digitization has created a wide range of new opportunities.

The Internet of Things enables more efficient and partially autonomous business models and production chains, as interconnected devices and systems enhance and optimize current warehouse processes, making them more "intelligent." To address the growing need for efficient internal logistics, companies are turning more toward digital networking across the entire supply chain. Within smart warehouses, advanced IT systems oversee and coordinate each phase of the process flow.

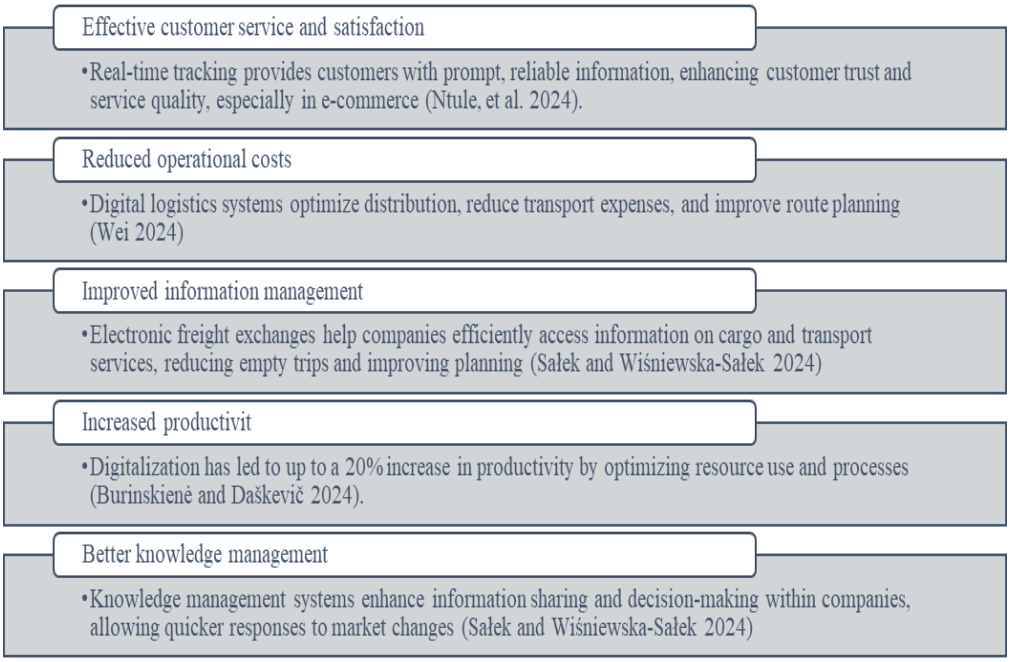
According to some authors (Kumar *et al.*, 2021; Marino 2023; Tiwari, 2023), smart warehousing is the most effective and efficient way to increase a company's return on investment by improving accuracy and productivity, overall service quality, and reducing costs, failures, and manual labour costs. Companies are recognizing that it is better to adapt to the changing competitive business environment through smart digital and integrated warehouse management systems (Kumar *et al.*, 2021)

Additionally, smart contracts powered by blockchain facilitate automated transactions when predefined conditions are met, reducing the need for intermediaries and expediting operations (Ekhsonov, 2024). AI further supports logistics by enabling predictive analytics for demand forecasting, enhancing route optimization, and facilitating inventory management (Zemlyak, Nozdreva, and Sivakova, 2024).

These technologies together create an interconnected system that not only improves operational efficiency but also aligns with sustainable practices, reducing waste and energy consumption (Rahman *et al.*, 2024). Oyetoro (2024) revealed, that smart technologies are reshaping logistics by promoting a collaborative, data-driven approach that improves service quality, enhances decision-making, and contributes to a sustainable logistics framework.

Furthermore, Andreas (2024) discusses the application of robotics, drones, and automated vehicles in last-mile delivery, especially within the context of smart cities, which helps in reducing delivery times and optimizing urban logistics infrastructure. This focus on last-mile efficiency not only decreases transportation costs but also contributes to lower carbon emissions, aligning with sustainability goals. In Figure 2, we present the benefits of smart logistics identified by the latest scientific research.

Figure 2. *Benefits of smart logistics*



Source: *Created by authors based on Ntule et. al. (2024), Wei (2024), Sałek and Wiśniewska-Sałek (2024), Burinskienė and Daškevič (2024).*

These smart technologies collectively transform logistics by improving decision-making, enhancing customer satisfaction, and supporting sustainability efforts. As noted by Oyetoro (2024), adopting these technologies allows companies to increase operational efficiency and provide superior customer service, thus gaining a competitive edge in the rapidly evolving logistics sector.

