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FROM TRADITIONAL TO SMART: AN ANALYSIS OF COMPANIES IN DIFFERENT STAGES OF INTELLIGENT LOGISTICS ADOPTION

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Abstract

New digital technology has significantly changed logistics on a global level, and has created intelligent logistics that help business become more productive, more innovative and more competitive. In the case of developing countries like North Macedonia, intelligent logistics are still being adopted, and this adoption is affected by many opportunities and challenges. This paper provides a comprehensive analysis of the level of the perceptions and implementation levels of digital logistics by companies and how companies benefit from them as an alternative to manual processes; as well as describes the financial and organizational challenges companies are facing. The research aims to assess the extent to which companies have adopted such solutions, the benefits they perceive, and the barriers they encounter during implementation. In this context the results are analyzed using the SPSS softer package. The paper findings present that intelligent logistics play a vital role in improving efficiency, reducing costs, and supporting sustainable business practices, although the initial costs are high.

Key Words: *digital technology, intelligent logistics, digitalization, companies, North Macedonia*

JEL classification: *C10, R4, L86*

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Introduction

The rapid development of digital technologies (DT) has significantly transformed logistics and supply chain management worldwide. Traditional logistics systems, largely dependent on manual operations, fragmented communication, and slow information exchange, are increasingly being replaced by intelligent logistics systems supported by automation, artificial intelligence (AI), the Internet of Things (IoT), cloud computing, blockchain, and predictive analytics. For developing economies such as Republic of North Macedonia (RNM), the transition toward intelligent logistics remains challenging. Many companies continue to rely on conventional logistics practices due to financial constraints, insufficient digital infrastructure, limited technological readiness, lack of qualified human resources, and resistance to organizational change. Nevertheless, as a small open economy with export-oriented industries and increasing integration into European markets, RNM faces growing pressure to modernize logistics systems and align with global digital standards.

Beyond manufacturing and general supply-chain efficiency, intelligent logistics is increasingly recognized as an important driver of sustainable tourism transformation. Smart logistics solutions, such as AI-supported transport optimization, digital inventory systems, and smart mobility platforms, contribute to reducing emissions, energy consumption, and operational inefficiencies within tourism-related industries. Therefore, understanding digital logistics adoption among companies in RNM provides valuable insights not only into business modernization, but also into broader processes of sustainable economic and tourism transformation.

Literature Review

With the emergence of Industry 4.0, research increasingly connected logistics transformation with cyber-physical systems, IoT, robotics, automation, and data-driven decision-making, highlighting their role in improving supply chain resilience, flexibility, and sustainability (Ivanov et al., 2019; Frank et al., 2019). Their findings suggest that companies at different levels of digital maturity face distinct implementation barriers and opportunities, particularly in emerging and transition economies. Subsequent studies demonstrate that intelligent logistics contributes to higher productivity, lower operational costs, improved inventory

visibility, and stronger responsiveness to market disruptions. Winkelhaus and Grosse (2020) argue that digital technologies enable increasingly autonomous logistics systems and improve strategic decision-making processes, while Verhoef et al. (2021) emphasize that digital transformation should be understood not only as technological adoption, but also as a broader organizational and managerial transformation process involving leadership, investment capacity, and institutional adaptation. Despite the growing literature, most empirical evidence focuses on developed economies and multinational corporations, whereas studies from the Western Balkans remain limited. In transition economies such as RNM, digital transformation is frequently constrained by institutional weaknesses, financing limitations, insufficient technological readiness, and limited managerial support. Consequently, there is still limited empirical evidence regarding how companies perceive intelligent logistics, the stages of implementation they have reached, and the financial or organizational barriers they encounter.

Recent literature also increasingly links intelligent logistics with sustainable tourism transformation. Smart logistics systems, including AI-supported transport optimization, digital coordination platforms, and smart mobility applications, contribute to reducing emissions, improving resource efficiency, and supporting environmentally sustainable tourism development (Sigala, 2020; Gössling et al., 2021). Following the COVID-19 pandemic, digital logistics and real-time coordination technologies became increasingly important for improving operational efficiency and strengthening sustainable tourism competitiveness (Buhalis & Sinarta, 2019).

Methodology

The research aims to discover the role of intelligent logistics in companies in RNM. The main research problem is the company perception of intelligent logistics solutions. The research subject is focused on Macedonian companies and their capabilities to adopt intelligent logistics in operational processes. Data were collected by means of a self-administered questionnaire, prepared in Google Docs. The questionnaire contained questions in a closed-ended format and included logically connected questions measured using a 5-point Likert scale. The introduction part was designed to gather basic information such as sector, company size, company age and job position. Other questions concern the level of digitalization, the implementation of intelligent logistics, and the

main challenges that companies face when adopting digital and intelligent logistics solutions, particularly in terms of financial constraints, organizational readiness, and technological capabilities.

