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IoT Adoption in the Logistics Sector: The Case of Lithuania

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Abstract. The Internet of Things (IoT) has become a key driver in transforming traditional logistics systems into intelligent, data-driven technological platforms that enable the integration of devices, sensors, and software into unified networks for monitoring and optimizing logistics processes. Through the interconnection of physical objects and digital infrastructures, IoT technologies facilitate continuous data exchange and real-time visibility across logistics operations. This capability supports improved decision-making, enhanced process control, and greater transparency throughout supply chains. As a result, the logistics sector is widely regarded as one of the primary beneficiaries of IoT-driven digital transformation, as it increasingly relies on real-time data, automation, and connectivity to improve operational efficiency and service quality. Against this backdrop, this study examines the adoption of IoT technologies in the logistics sector in Lithuania, focusing on how different patterns of IoT application are associated with perceived benefits and digital transformation outcomes.

Keywords: IoT, logistics sector, digital transformation.

1. Introduction

In the context of globalization, technological advancement, and the increasing complexity of supply chains, the logistics sector is undergoing a significant transformation increasingly shaped by processes of digitalization. One of the main driving forces behind this transformation is the integration of Internet of Things (IoT) technologies, which fundamentally alter traditional logistics operations and create opportunities for more efficient, accurate, and transparent supply chain management. The ability of IoT to generate real-time information becomes particularly important in a sector where operational efficiency and precision directly determine competitiveness. By employing RFID, GPS, and various sensor systems, logistics organizations can continuously monitor the location and condition of goods—a capability especially critical for managing perishable or environmentally sensitive products (Xu et al., 2013; Castro et al., 2012).

Mashayekhy et al. (2022) emphasize that IoT technologies also contribute to the optimization of inventory management, as automated data collection systems enable precise monitoring of inventory levels and movements, thereby reducing excess stock, shortages, and human error. Such real-time information capabilities are highly significant because they enable more effective resource planning and ensure smoother functioning of supply chain processes. The importance of this technological progress becomes even more pronounced when IoT is integrated with cloud computing and big data analytics. These technologies allow the processing of large information flows and the generation of forecasts that support more accurate demand planning, route optimization, and proactive maintenance strategies, thereby reducing the risk of operational disruptions (Abhulimen & Ejike, 2024; Pathuri, 2024). According to Kupunarapu (2024), even greater synergistic value emerges when IoT is combined with blockchain technology. IoT enables continuous real-time data collection, while blockchain ensures that this data can be stored in a decentralized and immutable system, thereby increasing transparency and trust among supply chain participants. Rejeb et al. (2019) note that such integration is critical in domains requiring a high level of traceability, as well as in crisis logistics, where uninterrupted and accurate data flows are essential for effective coordination of actions. Furthermore, beyond improving operational efficiency, IoT technologies also create conditions for the development of more sustainable logistics practices. Continuous monitoring of energy use, transportation routes, and environmental parameters enables companies to assess the environmental impact of their operations and identify opportunities for reducing it (Haddud et al., 2017). As Liu (2022) points out, IoT provides the data necessary for companies to optimize resource use and implement sustainability strategies.

Given these considerations, the role of IoT in the logistics sector is becoming increasingly important, and research on its practical application is highly relevant. However, despite extensive discussion of IoT benefits in the literature, empirical evidence regarding how different IoT technologies and their applications translate into perceived operational benefits remains limited. Therefore, the aim of this article is to evaluate the impact of IoT technology adoption on logistics sector performance, with a particular focus on the relationship between the scope of IoT usage and perceived operational benefits.

To achieve this aim, the study employs a quantitative research approach based on three complementary analytical methods. First, correlation analysis is used to examine whether the number of IoT technologies implemented by logistics organizations is associated with higher operational efficiency levels. Second, cluster analysis is applied to identify patterns of IoT technology usage across different logistics activities, highlighting how the same technologies may be employed in multiple functional areas rather than being limited to a single operational domain. Third, regression analysis is conducted to determine which specific aspects of IoT applications are statistically significantly related to the perceived benefits of IoT adoption in the logistics sector.

The remainder of the article is structured as follows. The next section presents a review of the relevant literature on IoT applications in logistics and supply chain management. This is followed by a description of the research methodology, data collection process, and analytical techniques employed in the study. Subsequently, the empirical results of the correlation, cluster, and regression analyses are presented and discussed. Finally, the article concludes with a discussion of the main findings, their implications for logistics practitioners and policymakers, and directions for future research.