4. Research Methodology

A quantitative study was conducted with 46 representatives from logistics companies participating in the survey. A questionnaire consisting of eight questions was developed to explore: the extent of smart technology use within these companies; the reasons driving the adoption of smart technologies; plans for future smart technology implementations; and the challenges faced in deploying these technologies. Additionally, demographic questions were included.

The companies surveyed operate across Lithuania, with 73.9% primarily serving international markets, 15.2% focusing on national markets, and 10.9% on regional markets. A majority (56.5%) of the companies have been in operation for over 10 years, while 23.9% have been operating for 6 to 10 years, and 19.6% for 1 to 5 years.

The predominant business activity among respondents (43.5%) is road transport, indicating it as the primary service offered by the surveyed group. Warehousing and distribution services are provided by 19.6% of companies, while 17.4% focus mainly on maritime transport.

Managers and specialists knowledgeable about their organizations' operations and smart technology use participated in the survey. Each company was contacted directly and invited to participate, with 46 specialists ultimately agreeing to take part. The majority of respondents (26.1%) were from large organizations with more than 250 employees, while 21.7% represented medium-sized companies with 51 to 250 employees. Additionally, 37.0% of participants were from small companies, and 15.2% from very small companies.

The study was conducted in strict adherence to ethical research standards to ensure the integrity of the data and the protection of participants' rights. Companies were invited to participate voluntarily, with no coercion or undue influence to ensure their decision to participate was based solely on interest and willingness. All participants were informed of the study's aims and were provided the opportunity to review the conclusions.

To maintain strict confidentiality, participants were assured that all individual data would be anonymized and handled with the utmost care. Data storage and handling procedures were designed to prevent unauthorized access and to protect participants' privacy. Additionally, findings were reported only in aggregate form, so that no individual company or participant could be identified from the results. This approach not only safeguarded confidentiality but also encouraged honest and open feedback from participants, strengthening the reliability and validity of the study's findings.

5. Research Results

The research data highlights several key trends in technology adoption across organizations, particularly in logistics and supply chain management. The findings indicate that *Smart real-time cargo tracking technologies* are the most widely used, with a substantial 69.6% of organizations implementing these tools.

Such tracking technologies provide real-time insights into cargo location, status, and expected delivery times, which significantly enhances supply chain transparency and efficiency. Following closely, *route planning and optimal route selection programs* are employed by 60.9% of organizations. These programs help streamline delivery routes, minimize fuel consumption, and reduce travel time by identifying the most efficient paths for transporting goods.

This use of advanced routing technology reflects a strong interest in optimizing logistics to save both time and resources. *Digital documentation systems* are utilized by 58.7% of organizations, simplifying administrative processes and reducing the

reliance on physical paperwork. Digitizing documentation can streamline operations, reduce errors, and facilitate quicker information exchange among stakeholders, all of which are critical in a fast-paced logistics environment. *Intelligent vehicle technologies* use 52.2% of organizations. These technologies may include advanced driver-assistance systems (ADAS), fleet management software, and telematics, all of which improve vehicle safety, efficiency, and fleet coordination.

Smart manufacturing process technologies are the least used, with only 4.3% adoption. These technologies typically involve automation and robotics in manufacturing processes, which can be costly and may not yet be widely applicable for smaller organizations in the logistics sector. Similarly, only 10.9% of organizations are using *data analysis and predictive modeling technologies,* which provide insights from historical data to forecast future trends and optimize decision-making.

This relatively low adoption rate may stem from the resource-intensive nature of data analysis or a lack of expertise in handling complex data. *Smart warehousing systems* are employed by 13.0% of organizations. These systems might include automated storage and retrieval systems (AS/RS), robotics, and other technologies to enhance warehousing efficiency, but their adoption remains limited, possibly due to high costs and the specific infrastructure requirements.

Interestingly, *autonomous vehicles for delivery* are not currently used by any organization in the sample, reflecting either the early stage of technology adoption in this area or concerns around regulatory, cost, or infrastructure challenges.

Several organizations use *automatic gate systems for receiving and issuing containers*, as well as electric loaders and solar collectors. These additional technologies suggest a growing interest in automation for improving site security and container management, as well as a shift toward sustainable practices, with electric loaders and solar collectors reflecting efforts to reduce carbon emissions and increase energy efficiency.

