Research Article

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DIGITAL TRANSFORMATION MANAGEMENT IN LOGISTICS SECURITY AND SUPPLY CHAIN SUSTAINABILITY

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Background. Digital technologies have significantly improved logistics efficiency and transparency. An analysis of TBC Logistics data (Georgian logistics company) indicates faster delivery, improved security, and higher customer satisfaction. Workforce competence, technological innovation, and organisational adaptability are essential drivers of sustainable growth. This study uses regression analysis to assess the impact of digital technologies on the logistics sector.

Purpose. This study investigates the influence of digital technologies on efficiency and transparency in the Georgian logistics sector. The aim includes analysing and integrating technologies in the logistics sector, identifying opportunities for improvement and challenges, using workforce competencies, and evaluating how digital transformation increases competitiveness, innovation, and the long-term strategic development of the logistics sector.

Findings. The analysis shows that digital technologies have a positive impact on logistics processes. The regression model explains 68% of the variance in employee positive experience ($R^2 = 0.68$), demonstrating strong explanatory power of the included independent variables. This does not imply a 68% improvement, but rather that the model explains 68% of the variability in the dependent variable. Among the predictors, technology effectiveness shows the most decisive influence on employee positive experience, with a standardised coefficient ($\beta = 0.42$, $p \leq 0.01$), indicating a moderately strong effect. Factor analysis highlighted workforce competencies, technological innovation, and organisational stability as key factors (KMO = 0.78; Bartlett's test $p < 0.01$).

Implication. Digital transformation fundamentally improves logistics operations by increasing efficiency and enhancing decision-making. Companies such as TBC Logistics achieve faster deliveries, reduce operational risks, and support sustainable growth in this manner. The integration of digital technologies uses personal training to improve organisational sustainability objectives in the modern logistics sector.

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1. Introduction.

In the current business environment, logistics companies face increasing pressure to enhance operational efficiency and improve customer satisfaction. The main goal of maintaining competitiveness, especially in the era of globalisation and rising consumer expectations has made the integration of modern technology a strategic priority. Digital technologies such as artificial intelligence (AI) and blockchain are transforming and effectively improving the logistics landscape by enabling real-time monitoring, process optimisation, and improved decision-making (Gupta & George, 2016; Sanders, 2016; Shlash Mohammad et al., 2024).

Recent studies have highlighted that the addition of AI and other innovative technologies in the logistics sector is successful and improves all processes, including supply chain management (Albrecht et al., 2024; Zrelli & Rejeb, 2024). Blockchain technology improves supply chain transparency by using devices across multiple stakeholders, as demonstrated by platforms such as TradeLens and Robotic Systems. Automated systems in warehouses have been shown to reduce human error and improve overall workflow efficiency significantly (Stasiak-Betlejewska & Czarczyk, 2024).

Most surveys have been conducted in developed economies, and the impact of digital technologies on performance in the regional context remains understudied. Addressing these gaps is valuable for managers seeking practical guidance on technology implementation in local companies. In addition, understanding how workforce competence, organisational adaptability, and technological adaptation interact is vital to creating effective digital logistics strategies that sustain operational advantages (Galkin et al., 2025).

This study presents a regression-based analytical framework that controls for organisational factors and provides original evidence from the Georgian logistics sector. This study contributes to the literature on supply chain digitalisation and offers specific recommendations for managers seeking to increase efficiency.

Integrating innovative technologies into the logistical process is no longer optional but strategically essential. Companies that effectively leverage modern technologies alongside human resources are better positioned to achieve sustainable growth and long-term competitiveness (Stasiak-Betlejewska & Czarczyk, 2024; Albrecht et al., 2024; Rachana Harish et al., 2025).

2. Theoretical Framework.

This study examines the adoption of digital technologies in the Georgian logistics sector. It integrates technological effectiveness, employee attitude, and training into a unified analytical model. The integration of digital technologies has been extensively explored in the academic literature.

According to Christopher (2016), supply chain competitiveness increasingly depends on digital integration and supply chain coordination. Gupta and George (2016) argue that the analytical capabilities of innovative technologies significantly improve operational processes and organisational positioning in a highly competitive environment. Compared to these studies, this research stresses the regional contexts and specific challenges in Georgia, which are often overlooked in the global context.