2. Literature review

2.1. Foundational IoT Technologies and Their Transformative Role in Logistics

The Internet of Things (IoT) represents a transformative technological paradigm that has fundamentally reshaped logistics and supply chain management across industries. Hasan and Habib (2022) emphasize that IoT has become a critical enabler of Industry 4.0, providing unprecedented levels of visibility, efficiency, and operational intelligence throughout logistics networks. Altubaishe and Desai (2023) note that the integration of IoT technologies into logistics operations has created intelligent and interconnected sensor networks that link suppliers, manufacturers, and service providers, allowing organizations to transition from reactive to proactive supply chain management. The significance of IoT adoption extends beyond technological implementation, as it represents a fundamental shift in how organizations conceptualize, monitor, and optimize their supply chains. With increasingly complex and globally distributed supply chains, the need for real-time visibility and data-driven decision-making has become essential (Akyüz & Bıcer, 2022). IoT technologies provide the infrastructure needed to meet these demands, offering capabilities previously unattainable with conventional logistics systems.

Song & Wu (2024) emphasize that Radio Frequency Identification (RFID) technology is a foundational IoT component in logistics, enabling automated identification and data capture across supply chains. RFID addresses key logistics challenges, such as misplaced inventory and long lead times (Zhang et al., 2014), and has evolved into a core IoT technology used across various industries, including retail, pharmaceuticals, healthcare, and asset tracking (Abdulghani et al., 2022). Its low-power, contactless operation makes it suitable for logistics environments requiring continuous monitoring (Hsu & Liang, 2021). Integrating RFID with IoT creates RFID-IoT systems where sensors and RFID technology interact via wireless networks (Gabsi et al., 2021), supporting supply chain management, automatic identification, inventory control, and retail operations (Maïzi & Bendavid, 2023). Complementing RFID, sensor networks are a critical component of IoT, enabling continuous monitoring and real-time data collection throughout supply chains. Wireless sensor networks (WSN) play a significant role in cold chain logistics, where temperature-sensitive goods require constant monitoring (Çeken & Abdurahman, 2019). Sensors allow organizations to collect extensive data about product conditions, location, movement speed, and environmental parameters (Vass et al., 2018; Singh et al., 2022). Hardware supporting such networks includes automated data recognition systems, RFID tags, sensor tags, and telematics modules, which provide visibility, mobility, and adaptability across logistics applications (Liu, 2022).

One of IoT's most substantial contributions to logistics is the enhancement of real-time visibility and transparency. IoT-enabled supply chains operate as intelligent sensor networks, linking multiple tiers of suppliers, manufacturers, and distributors (Altubaishe & Desai, 2023). Visibility now spans the entire supply chain, from raw materials to end consumers. Studies indicate that integrating IoT and blockchain can improve real-time visibility by up to 25% in food supply chains. IoT-based systems generate multiple data streams that offer comprehensive insights into supply chain operations, allowing organizations and consumers to access timely product information (Kmiecik & Egbunu, 2022; Kian, 2022). IoT has also revolutionized product traceability and authentication, particularly through IIoT environments in which sensors continuously produce and process large data volumes (Al-Rakhami & Al-Mashari, 2022). RFID and GPS-enabled IoT solutions help optimize supply chain tracking from suppliers to consumers (Khrais et al., 2023) and are crucial in preventing counterfeit products, ensuring authenticity, and enabling complete traceability (Fuyao, 2023). EPCIS standards facilitate information sharing across supply chain partners by standardizing the exchange of serial numbers, event data, timestamps, and locations (Tu et al., 2018).

2.2. IoT-Driven Operational Optimization and Multi-Sector Logistics Applications

IoT technologies have significantly enhanced inventory management, providing real-time visibility into inventory levels and facilitating more effective stock optimization (Chen et al., 2014). IoT implementations across industries demonstrate major value creation through improved inventory tracking, reduced losses, and minimized stockouts (Altubaishe & Desai, 2023; Zhang et al., 2014). The adoption of IoT or IIoT improves operational efficiency by enabling real-time data collection, reducing waste, redundancies, and energy consumption (Tu, 2018; Cao et al., 2022). Organizations benefit through optimized transportation routing, enhanced warehouse operations, reduced operational costs, and improved overall profitability.

Industry-specific applications of IoT provide further insights into its versatility. In cold chain logistics, IoT ensures strict control of environmental conditions for pharmaceuticals, vaccines, and perishable foods (Çeken & Abdurahman, 2019). IoT-based tracking enhances the reliability of medication cold chains, preventing temperature excursions that degrade the effectiveness of the product (Bouazzi et al., 2025). Similar benefits are also evident in food supply chains, where IoT enables end-to-end monitoring, enhances food safety systems, reduces waste, and improves quality control (Jabbar et al., 2024; Hasan et al., 2023; Fan, 2019). Modern agriculture and food systems increasingly rely on IoT for sensory monitoring, data exchange, and supply chain coordination (Ping et al., 2018). In pharmaceutical and healthcare logistics, IoT plays a critical role in ensuring regulatory compliance, secure tracking, and asset management (Abdulghani et al., 2022). Combining IoT with blockchain enhances data integrity and product authenticity in sensitive healthcare supply chains (Nanda et al., 2023). IoT also supports specialized logistics fields, such as halal supply chains, ensuring compliance with halal standards through real-time monitoring and environmental data collection (Rejeb et al., 2019).