This research underscores both the advances and the adoption barriers in logistics technology, indicating a trend toward digitization and automation, balanced by practical considerations around cost, infrastructure, and readiness for emerging technologies.

Table 1. *Smart technologies used in companies' operations*

Smart technologies used by companies	**%**
a) Route planning programs / optimal route selection programs (e.g., programs that plan/select the optimal route: fastest, shortest, cheapest, least polluting, etc.)	60.9
b) Smart real-time cargo tracking technologies (e.g., for clients to know the location of their cargo in real time)	69.6
c) Intelligent vehicle technologies (e.g., smart safety sensors that alert the driver of	52.2

danger while driving; vehicle monitoring technologies to maintain appropriate temperature and humidity when transporting temperature-sensitive cargo, etc.)	
d) Use of artificial intelligence in customer service (e.g., AI-based chatbots to provide quick responses to customers)	21.7
e) Data analysis and predictive modeling technologies (e.g., to optimize routes, forecast demand, and manage cargo flows)	10.9
f) Driver behavior analysis technologies (e.g., to monitor and analyze driver behavior, including speeding, sudden braking, and other aspects of safe/economical driving)	37.0
g) Autonomous vehicles for delivery (e.g., robots that deliver parcels to customers without human intervention)	0.00
h) Smart warehousing systems (e.g., use of robots for order picking and packing)	13.0
i) Smart manufacturing process technologies (e.g., using robots or automating manufacturing processes to shorten production cycle time, reduce energy consumption, etc.)	4.3
j) Digitization of documents	58.7
k) Other (please specify): Automatic gate system for receiving and issuing containers; Electric loaders, solar collectors	0.00

Note: *It was possible to choose several answer options, so it is more than 100 percent.*
Source: *Created by authors based on the research 2024 data.*

The main motivation for organizations to implement smart technologies were cost reduction (95.7%), improving operational efficiency (93.5%) and improvement in serve quality (69.6%). Secondary motivations, such as customer satisfaction (34.8%) and regulatory compliance (32.6%)**,** appear to be less of a priority for most organizations, though still relevant for some.

This suggests that, while these factors are acknowledged, they are not primary drivers in the decision to implement smart technologies. An additional motivation noted by one respondent was the reduction of environmental pollution, highlighting an awareness among some organizations of the environmental impact and the potential of smart technologies to contribute to sustainability goals. This may reflect a growing, if still emerging, interest in aligning technological investments with broader social and environmental responsibility.

Overall, the data illustrates that organizations are primarily focused on adopting smart technologies that have tangible and measurable impacts on their efficiency, costs, and service quality, with other factors playing a more supplementary role in their strategic considerations.

After comparing the data with the size of the company and the time it has been company operating, statistically significant differences were obtained *($p \leq 0.05$)*. Companies with more than 10 years of experience in the market believe that reducing costs *($p=0.036<0.05$)* and increasing customer satisfaction *($p=0.027<0.05$)* are the main drivers for the adoption of smart technologies.

Figure 3. *Main motivations for company's to implement smart technologies*

Source: *Created by authors based on the research 2024 data.*

In contrast, shorter-term companies may prioritize different goals when deploying these technologies. In addition, both small and large companies consistently consider the improvement of service quality *(p=0.007<0.05)* as the main motivation to use smart technologies. This shared focus underscores the universal importance of delivering the highest quality customer experience, regardless of company size or length of time in business.

Such trends highlight the role of smart technology in driving operational efficiency, customer loyalty and competitive differentiation in various business contexts. For other options, the size of the organization and time company operates in the business does not have a statistically significant effect.

Table 2. *Company's main motivations for implementing smart technologies comparing with company size and time company is operating in business.*

Motivations to implement smart technologies	Company size	The time company is operating in business
Improving operational efficiency	p=0.140>0.05	p=0.101>0.05
Cost reduction	p=0.312>0.05	p=0.036<0.05
Improvement in service quality	p=0.007<0.05	p=0.371>0.05
Increased customer satisfaction	p=0.511>0.05	p=0.027<0.05
Regulatory compliance	p=0.558>0.05	p=0.198>0.05

Note: *Chi-square was used to determine statistical significance.*
Source: *Created by authors based on the research 2024 data.*

We asked respondents to identify the smart technologies they plan to implement in the future. A large number of respondents indicated they have no plans to implement any systems at this time.