The questionnaire was sent randomly to more than 500 companies in the RNM, and responses were received from 126 companies. The survey ran from February 1 to March 31, 2026. Most of the companies belong to the manufacturing industry, have been operating on the market for more than 20 years, have between 1 to 10 employees, and most of the respondents are company owners. The data analysis was accomplished using SPSS v20 statistical software. Due to the scope of the research, this paper presents only one test using the two-way ANOVA.

Empirical Research and Discussion

The paper analyzes the influence of company size and age on the level of digitalization for implementing intelligent logistics in Macedonian companies. Hence, the hypothesis is:

H1: There is a statistically significant relationship between company size and company age, and the level of digitalization for the implementation of intelligent logistics

The descriptive statistics (Table 1) provide an overview of how different company size and age groups view the impact of digitalization for implementing intelligent logistics in Macedonian companies. Generally, companies that have been operating for more than 20 years consistently show higher average digitalization levels compared to younger companies, suggesting that more established companies may have greater resources, experience, capacity, and level of digitalization to adopt and integrate intelligent logistics. Across different company size categories, the differences in mean values are relatively small, indicating that size alone does not strongly differentiate the level of digitalization for implementing intelligent logistics in companies.

Table 1: *Descriptive Statistics*

Company size	Company age	Mean	Std.Dv	N
from 1 to 10 employees	Up to 5 years	3.38	0.961	13
	10 to 20 years	3.29	1.267	14
	more than 20 years	4.04	0.774	26
	Total	3.68	1.015	53

from 11 to 50 employees	Up to 5 years	3.33	1.155	3
	10 to 20 years	3.25	0.957	4
	more than 20 years	3.70	1.160	10
	Total	3.53	1.068	17
from 51 to 250 employees	Up to 5 years	3.50	2.121	2
	10 to 20 years	3.56	1.130	9
	more than 20 years	3.71	1.139	14
	Total	3.64	1.150	25
more than 250 employees	Up to 5 years	3.11	0.782	9
	10 to 20 years	3.88	1.126	8
	more than 20 years	3.86	0.949	14
	Total	3.65	0.985	31
Total	Up to 5 years	3.30	0.953	27
	10 to 20 years	3.49	1.147	35
	more than 20 years	3.88	0.951	64
	Total	3.64	1.031	126

Source: *Own elaboration*

Table 2 presents Levene's Test for Equality. The p-value of 0.094 indicates that the assumption of homogeneity of variances is not disturbed (since $p > 0.05$). This suggests that variability in responses regarding the level of digitalization for implementing intelligent logistics is consistent across different groups defined by company size, company age, and their interaction. This implies that these grouping variables do not lead to significant differences in the dispersion of responses. It provides further confidence in the robustness and validity of the ANOVA analysis, as the assumption of equal variances across groups is satisfied.

Table 2: *Levene's Test for Equality*

F	df1	df2	Sig.
1.651	11	114	0.094

Source: *Own elaboration*

Result of the two-way ANOVA (Table 3) for the Corrected Model shows that it is not statistically significant ($p = 0.471$). This suggests that, collectively, company size, company age, and their interaction do not explain a significant proportion of the variance in the perceived level of digitalization for implementing intelligent logistics in companies. The result for the intercept shows that it is highly significant ($p = 0.000$), reflecting an overall general tendency in respondents' evaluation of the level of digitalization for implementing intelligent logistics in companies,

independent of company size and age. This result does not imply that the specific age or size groups differ, but rather highlights a general perception. The main effect of company size ($F = 0.103$, $p = 0.958$) and company age ($F = 1.919$, $p = 0.151$) are not significant. This indicates that there are no notable differences in the perceived level of digitalization across different company sizes or age categories. Additionally, the interaction effect between company size and company age is also not significant ($F = 0.511$, $p = 0.799$) suggesting that the combined influence of these two variables does not lead to differing perceptions of digitalization for implementing intelligent logistics in companies. These results imply that the assessment of digitalization levels is relatively uniform across companies, regardless of their size or age. This consistency suggests that other factors, beyond basic company characteristics, may play a more important role in shaping perceptions of the level of digitalization for implementing intelligent logistics in companies.

Table 3: *Tests of Between-Subjects Effects*

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	11.459 ^a	11	1.042	0.978	0.471	0.086
Intercept	975.798	1	975.798	915.791	0.000	0.889
Company_size	0.328	3	0.109	0.103	0.958	0.003
Company_age	4.090	2	2.045	1.919	0.151	0.033
Company_size *Company_age	3.268	6	0.545	0.511	0.799	0.026
Error	121.470	114	1.066			
Total	1805.000	126				
Corrected Total	132.929	125				

Source: *Own elaboration*

Results presented in Table 4 suggest that there are no statistically significant differences in the perceived level of digitalization for implementing intelligent logistics in companies between different company size categories. This indicates that the level of digitalization for implementing intelligent logistics in companies is consistent across all company size categories.