The adoption of IoT strengthens organizational capabilities and positively impacts supply chain performance. Research shows that IoT capabilities, logistics capabilities, and supply chain integration are key determinants of overall firm performance (Vass et al., 2018; Nazir & Fan, 2024; Zafar, 2024). IoT improves stakeholder interactions and allows more efficient coordination of supply chain activities (Khrais et al., 2023). Network freight transport platforms function as integrators in IoT environments, connecting carriers, shippers, and scattered resources into cohesive logistical ecosystems (Bai et al., 2021).

IoT is also a pivotal enabler of green logistics and sustainability. Through efficiency improvements, IoT reduces energy consumption, lowers emissions, minimizes waste, and supports environmentally responsible supply chain practices (Shafique et al., 2018; Cao et al., 2022). Continuous monitoring of storage conditions helps reduce spoilage, particularly in perishable goods supply chains. Big data analytics derived from IoT enables organizations to improve performance, flexibility, productivity, and waste reduction (Raj et al., 2023). AIoT solutions further enhance predictive capabilities, anomaly detection, and intelligent decision-making (Nozari et al., 2022). To fully utilize IoT data, standardized frameworks such as EPCIS are essential, enabling seamless interoperability across systems (Tu et al., 2018). Ontology-based IoT middleware further supports integration among heterogeneous devices, facilitating unified logistics platforms (Allouch et al., 2017). Scalable, unified identity technologies enhance traceability and product authenticity, thereby strengthening supply chain efficiency (Guo et al., 2025). Emerging IoT applications integrate blockchain for secure, transparent, and tamper-proof supply chain record-keeping. Blockchain–IoT integration has been shown to enhance real-time visibility across supply chains and support business continuity. Applications in agriculture and food systems demonstrate improved traceability, credibility, and product authenticity. Artificial intelligence and machine learning embedded within IoT systems enable advanced sensing, quality assessment, and operational optimization (Song & Wu, 2024; Liu, 2022).

Despite its benefits, IoT poses security and privacy challenges. RFID-based IoT applications require strict security standards to prevent unauthorized access and data tampering (Abdulghani et al., 2022). Novel authentication protocols, such as ECC-based RFID mutual authentication, help mitigate emerging cyber threats (Gabsi et al., 2021). Studies evaluating the vulnerabilities of commercial RFID tags highlight the need for robust security mechanisms (Fernández-Caramés et al., 2016). Privacy concerns necessitate comprehensive governance frameworks, particularly in sectors such as healthcare, where sensitive data are processed (Nanda et al., 2023). Multilayer validation systems in wireless sensor networks ensure data integrity and authenticity.

IoT has also transformed logistics service provider models. Fourth-party logistics (4PL) providers are increasingly leading the integration of IoT-based supply chains, surpassing traditional third-party logistics (3PL) providers due to their stronger data integration and coordination capabilities. Network freight platforms further enhance value co-creation by integrating scattered supply chain resources (Bai et al., 2021). IoT supports redesigning logistics services to meet Industry 4.0 requirements, enabling providers to enhance customer satisfaction and operational efficiency (Tiwong et al., 2020). Model-based systems engineering facilitates the implementation of IoT in palletized distribution systems (Navarro et al., 2021). IoT applications in perishable product supply chains have demonstrated improvements in performance, revenue, and sustainability outcomes (Zhang et al., 2017; Yan, 2017). IoT-driven product traceability and anti-counterfeiting technologies have been successfully deployed in the pharmaceutical and luxury goods sectors (Fuyao, 2023). RFID-based monitoring systems enhance sustainability and safety in fishery supply chains. IoT applications in retail, such as beer inventory monitoring systems at SteadyServ, illustrate how IoT enables the development of new digital business models (Angeles, 2019; Violino et al., 2020). Hybrid RFID-IoT simulation approaches show strong potential for use in healthcare supply chains (Maïzi & Bendavid, 2023). IoT technologies have also been applied to supply chain financial supervision, where RFID combined with wireless sensor networks improves monitoring efficiency, communication, and energy consumption (Zhu & Cai, 2021). Lifecycle sustainability assessments of RFID and WSN support environmental decision-making (Kluczek et al., 2021). IoT-enabled sustainable supply chain management frameworks demonstrate benefits for B2B e-commerce and textile logistics (Prajapati et al., 2022). ICT and IoT integration support greener logistics processes by linking orders, packaging, distribution, transportation, storage, and returns (Shafique et al., 2018).