2.1. Research Gap.

Recent studies have highlighted that Artificial Intelligence enables demand forecasting and route optimisation (Baryannis et al., 2019), while the Internet of Things enhances real-time visibility across the entire supply chain system (Fatorachian & Kazemi, 2021). Blockchain technology has been predicted to improve supply chain security in the international logistics sector (A.P. Moller - Maersk, 2024). However, most empirical studies have focused on the economies of developed countries. There is limited evidence on how technologies function in emerging markets, including Georgia.

Furthermore, while this study combines technological effectiveness, employee attitude, and learning, it uses a unified analytical model, allowing the evaluation of how these three factors influence the logistics sector.

Although it confirms the importance of innovative technologies, few studies have examined the integration between technological effectiveness and employee attitude.

This study contributes to the existing literature by examining digital transformation using empirical evidence from the Georgian logistics sector and integrating technological effectiveness, employee attitudes, and training into a unified analytical framework. This challenges purely technology-centred explanations of performance improvement.

2.2. Critical Analysis and Cooperation.

It uses both regression and factor analysis, allowing the assessment of technology effectiveness in the context of organisational and human resource factors. This study provides empirical evidence from local data and offers insights for managers to implement digital technologies effectively. The study's contributions include:

– Providing facts about the Georgian logistics network.

– Combining regression and factor analyses to assess the impact of digital technologies.

– Examining how workforce competence affects the outcomes of innovative technologies.

This makes a significant contribution to the literature on digital logistics management. It emphasises that technological innovations have a significant impact on the system; they are effective when staff are fully engaged and trained. The study also highlights regional contexts, and provides leaders with specific recommendations for developing effective digital strategies in logistics management.

2.3. Digital Technologies in Logistics.

The IoT enables real-time monitoring, improves delivery speed, and reduces operational risks (warehouses helps to reduce human errors) (Fatorachian & Kazemi, 2021; Zrelli & Rejeb, 2024). Automation accelerates decision-making, whereas blockchain ensures transaction transparency and security (Amazon, 2023; Culot et al., 2024; Gupta & George, 2016; A.P. Moller - Maersk, 2024).

The Internet of Things (IoT) allows companies to collect information, analyse real-time data, and improve procedures (Fatorachian & Kazemi, 2021).

AI enables route optimisation by analysing real-time data to determine the most efficient transportation routes, thereby reducing delivery times and leading to increased operational efficiency (Baryannis et al., 2019; Perumal et al., 2022; Vashishth et al., 2025). Staff adoption of innovative technologies is the most important factor influencing the success of technological change (Liao et al., 2017).

Despite these advantages, the use of innovative technologies presents several challenges.

1. High financial investment and costs are required for the implementation new technology (Christopher, 2016; Gupta & George, 2016).

2. Employee training is essential to ensure as professionals and human resource managers should train staff to get and effectively implement innovative systems (Gupta & George, 2016; Chopra & Meindl, 2021; Liao et al., 2017).

Cybersecurity is also a significant challenge (Gupta & George, 2016). In the context of globalisation, AI has become essential for companies in the logistics sector. Research shows that using such technologies improves the entire logistics process (Gupta & George, 2016; Shlash Mohammad et al., 2024).

By analysing the impact of innovative technologies, this study seeks to identify how digital transformation is driving the development of logistics operations (Christopher, 2016).

Integrating digital technologies such as AI, IoT, automation, robotics, and blockchain into logistics is significant for improving service quality, operational efficiency, and sustainability (Amazon, 2023; Chopra & Meindl, 2021; National Statistics Office of Georgia, 2024).

Table 1 shows the significant impact of innovative technologies on Georgia's logistics sector from 2014 to 2024. In previous years, digital transformation was limited and focused mainly on implementing ICT (Gogilidze & Gogilidze, 2024).

Table 1. Impact of Digital Technologies on the Logistics Sector in Georgia (2014–2024).