However, a significant number expressed plans to deploy the following smart technologies within their companies: Automated systems; Electrification of the car fleet, alongside other fuel options such as biodiesel; Automated gate systems (currently under development); Artificial intelligence for customer communication; Data analysis technologies; Integration of AI into operations; Adoption of less-polluting vehicles for the company's fleet. Very small companies emphasized that they do not currently have any plans. Large and medium-sized organizations have the most plans for future.

The biggest challenges which companies face are: the costs of implementing smart technologies can be prohibitive, especially for small and medium-sized enterprises (SMEs) (mean 4.37, mode 5), The implementation of smart technologies requires workers with special skills (mean 3.47, mode 4) and Integrating new technologies into existing systems can be complex and expensive (mean 3.41, mode 4) (Table 3).

Table 3. *The biggest challenges companies face by implementing smart technologies*

Challenges faced in implementing smart technologies	Mean	Median	Mode	Std. Deviation
Integrating new technologies into existing systems can be complex and expensive	3.41	3.50	4	0.832
Effective data management and storage is a major challenge as AI, IoT and blockchain generate massive amounts of data.	3.22	3.00	3	0.696
Cybersecurity	3.30	3.00	3	1.113
The implementation of smart technologies requires workers with special skills.	3.47	3.50	4	1.142
The costs of implementing smart technologies can be prohibitive, especially for small and medium-sized enterprises (SMEs).	4.37	4.00	5	0.950
There may be concerns about job losses due to automation and other smart technologies.	3.09	3.00	3	1.092
Market readiness to adopt and use smart technologies can vary widely, affecting the pace of implementation.	3.09	3.00	3	0.784

Note: *Evaluate from 1 to 5. 1 means that there is no challenge for the organization and 5 that is a very big challenge.*
Source: *Created by authors based on the research 2024 data.*

The average challenges companies see in Cybersecurity (mean 3.30, mode 3), Effective data management and storage is a major challenge as AI, IoT and blockchain generate massive amounts of data (mean 3.22, mode 3), There may be concerns about job losses due to automation and other smart technologies (mean

3.09, mode 3) and Market readiness to adopt and use smart technologies can vary widely, affecting the pace of implementation (mean 3.09, mode 3).

The study reveals that company size significantly influences how organizations perceive and prioritize the challenges of implementing smart technologies. The Kruskal-Wallis test confirmed that there are statistically significant differences ($p \leq 0.05$) in these perceptions based on company size, suggesting that companies of different sizes face different challenges when adopting smart technologies. It should also be noted that the length of time a company has been in business does not have a statistically significant effect on the choices. Therefore, this data has not been analyzed (Table 4).

Table 4. *Kurkal-Wallis test. Challenges faced in implementing smart technologies and company size.*

Challenges faced in implementing smart technologies	*Company size*	Mean Rank	Asymp. Sig.
Integrating new technologies into existing systems can be complex and expensive	**Up to 10 employees**	**37.29**	**p=0.006<0.05**
	11-50 employees	**24.29**	
	51-250 employees	**18.00**	
	Over 250 employees	**18.92**	
Effective data management and storage is a major challenge as AI, IoT and blockchain generate massive amounts of data.	**Up to 10 employees**	**35.29**	**p=0.025<0.05**
	11-50 employees	**23.47**	
	51-250 employees	**19.50**	
	Over 250 employees	**20.00**	
Cybersecurity	**Up to 10 employees**	**19.07**	**p=0.713>0.05**
	11-50 employees	**25.74**	
	51-250 employees	**23.10**	
	Over 250 employees	**23.25**	
The implementation of smart technologies requires workers with special skills.	**Up to 10 employees**	**15.79**	**p=0.229>0.05**
	11-50 employees	**23.12**	
	51-250 employees	**23.45**	
	Over 250 employees	**28.58**	
The costs of implementing smart technologies can be prohibitive, especially for small and medium-sized enterprises (SMEs).	**Up to 10 employees**	**19.64**	**p=0.848>0.05**
	11-50 employees	**24.12**	
	51-250 employees	**23.95**	
	Over 250 employees	**24.50**	
There may be concerns about job losses due to automation and other smart technologies.	**Up to 10 employees**	**38.43**	**p=0.001<0.05**
	11-50 employees	**15.71**	
	51-250 employees	**20.95**	
	Over 250 employees	**27.96**	
Market readiness to adopt and use smart technologies can vary widely, affecting the pace of implementation.	**Up to 10 employees**	**19.93**	**p=0.023<0.05**
	11-50 employees	**17.32**	
	51-250 employees	**28.70**	
	Over 250 employees	**30.00**	

Note: The higher the mean rank, the bigger the challenge.
Source: Created by authors based on the research 2024 data.