Digital transformation under Industry 4.0 continues redefining supply chains by enhancing efficiency, flexibility, and automation (Altubaishe et al., 2024). The physical internet paradigm aims to create a global, interoperable, and efficient logistics ecosystem (Tran-Dang & Kim, 2021). Smart warehouse configurations and data-driven logistics solutions help overcome challenges such as inaccurate inventory records (Ruiz et al., 2024). Systematic reviews of digital supply chain technologies highlight IoT and RFID as central components of Supply Chain 4.0 (Zhang et al., 2024). Future IoT evolution includes integration with 5G systems, enabling faster, more reliable, and scalable logistics connectivity (Han, 2021). Blockchain-enabled decentralized systems are gaining importance for anti-counterfeiting, ownership tracking, and transparency (Al-Rakhami & Al-Mashari, 2022). Scalable unified identity technologies strengthen traceability and operational effectiveness across supply chains (Guo et al., 2025).

2.3. Technological State of the Lithuanian Logistics Ecosystem in the Context of IoT

The application of Internet of Things (IoT) technologies in Lithuania's logistics sector is becoming increasingly important for enhancing efficiency, transparency, and competitiveness within global supply chains. As a digitally advanced Baltic nation and a transit hub between Western Europe and Eastern markets, Lithuania has favorable conditions for IoT expansion; however, it simultaneously faces infrastructural, organizational, and regulatory challenges (Burinskienė & Daškevič, 2024). Despite the country's well-developed digital ecosystem, IoT network coverage and stability remain uneven, largely due to the unsystematic deployment of devices across logistics chains (Abbas & Marwat, 2020). Moreover, real-time data transmission and analysis impose significant demands on data infrastructure, compelling Lithuanian organizations to invest in big data processing capabilities to fully leverage the value generated by IoT. The rollout of EU-supported 5G networks is expected to enhance the quality of connectivity and improve the reliability of IoT solutions in the logistics sector (Han, 2021; Apruzzese et al., 2023; Çiğdem et al., 2023; Meidutė-Kavaliauskienė et al., 2024).

At the organizational level, the Lithuanian logistics sector, like that of many other countries, faces shortages of technical skills and digital competencies, particularly among small and medium-sized enterprises, which constitute a significant share of the national logistics market (Al Majzoub et al., 2020; Tadesse et al., 2021; Meidutė-Kavaliauskienė et al., 2021). IoT adoption is further constrained by financial factors, uncertain return on investment, and organizational resistance to innovation, resulting in slow and fragmented implementation of technological solutions (Tu, 2018; Bui & Le, 2025). Data security and privacy also pose significant barriers to the expansion of IoT in Lithuania. Since each connected device can become a potential vulnerability, the risk of cyber threats increases (Wright, 2023). IoT management is complicated by challenges related to access control, device heterogeneity, and identified RFID security weaknesses (Ragothaman et al., 2023; Mohammed & Wahab, 2024). Furthermore, organizations must ensure full compliance with European Union data protection regulations, particularly the GDPR, which increases administrative and technical burdens (Ahmed et al., 2021; Souza, 2024). Although blockchain technology could enhance transparency and data integrity in IoT systems, its implementation in Lithuania—as in many other countries—is complicated by high resource requirements and the limited technological capacity of smaller enterprises (Nazir & Fan, 2024; Çiğdem et al., 2025; Meidutė-Kavaliauskienė et al., 2022; Yildirim et al., 2025; Alutas et al., 2021).

Overall, Lithuania has favorable conditions for IoT development in logistics; the successful integration of such technologies will depend on infrastructure modernization, workforce skill enhancement, the development of effective financial models, and the implementation of robust cybersecurity measures. The greatest opportunities for Lithuania lie in the integration of 5G, blockchain, artificial intelligence, and autonomous systems, which can significantly improve supply chain visibility, efficiency, and resilience. Organizations capable of strategically planning and consistently implementing IoT solutions will be best positioned to strengthen their competitiveness within both the Lithuanian and the broader European logistics landscape (Meidutė-Kavaliauskienė et al., 2024).