Table 4: *Post Hoc Tests*

(I) Company size	(J) Company size	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
from 1 to 10 employees	from 11 to 50 employees	0.15	0.288	0.954	-0.60	0.90
	from 51 to 250 employees	0.04	0.250	0.999	-0.61	0.69
	more than 250 employees	0.03	0.233	0.999	-0.57	0.64
from 11 to 50 employees	from 1 to 10 employees	-0.15	0.288	0.954	-0.90	0.60
	from 51 to 250 employees	-0.11	0.324	0.986	-0.96	0.74
	more than 250 employees	-0.12	0.312	0.982	-0.93	0.70
from 51 to 250 employees	from 1 to 10 employees	-0.04	0.250	0.999	-0.69	0.61
	from 11 to 50 employees	0.11	0.324	0.986	-0.74	0.96
	more than 250 employees	-0.01	0.277	1.000	-0.73	0.72
more than 250 employees	from 1 to 10 employees	-0.03	0.233	0.999	-0.64	0.57
	from 11 to 50 employees	0.12	0.312	0.982	-0.70	0.93
	from 51 to 250 employees	0.01	0.277	1.000	-0.72	0.73

Source: *Own elaboration*

To further examine potential differences in how companies perceive the level of digitalization for implementing intelligent logistics, a homogeneous subset analysis was conducted (Table 5). The results confirm the previous findings that company size does not play a significant role in shaping perceptions of the level of digitalization for implementing intelligent logistics in companies. All groups are included within a single homogeneous subset, indicating that there are no statistically significant differences between them. This suggests that companies, regardless of their size, share similar views regarding the level of digitalization for implementing intelligent logistics in their operations. In Figure 1, it can be seen that the lines representing different

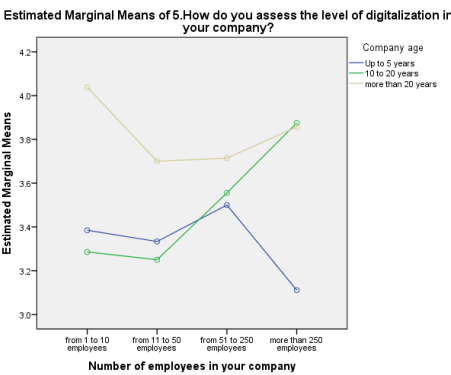
company age groups are relatively close and mostly parallel across the various company size categories. It can be concluded that neither company size nor company age has a significant influence on the perceived level of digitalization for implementing intelligent logistics in companies, nor does the relationship between company size and the level of digitalization differ depending on company age.

Table 5: *Homogeneous Subsets*

Number of employees in your company	N	Subset
		1
from 11 to 50 employees	17	3.53
from 51 to 250 employees	25	3.64
more than 250 employees	31	3.65
from 1 to 10 employees	53	3.68
Sig.		0.952

Source: *Own elaboration*

Figure 1: *Profile Plots*



Source: *Own elaboration*

This interpretation supports the ANOVA results, confirming the absence of a significant interaction effect.

Conclusion

This study examined the implementation of intelligent logistics among companies in RNM and analyzed how organizations at different stages of digital transformation perceive the opportunities and challenges associated with smart logistics adoption. The findings confirm that digital technologies are increasingly recognized as important drivers of operational efficiency, competitiveness, and organizational modernization. Companies that adopt intelligent logistics solutions report benefits related to improved coordination, faster information exchange, greater flexibility, and enhanced decision-making processes. However, the study also reveals that the level of implementation remains uneven across firms, reflecting differences in financial capacity, technological readiness, managerial support, and organizational adaptability.

The results indicate that many companies in RNM still operate within traditional logistics frameworks and face important barriers to digital transformation. Financial limitations, insufficient digital infrastructure, lack of qualified human resources, and resistance to organizational change continue to constrain the broader adoption of intelligent logistics systems. These findings are consistent with previous studies emphasizing that digital transformation in developing and transition economies is influenced not only by technology availability, but also by institutional readiness and strategic management capabilities. At the same time, firms that demonstrate higher levels of digital maturity appear better positioned to respond to market disruptions, optimize logistics processes, and strengthen long-term competitiveness. Beyond operational efficiency, the study highlights the broader role of intelligent logistics in supporting sustainable economic and tourism transformation. Smart logistics solutions such as AI-supported transport optimization, digital inventory management, and integrated mobility systems can contribute to reducing operational inefficiencies, emissions, and resource waste. Consequently, intelligent logistics should be viewed not only as a technological innovation, but also as a mechanism for improving sustainability and supporting environmentally responsible business practices. This is particularly relevant for RNM, where tourism, hospitality, transportation, and export-oriented industries increasingly depend on efficient and sustainable logistics systems.

The study contributes to the growing literature on digital transformation and smart logistics in small developing economies by providing empirical evidence from RNM, a context that remains underrepresented in existing research. The findings may be useful for policymakers, business managers, and industry stakeholders in designing strategies that support digital readiness, technological investment, employee training, and sustainable transformation. Nevertheless, the study has several limitations, including its focus on a single national context and reliance on cross-sectional organizational data. Future research may extend the analysis through comparative regional studies, sector-specific investigations, or longitudinal approaches examining the long-term effects of intelligent logistics adoption on organizational performance and sustainability outcomes.

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