Respondents from small organizations view the cost of integrating new technologies into existing systems as a significant challenge, more so than those from companies of other sizes *($p=0.006<0.05$).* Conversely, respondents from large organizations see this as one of the least concerning challenges.

For micro and small businesses, effective data management and storage pose relatively big challenges, while medium-sized businesses and large organizations consider this less problematic *($p=0.025<0.05$).* Job loss is cited as a potential challenge by respondents from both very small and large organizations, whereas small businesses do not consider it an issue *($p=0.001<0.05$).*

Market readiness to adopt and utilize smart technologies varies widely, influencing the pace of implementation. Large and medium-sized companies see this as a major challenge, while small business respondents generally perceive it as less of a concern *($p=0.023<0.05$).* For other options, the size of the organization does not have a statistically significant effect.

The findings emphasize that technology adoption strategies should be tailored according to company size. Larger companies may need to focus on industry-wide technological readiness and workforce transition management, while smaller companies might benefit from support in handling upfront costs and developing effective data management solutions.

6. Discussion

The studies presented in the introductory part illustrate the diverse, but interrelated ways in which EU countries apply smart logistics technologies. From blockchain and smart grids to digital knowledge management and resilience strategies, these technologies are transforming logistics processes, enabling EU countries to achieve sustainability and efficiency goals while strengthening supply chain resilience across borders.

We conducted a study aimed at exploring the smart technologies being implemented by logistics companies in Lithuania. The findings of this study closely align with research conducted in other European countries, confirming the widespread adoption of cutting-edge technologies within the logistics sector across the continent. In Lithuania, logistics companies are extensively using route planning and optimal route selection programs, which help improve operational efficiency by identifying the most cost-effective and time-efficient routes for transportation.

Additionally, smart real-time cargo tracking technologies are increasingly being utilized, enabling companies to monitor shipments in real-time and ensure the timely delivery of goods. Another notable trend is the digitization of documents, which streamlines administrative processes and reduces the risk of human error. As Oztemel and Gursev (2020) noted digitization of data helps to combine various

activities in order to generate additional benefits for the final product and its users. Moreover, intelligent vehicle technologies are becoming more prevalent.

These include smart safety sensors that alert drivers to potential hazards, as well as smart vehicle monitoring systems that regulate temperature and humidity for the transport of temperature-sensitive cargo, ensuring compliance with safety standards.

Despite these advancements, the study also highlighted key challenges faced by logistics companies in Lithuania. Oyetoro (2024) and Andreas (2024) noted that cybersecurity and data protection remain fundamental concerns for many industries implementing smart technologies.

However, our research suggests that while Lithuanian logistics companies acknowledge these risks, they perceive them as an average-level challenge, potentially indicating that data security measures are being addressed adequately within the sector. In contrast, the most significant challenge identified by Lithuanian companies was the high cost of implementing these smart technologies.

This is particularly pronounced for small and medium-sized enterprises (SMEs), which often lack the financial resources to invest in expensive technological infrastructure. The financial burden of adopting new technologies, combined with limited budgets, was a major concern for many companies, mirroring trends observed in other regions. Oladele (2024) highlighted the challenges associated with the implementation of smart technologies in logistics, particularly the high initial investment costs and the complexities of ensuring compatibility with existing systems.

Our study corroborates these findings, showing that Lithuanian companies face similar obstacles in integrating new technologies with their current systems. The investment required for technological upgrades, coupled with potential integration issues, makes the process daunting for many businesses. In addition, Sumets (2023) pointed out that the lack of qualified personnel and resistance to change can act as significant barriers to the adoption of smart technologies.

Our findings align with this observation, as a considerable number of companies in Lithuania cited the shortage of skilled workers as the primary challenge in successfully implementing smart technologies. This skill gap hampers the efficient deployment of new systems and technologies, as companies struggle to find or train personnel with the necessary expertise. Moreover, the cultural resistance to change, which is common in many organizations, further complicates the smooth integration of technological innovations.