3. Methodology

A quantitative research approach was employed in this study, aiming to empirically assess the application of Internet of Things (IoT) technologies in Lithuania's logistics sector. The study was conducted using a structured questionnaire survey developed based on an analysis of the scientific literature. The questionnaire consisted of five thematic sections: the first described the respondent and organisational profile; the second examined respondents' understanding of IoT technologies and their use in company operational processes; the third assessed the benefits provided by IoT; the fourth addressed sustainability aspects; and the fifth discussed the prospects for IoT implementation in the logistics sector. The study involved logistics professionals, including logistics and freight forwarding managers, sustainability specialists, and managers at various levels, most of whom work in transport and manufacturing-oriented companies in Lithuania. The analysis of the collected data was conducted using a consistent methodological sequence. Correlation, cluster, and regression analyses were applied to systematically examine the use of Internet of Things (IoT) technologies in Lithuania's logistics sector. In the first stage, correlation analysis was conducted to identify relationships between the intensity of IoT adoption and the perceived benefits and overall evaluation of these technologies in logistics companies.

RQ1: Is the number of Internet of Things (IoT) technologies used associated with their perceived benefits for logistics companies?

In the second stage of the analysis, cluster analysis was applied to identify distinct groups of companies based on their use of Internet of Things (IoT) technologies. Cluster analysis enables the determination of whether logistics sector companies differ in terms of IoT usage and the identification of distinct company segments. This approach allows not only the assessment of overall trends but also the identification of different patterns of technology adoption within the sector.

RQ2: What combinations of IoT technology use predominate in Lithuania's logistics sector?

In the third stage of the analysis, regression analysis was conducted to assess the relationships between the intensity of Internet of Things (IoT) technology adoption, the number of application areas, perceived implementation challenges, and the perceived benefits of these technologies in logistics sector companies. Regression analysis was used to determine which of these factors are statistically significantly associated with the perceived benefits of IoT technologies when all factors are evaluated simultaneously.

RQ3: How is the intensity of IoT technology adoption and other adoption-related aspects associated with their perceived benefits in logistics sector companies?

By applying correlation, cluster, and regression analyses, the study enables a comprehensive assessment of the use of Internet of Things (IoT) technologies in Lithuania's logistics sector. This analytical approach enables not only the evaluation of the intensity and prevalence of technology adoption, but also the identification of different usage patterns and the examination of how various adoption-related aspects are associated with perceived benefits in logistics sector companies. In this way, the study provides a basis for a deeper understanding of the role of IoT technologies and their practical significance within the sector's context. The study findings are based on respondents' subjective assessments; therefore, they reflect the views of logistics sector professionals during the study period.

4. Results

In the first stage of the data analysis, the aim was to assess whether the number of Internet of Things (IoT) technologies used is associated with the evaluation of logistics system performance. To achieve this objective, a correlation analysis was conducted to examine the relationships between the intensity of technology adoption and key logistics performance dimensions, including transport control, warehousing efficiency, safety, service quality, and environmental aspects.

Table 1. Correlation analysis results

Correlations						
		Transport control	**Warehouse efficiency**	**Security (cargo, personnel, and data)**	**Service quality**	**Environmental protection**
The number of IoT technologies used	Pearson Correlation	,272	,282	,105	,144	-,147
	Sig. (2-tailed)	,074	,063	,496	,352	,341
	N	44	44	44	44	44
**. Correlation is significant at the 0.01 level (2-tailed).						

In Table 1, the correlation analysis showed that the number of Internet of Things (IoT) technologies used is not statistically significantly associated with any of the examined logistics performance evaluation dimensions (in all cases, $p > 0.05$). This suggests that a greater number of technologies alone is not inherently linked to higher performance ratings in specific areas of logistics systems. The findings indicate that the perceived impact of IoT is not directly determined by the quantitative extent of adoption; rather, it is more likely influenced by other factors, such as how the technologies are integrated, how they are tailored to specific processes, or organisational decisions. In other words, a higher number of technologies does not necessarily translate into greater benefits or better performance outcomes. These results highlight that the quality of IoT use and the areas in which these technologies are implemented may be more important than their sheer quantity. Therefore, the subsequent analysis focuses on a deeper assessment of IoT adoption aspects, using cluster and regression analyses.

To determine the optimal number of clusters and to assess the structure of IoT adoption in logistics sector companies, the first stage of the cluster analysis involved hierarchical clustering using Ward's linkage method (Fig. 1). This method was selected because it forms homogeneous groups by minimising within-cluster variance.

Hierarchical cluster analysis was conducted using Ward's linkage method. This method enabled the highlighting of how respondents' group according to the extent of technology adoption and their assessment of perceived benefits. An analysis of the dendrogram showed that at lower linkage distances (around 5–6), small and highly homogeneous groups emerge, which then merge into larger structures as the linkage distance increases. Before a pronounced jump in linkage distance at higher levels (around 20–22), three main groups become evident; therefore, a three-cluster solution was selected as the most appropriate for further analysis. In this case, the dendrogram was used not for the final assignment of respondents to clusters, but to justify the number of clusters, which was later refined using k-means cluster analysis.