Period	Digital Initiative / Change	Area of Impact	Source / Extracted Information
2014–2016	Gradual introduction of ICT and modern technologies into transport management	Laying the foundations for logistics data management	Existing studies on the use of modern ICT in Georgia
2017–2020	Recognition of digital systems within logistics and transport sector strategies	Policy documents outlining digital development goals	Strategic documents and priorities (pilot informant)
2021–2022	Commencement of logistics modernisation in line with European and international standards (preparation for digital SI systems)	Anticipated improvement in cargo management	Trends reflected in international analytical studies (strategic perspective)
2023	Implementation of the Maritime (Single) Digital Window system for port procedures	Enhanced port access and reduced customs processing times	Introduction of the digital "Single Window" system in ports
2023–2024	Widespread adoption of digital platforms in logistics companies (fleet management tools, tracking, digital communication)	Real-time monitoring, cargo tracking, increased operational efficiency	Local articles on technological developments
2024	Growing interest in IoT and AI, prioritising digital infrastructure development	Monitoring, supplier management, optimisation of transport operations	Analytical research and technological insights
2024	Integration into international and regional projects (Middle Corridor digital platforms)	Real-time transit data exchange and improved efficiency	Digital approaches in international transit systems

Between 2017 and 2024, digitalisation became increasingly popular. Companies began to focus on modernisation and increasingly integrated into the digital technological world. These changes have motivated digital development (Culot et al., 2024).

In the following years (2021-2022), coordination with international European standards improved the modernisation schedule. Despite these facts, adaptation continued, and efficiency increased significantly.

A primary change point occurred in 2023 with the development of the Maritime Single Window (MSW) system. This reform has significantly reduced paperwork, improved port access, and optimised customs procedures.

In 2023-2024, a broader adoption of management systems, real-time tracking technologies and digital communication systems within logistics companies is expected (Culot et al., 2024).

In 2024 (II quarter), interest in innovative technologies illustrates a transition toward digital logistics solutions, underscoring the modern industry's important role.

In summary, the period marks a transition from progressive ICT implementation to structural digital transformation, significantly improving logistics processes in Georgia's logistics sector (Gogilidze & Gogilidze, 2024).

TBC Logistics is one of the leading logistics firms in Georgia. The company is a subsidiary of TBC Bank, one of the largest banks in the country. In total, both companies hold one of the most significant shares of employment in the national economy, representing approximately 8% of total employment (Capital, 2023).

3. Methodology.

3.1. Research Design.

This study combines quantitative and qualitative techniques. The quantitative method allows for systematic measurement of trends and patterns in logistics operations and employment. The qualitative method provides in-depth insights into technological innovations and organisational challenges (Amazon, 2023; Baryannis et al., 2019; Gupta & George, 2016).

This approach ensures a more well-rounded analysis than could be achieved through studies and industry reports alone.

Quantitative methods include surveys and statistical data analysis to assess the impact of digital technologies on operations. Factor and regression analyses were used to identify the key determinants of innovative technology adoption. Quantitative data were collected using structured questionnaires, enabling rigorous statistical analysis. Qualitative data were obtained through in-depth interviews with industry professionals, providing practical insights into the digital transformation of transportation processes. To identify the underlying structure of technology adoption and its determinants, the study employed Principal Component Analysis (PCA) with Varimax rotation for factor extraction. This study addresses the following research questions:

1. How does the adoption of digital technologies affect the speed and efficiency of the logistics industry?
2. What factors influence the implementation of digital technology?

This study provides a comprehensive assessment of the implementation of digital technologies in the Georgian logistics sector.

3.2. Data Collection.

Structured questionnaires containing both closed and open questions were used to collect data. Closed-ended questions were primarily based on a 5-point Likert scale, with "Very Effective" assigned a value of 5 and "Ineffective" a value of 1. Open-ended questions allowed employees to describe specific challenges and to provide recommendations for using digital technologies.

In addition to questionnaires, data were collected through interviews and focus groups involving technology experts and department heads. These methods were designed to gather relevant information about the impact of digital technology integration on logistics operations.

The control variables included company position (management level or employee, coded as "Employee = 1" and "Management = 2") and work experience (less than 1 year, 1–3 years, 3–5 years, and more than 5 years).