Overall, while the study reveals that Lithuanian logistics companies are making notable progress in adopting smart technologies, it also highlights the ongoing challenges they face. These include financial constraints, the need for qualified

personnel, and the complexities of technology integration—issues that must be addressed for these companies to fully capitalize on the potential benefits of digital transformation in the logistics sector.

In Europe, a study conducted by Burinskienė and Daškevič (2024) explored the integration of digital technologies, such as artificial intelligence (AI) and the Internet of Things (IoT), within logistics processes. The primary focus of their research was on how these technologies can be utilized to enhance the competitiveness of companies and improve supply chain transparency.

The findings of this study highlighted the substantial potential of digital technologies to significantly boost productivity, with estimates suggesting an increase of up to 20%. Moreover, the adoption of AI and IoT can contribute to enhanced competitiveness by providing companies with the tools needed to streamline operations, make data-driven decisions, and stay ahead in an increasingly competitive global market.

Our research aligns with the broader trends observed in the European logistics sector, revealing that organizations are highly motivated to implement smart technologies for several key reasons. The most significant motivation identified by our study was cost reduction, with an overwhelming 95.7% of organizations citing this as a primary driver for adopting smart technologies.

The desire to lower operational costs through automation, optimization, and real-time data tracking is a critical factor in making the transition to digital systems. By adopting these technologies, companies can reduce waste, improve resource allocation, and minimize unnecessary expenditures, thereby improving their financial performance.

Another significant factor motivating the adoption of smart technologies in the logistics industry is the improvement of operational efficiency, which was cited by 93.5% of organizations in our study. The implementation of AI, IoT, and other digital tools can lead to more efficient workflows, better route planning, enhanced cargo tracking, and quicker decision-making, all of which directly contribute to smoother, faster, and more reliable operations.

These improvements in operational efficiency help companies stay agile in responding to market demands, customer needs, and unforeseen challenges, such as disruptions in the supply chain.

Additionally, 69.6% of organizations in our study reported that improving service quality was another key motivation for implementing smart technologies. With real-time data and smart systems, companies can ensure higher levels of accuracy, timeliness, and reliability in their services. This leads to improved customer

satisfaction and loyalty, which are essential factors for maintaining competitiveness in the logistics industry.

All these motivations—cost reduction, improved operational efficiency, and enhanced service quality—contribute to a significant increase in overall work productivity. As organizations streamline their operations and reduce inefficiencies, their workforce can focus on higher-value tasks, boosting both individual and team productivity.

Furthermore, these improvements not only enhance the day-to-day operations of logistics companies but also contribute to the long-term competitiveness of these firms. By leveraging the advantages of smart technologies, companies can differentiate themselves in the market, offering superior services while reducing operational costs, ultimately allowing them to outperform competitors.

The integration of smart technologies such as AI and IoT in the logistics sector is a powerful tool for improving productivity and competitiveness. As demonstrated by the findings of both Burinskienė and Daškevič (2024) and our own research, the adoption of these technologies is driven by the desire to reduce costs, improve operational efficiency, and enhance service quality—factors that collectively boost work productivity and elevate a company's position in the competitive landscape.

As Nishani Edirisinghe and Tadesse, (2020) noted when implementing smart technologies, it is necessary to examine all possible options and determine which one is most acceptable in terms of financial, maintenance and application aspects.

7. Conclusions

Recent studies across the European Union reveal a strong focus on the adoption of smart technologies in the logistics sector, with goals aligned with EU policies on efficiency, sustainability, and resilience. Studies conducted in European countries generally emphasize the importance of digital transformation in EU logistics, addressing both operational and environmental objectives.

By integrating smart technologies, blockchain, digital platforms, and cross-border coordination, the EU logistics sector is increasingly able to adapt to industry changes, increase competitiveness, and reduce its carbon footprint.

Additionally, these technologies support transparency within supply chains, reduce operational costs through optimized route planning, and enhance real-time tracking and data management. While challenges such as high initial investments, regulatory requirements, and a shortage of skilled professionals remain, the long-term benefits of implementing smart technologies are driving continued investment and development in the sector. Smart technologies are not only transforming logistics processes but also supporting the EU's commitment to sustainable growth, creating a

foundation for more resilient, efficient, and eco-friendly logistics networks. Through strategic digital transformation, the EU logistics sector is positioned to meet future demands, respond to market shifts, and contribute to the broader goals of sustainable development across the region.