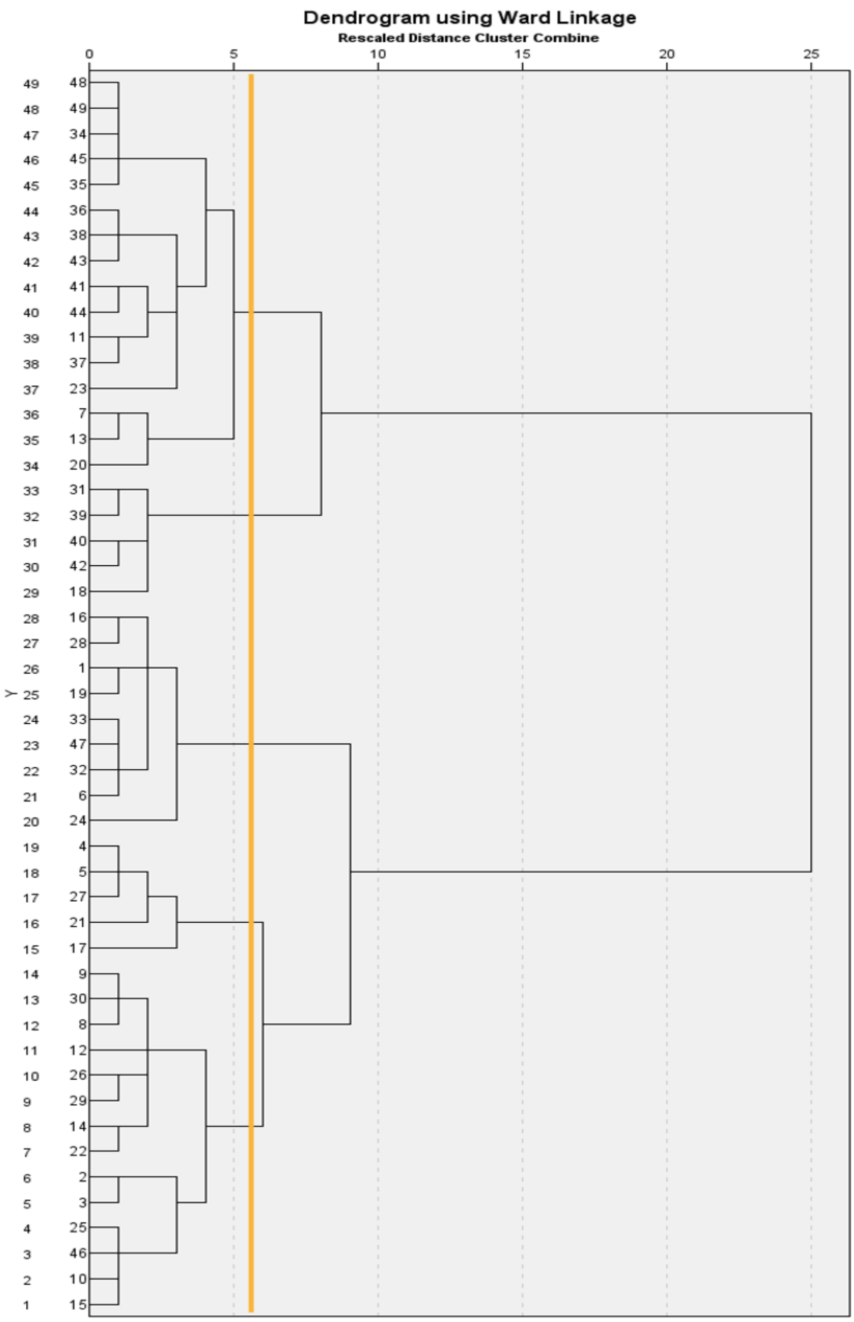

Fig. 1: Cluster analysis results

After determining the optimal number of clusters based on the hierarchical cluster analysis (in this study, 3 clusters were identified), K-means cluster analysis was applied for the subsequent stage (Table 2). This method was chosen to assign each respondent to one of the clusters and to obtain clear, mutually comparable cluster profiles.

Table 2: Case distribution by cluster

Number of Cases in each Cluster		
Cluster	1	19,000
	2	18,000
	3	12,000
Valid		49,000

Missing	,000

The K-means analysis enabled the assessment of cluster sizes and their mean values in terms of the extent of technology adoption and the evaluation of perceived benefits, providing a basis for a detailed interpretation of the clusters. All respondents who participated in the study were assigned to one of three clusters. Nineteen respondents were assigned to the first cluster, eighteen to the second, and twelve to the third. This distribution of cluster sizes indicates that the identified groups are of sufficient size and comparable to one another, making them suitable for further analysis and interpretation.