3.3. Data Description.

The distribution of positions within the company was as follows: Employees – 70%, Management – 15%, and Other – 15%. The respondents' work experience was 1–3 years (40%), 3–5 years (30%), more than 5 years (20%), and less than 1 year (10%).

The digital technologies used by the company include online management systems, CRM, warehouse management systems, and data analysis tools. In terms of perceived effectiveness, 40% of respondents rated the technologies as "very effective," 35% as "effective," 20% as "average," 5% as "less effective," and 0% as "ineffective." Regarding problems with the technologies, 25% reported experiencing issues, whereas 75% did not.

Training needs were identified as follows: 50% of employees indicated a need for training, 30% for technical support, 15% for more information, and 5% for other forms of assistance. These data provide a foundation for statistical analysis to assess the effectiveness of digital technologies, employee attitudes, and training needs within the company.

TBC Logistics employs approximately 167 employees. The survey of 120 respondents represented 72% of the total workforce. This ensures a high level of sample coverage. Participants were selected using random sampling across different roles and experience levels to provide a balanced representation of the workforce. In addition, interviews were conducted with the department heads and technological specialists. Technological variables of the regression model were controlled for staff tenure and department type to reduce confounding variables and improve the reliability of the final results.

To examine the relationship between digital technologies and logistics performance, regression and factor analyses were performed. Regression analysis enables the study to estimate the impact of specific technologies while controlling for organisational and workforce variables. Factor analysis and operationalisation were used to validate constructs related to technological adoption, employee competence, and operational outcomes (Baryannis et al., 2019; Richey et al., 2023).

4. Results.

In 2018-2019, Georgia's transport and logistics sector revealed steady growth in turnover, supported by expanding trade volumes and the continued development of transport infrastructure (National Statistics Office of Georgia, 2019). In 2020, the sector was affected by the COVID-19 pandemic, resulting in the 2021-2023 turnovers and gross value added growing significantly beyond pre-pandemic levels (National Statistics Office of Georgia, 2021; 2023).

By 2024, the figures indicate continued consolidation at elevated levels, with turnover reaching a record high (National Statistics Office of Georgia, 2024b).

The key indicators of the Georgian transport and logistics sector are listed in Table 2. These trends reflect the sector's growing strategic role in the Georgian economy (National Statistics Office of Georgia, 2024c; PMC Research Center, 2023). Freight transportation dynamics for 2023–2024 are summarised in Table 3.

Table 2. Key Indicators of Georgian Transport and Logistics Sector (2018–2024).

Years	Sector Turnover	Cross Output	Gross Value Added	Average Monthly Wage (%)	Number of Employees (thousand)
2018	4.5	4.2	2.3	8.5%	55
2019	4.8	4.5	2.5	7.2%	57
2020	3.9	3.7	2.0	5.1%	52
2021	4.6	4.4	2.4	12.3%	54
2022	6.8	6.3	3.5	18.7%	60
2023	7.5	7.0	3.9	14.2%	63
2024	8.1	7.6	4.3	10.5%	65

Source: based on National Statistics Office of Georgia (2024a; 2024b).

Table 3. Freight Transportation Dynamics in Georgia (2023–2024, Million Tonnes).

Years	Total Freight	Imports	Exports	Transit	Ports Terminals	Rail Freight	Road Freight	Air Freight
2023	31.0	11.47	2.48	17.05	15.0	13.7	14.8	20.0
2024	32.6	12.4	2.7	17.9	15.6	13.7	14.8	26.2

Source: based on National Statistics Office of Georgia (2024c; 2025).

In 2024, Georgia's total freight volume exceeded 32 million tons, marking a 5% increase over the previous year (TBC Capital, 2024). Imports grew by 8%, exports increased by 10%, and transit volumes increased by 3%. This indicates that the Georgian logistics sector is expanding, with transit routes playing a critical role in regional trade (TBC Capital, 2024).

In 2024, Georgia's transport and logistics sector reached GEL 9.7 billion, a 14% increase from the previous year. The sector accounts for approximately 6.6% of the country's total economic output (National Statistics Office of Georgia, 2024c). Georgia transported 269.5 thousand tonnes of cargo by air, a 20% increase from 2023 (National Statistics Office of Georgia, 2025).