The study revealed that logistics companies in Lithuania extensively use route planning and optimal route selection programs, which enhance operational efficiency by identifying the most cost-effective and time-efficient transportation routes. Additionally, the adoption of smart real-time cargo tracking technologies is on the rise, enabling companies to monitor shipments in real time and ensure timely delivery.

Another notable trend is the digitization of documents, which streamlines administrative processes and reduces the risk of human error. The primary motivations for organizations to implement smart technologies are cost reduction, improved operational efficiency, and enhanced service quality. However, companies face significant challenges, including the high costs of implementing smart technologies, which can be prohibitive, particularly for small and medium-sized enterprises (SMEs).

Moreover, implementing these technologies requires a skilled workforce, and integrating new technologies into existing systems can be complex and costly. In conclusion, while smart technologies offer substantial benefits for productivity and service quality in Lithuania's logistics sector, addressing cost and skill-related challenges will be essential for broader adoption. Overcoming these barriers will enable companies, particularly SMEs, to leverage digital tools more effectively, improving their competitive positioning in an increasingly dynamic market.

References:

Adesoga, T.O., Ajibaye, T.O., Nwafor, K.C., Imam-Lawal, U.T., Ikekwere, E.A., Ekwunife, D.I. 2024. The rise of the "smart" supply chain: How AI and automation are revolutionizing logistics. International Journal of Science and Research Archive, 12(02), 790-798. https://doi.org/10.30574/ijsra.2024.12.2.1304.

Akkaya, M., Kaya, H. 2019. Innovative and smart technologies in logistics. Conference Paper. 17th International Logistics and Supply Chain Congress October 17-18, Istanbul, Turkey. https://www.researchgate.net/publication/338423597.

Andreas, K. 2024. Sustainability and NewTechnologies: Last-Mile Delivery in the Context of Smart Cities. Sustainability, 16(18), 8037. https://doi.org/10.3390/su16188037.

Bajor, I., Torok, A., Rožic, T., Novačko, L. 2024. The EU Logistics Sector. Periodica Polytechnica Transportation Engineering, 52(3), 229-234. https://doi.org/10.3311/PPtr.23694.

Burinskienė, A., Daškevič, D. 2024. Application of digital technologies in the EU logistics sector. In: New Trends in Contemporary Economics, Business and Management. Selected Proceedings of the 14th International Scientific Conference "Business and Management 2024", 193-201. https://doi.org/10.3846/bm.2024.1158.

Dembińska, I. 2018. Smart Logistics in The Evolution of the Logistics. European Journal of Service Management, 27(2), 123-133. DOI: 10.18276/ejsm.2018.27/2-15.

Ekhsonov, J. 2024. Digital logistics: possibilities of smart contracts in the organization of intellectual transport systems, 219-228. https://www.researchgate.net/publication/380529347.

Gholizadeh, Y. 2024. Implementation of block-chain technology in the European Union energy payments and logistic. International Journal of Energy Sector Management, 1750-6220. DOI: 10.1108/IJESM-03-2024-0001.

Kadłubek, M., Thalassinos, E., Domagała, J., Grabowska, S., Saniuk, S. 2022a. Intelligent transportation system applications and logistics resources for logistics customer service in road freight transport enterprises. Energies, 15(13), 4668.

Kadłubek, M., Thalassinos, E., Noja, G.G., Cristea, M. 2022b. Logistics customer service and sustainability-focused freight transport practices of enterprises: Joint influence of organizational competencies and competitiveness. J. Green Econ. Low-Carbon Dev, 1(1), 2-15.

Kalenyuk, I., Riashchenko, V., Uninets, I. 2024. Smart marketing and global logistics networks. Baltic Journal of Economic Studies, 10(2), 113-122. https://doi.org/10.30525/2256-0742/2024-10-2-113-122.

Khatib, E.J., Barco, R. 2021. Optimization of 5G Networks for Smart Logistics. Energies, 14(6), 1758. https://doi.org/10.3390/ en14061758.

Klaric, M. 2024. Smart digitalization and public services in the EU. Conference: International Scientific Conference "Digitalization and Green Transformation of the EU". DOI: 10.25234/eclic/27446.

Kumar, S., Narkhede, B.E., Jain, K. 2021. Revisiting the warehouse research through an evolutionary lens: a review from 1990 to 2019. International Journal of Production Research, 59(11), 3470-3492. https://doi.org/10.1080/00207543.2020.1867923.