In addition, K-means cluster analysis enabled the identification of three distinct profiles of Internet of Things (IoT) technology adoption in logistics sector companies. These profiles emerged from analysing the mean values of the number of application areas, the number of technologies used, and perceived benefits, which provided a foundation for a more detailed characterisation of the clusters. Respondents evaluated their answers using a Likert scale (1 – very low benefit, 7 – very high benefit); therefore, values close to 1–2 are interpreted as indicating a low level of benefit, 3–5 as moderate, and 6–7 as high (Table 3).

Table 3: Cluster means and standard deviation

Report				
Cluster Number of Case		**Area of technology application**	**Technologies**	**Perceived benefits**
1	Mean	2,11	2,58	1,53
	N	19	19	19
	Std. Deviation	1,100	2,364	0,612
2	Mean	4,61	7,61	3,33
	N	18	18	18
	Std. Deviation	0,916	1,685	1,085
3	Mean	2,67	3,17	3,50
	N	12	12	12
	Std. Deviation	0,778	1,586	0,798
Total	Mean	3,16	4,57	2,67
	N	49	49	49
	Std. Deviation	1,477	3,035	1,248

Companies assigned to the first cluster are characterised by limited use of Internet of Things (IoT) technologies—both in terms of the number of IoT solutions used (M = 2.58) and the number of application areas (M = 2.11). Given the applied rating scale, companies in this cluster also report the lowest evaluation of perceived benefits (M = 1.53). Therefore, this cluster is described as a group with limited technology adoption and low perceived benefits. Companies in the second cluster demonstrate a substantially broader application of IoT technologies, encompassing a higher number of operational areas (M = 4.61) and a greater number of technological solutions (M = 7.61). The perceived benefit rating in this cluster (M = 3.33) corresponds to a moderate-to-high level, indicating an intensive technology adoption profile. The third cluster stands out because, despite a moderate level of technology adoption—both in terms of the number of technologies used (M = 3.17) and the number of application areas (M = 2.67) - companies in this cluster report the highest perceived benefit rating (M = 3.50), which, based on the interpretation of the scale used, can be attributed to a higher level of benefit. This suggests that the value generated by IoT technologies in the logistics sector is more closely associated with the purposeful and integrated implementation of these technologies, rather than with the sheer number of technologies adopted.

While the correlation analysis did not reveal a significant relationship between the number of technologies and perceived benefits, the cluster analysis results provide additional insight by identifying distinct IoT adoption profiles. This supports the conclusion that the value of IoT technologies in the logistics sector is more strongly linked to the nature of their application than to the quantity of technologies used. To assess which aspects of technology adoption are associated with perceived IoT benefits, the next stage of the analysis employed regression analysis. The regression results are presented in *Table 4*, where perceived IoT benefits were selected as the dependent variable and the number of technology application areas as the independent variable.

Table 4: Summary of the regression model

Model Summary[b]				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0,504[a]	0,254	0,238	1,089
a. Predictors: (Constant), Area of technology application				
b. Dependent Variable: Perceived benefits				

In regression analysis, the strength of the relationship is assessed using the correlation coefficient R, which can take values from 0 to 1. Values close to 0 indicate a weak relationship, whereas values closer to 1 indicate a stronger relationship between the variables under examination. The results indicate a moderate relationship between the analysed variables, with R = 0.504. The coefficient of determination, R Square = 0.254, suggests that the number of technology application areas explains approximately 25.4% of the variance in perceived benefits. The adjusted coefficient of determination, Adjusted R-squared = 0.238, supports the stability of the model and indicates that the model remains informative, given the sample size.

To assess whether the developed regression model is statistically significant in explaining variation in perceived IoT benefits, it is necessary to examine the values from the analysis of variance (ANOVA). Table 5 shows the ANOVA results indicate that the regression model is statistically significant ($F = 16.022$; $p < 0.001$), suggesting that the number of technology application areas significantly contributes to explaining perceived benefits. This confirms that the regression model is appropriate and can be used for further analysis of relationships among the variables.

Table 5: ANOVA results for the regression model

ANOVA[a]						
Model		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
1	**Regression**	19,010	1	19,010	16,022	<,001[b]
	Residual	55,765	47	1,186		
	Total	74,776	48			
a. Dependent Variable: Benefits						
b. Predictors: (Constant), Area						

The ANOVA results indicate that the regression model is statistically significant, with an F value of 16.022 and a p-value of 0.000. value ($p < 0.001$) means that the probability of obtaining such a regression result by chance is extremely low; therefore, the observed relationship is considered statistically reliable. Consequently, it can be stated that the number of technology application areas contributes significantly to explaining perceived benefits. This confirms that the developed regression model is appropriate and can be used for further analysis of relationships among the variables. The final and particularly important step in the regression analysis, aimed at determining which aspects of technology adoption are associated with perceived IoT benefits, is the evaluation of the regression coefficients. This enables the assessment of both the direction and magnitude of the effect of the number of technology application areas on the perceived benefit rating of IoT technologies.

Table 6: Estimated regression coefficients for perceived benefits

Coefficients[a]						
Model		**Unstandardized Coefficients**		**Standardized Coefficients**	**t**	**Sig.**
		B	Std. Error	Beta		
1	**(Constant)**	1,326	0,371		3,573	<,001
	Area	,426	0,106	0,504	4,003	<,001
a. Dependent Variable: Benefits						

The results showed that the number of technology application areas has a statistically significant positive effect on perceived benefits, with a coefficient of B = 0.426 and a standardized coefficient of β = 0.504, indicating a moderate relationship (Table 6). This means that as the number of application areas increases, the perceived benefit rating increases in a statistically significant way. The standardized beta coefficient reflects a moderate positive effect, confirming that the number of technology application areas plays a meaningful role in explaining variation in perceived benefits

5. Conclusions

This study complements prior research that identifies the Internet of Things (IoT) as one of the key drivers of Logistics/Industry 4.0, enhancing real-time visibility, traceability, inventory accuracy, and the optimization of routes and resources. When IoT is integrated with cloud computing, big data analytics, and (in some cases) blockchain technology, it enables more predictive, transparent, and resilient supply chain processes. The literature also emphasizes IoT's contribution to more sustainable logistics by enabling continuous monitoring of energy consumption, transportation routes, and environmental parameters. At the same time, scholarly sources highlight persistent implementation barriers, including complex interoperability and integration challenges, shortages of digital competencies (especially among small and medium-sized enterprises, or SMEs), uncertain return on investment, uneven development of connectivity and data infrastructure, and increasing cybersecurity, privacy, and GDPR-compliance risks. These challenges are particularly relevant in Lithuania's logistics ecosystem, despite the country's favorable conditions as a digitally advanced transit hub.

Within this theoretical context, the empirical results showed that the number of IoT technologies used is not associated with higher perceived benefits or better evaluations of key logistics performance dimensions (in all cases, $p > 0.05$); therefore, RQ1 is not supported, indicating that "more technology" does not automatically translate into "more value." Nevertheless, cluster analysis revealed three distinct IoT adoption profiles—groups characterized by limited adoption and low benefits, intensive adoption and moderate benefits, and moderate adoption but the highest benefits, thus addressing RQ2 and supporting the literature's proposition that value depends more on purposeful, process-based application and the quality of integration than on the sheer "quantity" of devices or solutions. Consistently, regression analysis confirmed that the number of application areas is a statistically significant positive predictor of perceived benefits ($R = 0.504$; $R^2 = 0.254$; $F = 16.022$; $p < 0.001$; $B = 0.426$; $\beta = 0.504$); therefore, RQ3 is supported, and it can be concluded that broader IoT use across different operational areas is associated with higher perceived returns. Based on the cluster findings, especially the group achieving higher benefit levels despite only moderate adoption, this study suggests a “strategic minimalism” effect: greater value may be created not by having more solutions, but by implementing carefully selected, interoperable, and process-integrated solutions supported by clear use-case logic and accountability structures. Because the explained variance is limited ($R^2 \approx 0.254$), it is likely that “hidden” organizational factors also play a significant role, including integration maturity (e.g., interfaces with TMS/WMS/ERP), data governance practices, digital skills, top management support, investment planning logic, and cybersecurity and GDPR compliance arrangements. Therefore, in practice, realizing IoT value requires transitioning from fragmented implementation to use-case portfolio management and cross-functional deployment, where the same IoT data streams support multiple processes (such as transportation, warehousing, quality, and sustainability) and are leveraged through analytics. From a public policy perspective, the results support the relevance of measures that strengthen connectivity infrastructure, data ecosystems, competencies, and cyber resilience. Integrated IoT deployment, rather than simply increasing the number of technologies, appears more closely linked to higher perceived value in the sector.

Finally, given that the findings are based on respondents’ subjective assessments and a limited sample, future research should employ larger samples, incorporate objective performance indicators (e.g., OTIF, delivery time, loss rates, inventory turnover, CO_2 metrics), and model moderating and mediating mechanisms (e.g., integration maturity or data quality) to more precisely explain under what conditions IoT creates the greatest benefits in Lithuania’s logistics sector.

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