Lebedeva, L., Shkuropadska, D. 2024. Resilience of Transport Logistics In EU and Ukraine. Foreign trade economics finance law 135(4), 108-127. DOI: 10.31617/3.2024(135)07.

Liu, Y., Zhao, J. 2024. Evaluation of the Smart Logistics Based on the SLDI Model: Evidence from China. Systems, 12(10), 405. https://doi.org/10.3390/systems12100405.

Marino, S. 2023. Delivering smart warehousing in Australia. In: Li, E.Y. *et al.* (Eds.) Proceedings of The International Conference on Electronic Business, 23, 131-138. ICEB'23, Chiayi, Taiwan, October 19-23. https://aisel.aisnet.org/iceb/.

Mutule, A., Antoskova, I., Carroll, P., Papadimitriou, C., Morch, A., Efthymiou, V. 2024. Smart grid standardisation: contributions and opportunities of EU horizon 2020 projects. Latvian journal of physics and technical sciences, 61(4), 17-40. DOI: 10.2478/lpts-2024-0025.

Nishani Edirisinghe, V., Tadesse, A. 2020. Blockchain or EDI? Strategic Finance. https://www.sfmagazine.com/articles/2020/june/blockchain-or-edi/.

Ntule, N.D., Ongo Nkoa, B.E., Fuein, V. 2024. Effect of Digitalization on Logistics Performance among Logistics Related Companies in Cameroon. American Journal of Supply Chain Management, 9(3), 1-16. https://doi.org/10.47672/ajscm.2099.

Oladele, O.K. 2024. Blockchain Technology in Logistics 4.0: A Comprehensive Review of Applications, Benefits, and Challenges, 27-42. https://www.researchgate.net/publication/385138049.

Oyetoro, A. 2024. The Application of Technology in Logistics. https://www.researchgate.net/publication/380395311.

Oztemel, E., Gursev, S. 2020. Literature review of Industry 4.0 and related technologies. Journal of Intelligent Manufacturing, 31, 127-182. https://doi.org/10.1007/s10845-018-1433-8.

Rahman, Md.H., Menezes, B.C., Baldacci, R. 2024. Exploring the role of blockchain technology, warehouse automation, smart routing, and cloud computing in logistics performance. Production & Manufacturing Research, 12 (1). https://doi.org/10.1080/21693277.2024.2393614.

Ravi, N., Seetharaman, A., Jayaraman, V. 2023. Influence of Iot on smart logistics. PEOPLE: International Journal of Social Sciences, 9(2), 1-13. https://doi.org/10.20319/pijss.2023.92.

Sałek, R., Wiśniewska-Sałek, A. 2024. The Role of the Freight Exchange in Knowledge Management of A Logistics Company. Proceedings of the 25th European Conference on Knowledge Management, ECKM 2024. https://doi.org/10.1080/14778238.2018.1475848.

Sandoval, N. 2021. Smart Warehousing: Three IoT-based Technologies Speeding Up Your Order. https://www.emnify.com/.

Sumets, O. 2023. Development of intelligent tools for logistics: practice and prospects of use. AIC Economics and Management, 2, 124-136. https://doi.org/10.33245/2310-9262-2023-185-2-124-136.

Tiwari, S. 2023. Smart warehouse: A bibliometric analysis and future research direction. Sustainable Manufacturing and Service Economics, 2, 100014. https://doi.org/10.1016/j.smse.2023.100014.

Tyagi, P., Grima, S., Sood, K., Balamurugan, B., Özen, E., Thalassinos, E. (Eds.). 2023. Smart analytics, artificial intelligence and sustainable performance management in a global digitalised economy. Emerald Publishing Limited.

Wang, M., Asian, S., Wood, L.C., Wang, B. 2019. Logistics innovation capability and its impacts on the supply chain risks in the Industry 4.0 era. Modern Supply Chain Research and Applications, 2(2), 83-99. https://doi.org/10.1108/MSCRA-07-2019-0015.

Wei, W. 2024. Effective Application of Smart Logistics Technology in Rural E-commerce Logistics Distribution. Applied Mathematics and Nonlinear Sciences, 9(1), 1-19. https://doi.org/10.2478/amns-2024-0179.

Zemlyak, S., Nozdreva, I., Sivakova, S. 2024. Implementation of AI in Smart Logistics Based on Mobile Technologies. International Journal of Interactive Mobile Technologies (iJIM), 18(17), 88-100. https://doi.org/10.3991/ijim.v18i17.50735.