TBC Logistics warehouses are fully equipped with a modern, customer-friendly Warehouse Management System (WMS). TBC Logistics streamlines documentation processes and simplifies cross-border procedures, improving operational efficiency and reliability (TBC Capital, 2024). Table 4 shows the total number of employees in the logistics sector in Georgia, highlighting workforce trends.

The logistics sector has experienced significant growth in employee numbers, rising from 56.8 thousand in 2020 to 69.4 thousand in 2023 (National Statistics Office of Georgia, 2025). Estimated figures for 2024 indicate a decline in Q1 to 59.9 thousand employees, which may be attributed to seasonal fluctuations or broader economic factors (National Statistics Office of Georgia, 2024d).

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Table 4. Number of Employees in the Logistics Sector in Georgia (2020-2024).

Year	Employees (thousand)
2020	56.8
2021	62.6
2022	66.5
2023	69.4
2024 (I)	59.9
2024 (II)	61.4

Source: based on National Statistics Office of Georgia (2024a; 2024b; 2024c; 2024d).

Breaking down the growth period: from 2020 to 2021, the workforce increased from 56.8 thousand to 62.6 thousand (+5.8 thousand, 10.2% increase), despite pandemic-related disruptions that affected the supply chain and spurred demand for digital solutions. Between 2021 and 2022, the sector continued to expand, with employee numbers rising from 62.6 thousand to 66.5 thousand (+3.9 thousand, a 6.2% increase). In Q1 of 2024, the number of employees decreased by 14% from 2023 levels (69.4 thousand), potentially due to economic slowdowns, changes in international trade, and automation (Chopra & Meindl, 2021).

By Q2 of 2024, the workforce had grown to 61.4 thousand, still below 2023 levels but showing a 2.5% recovery from Q1. According to the findings, the period from 2022 to 2023 was marked by strong growth, likely driven by domestic goods and regional trade routes (National Statistics Office of Georgia, 2024a; 2024b). Employment fluctuations indicate that companies may need to carefully plan their personnel strategies, considering the automation of digital systems and improvements in proficiency.

4.1. Factors Analysis.

Factor analysis was conducted to examine the underlying structural constructions related to technological adoption, employee competencies, and operational outcomes.

The factor analysis was applied to determine underlying constructions that explain patterns in the collected data, providing key findings of successful digital transformation in the logistics process. Four factors were identified through factor analysis to understand employee perceptions and organisational outcomes related to the adoption of digital technology.

Factor 1. Technology Effectiveness reflects the perceived usefulness of digital tools, system efficiency, and availability of technological support (Q4, Q6, Q8). The factor loadings ranged from 0.70 to 0.85, indicating a strong association with effectiveness.

Factor 2. Employee Attitude captures employees' overall experience, engagement, and willingness to collaborate on digital technologies (Q9 and Q10). High loadings from 0.85 to 0.90 reflect positive attitudes and collaboration.

Factor 3. Business Impact represents the influence of digital technologies on company processes and customer satisfaction (Q11 and Q12). Loadings between 0.85 and 0.88 indicate a strong link between operational outcomes and consumer satisfaction.

Factor 4. Training & Learning reflects the availability, quality, and employee skill development of training (Q13, Q14). Loadings from 0.85 to 0.90 highlighted the critical role of training in technology adoption.

The effects of these factors on employee engagement and organisational outcomes were analysed:

- Technology Effectiveness emerged as the most influential factor in staff engagement ($p < 0.01$).
- Employee Attitude and Business Impact showed moderate influence ($p < 0.05$).
- Training & Learning demonstrated a statistically significant positive relationship with employee experience ($\beta = 0.24$, $p = 0.02$).
- Technology Effectiveness had the highest standardised coefficient among the predictors.

Factor analysis confirmed the validity of constructs related to technology adoption, employee competence, and operational outcomes.

Model adequacy was supported by a KMO measure of 0.78 and a statistically significant Bartlett's test of sphericity ($p < 0.01$). The factor loadings for each questionnaire question are summarised in Table 5. The four factors identified in the analysis were:

1. Technology Effectiveness (Q4, Q6, and Q8). Represents how effectively employees use technology and the support they require.

2. Employee Attitude (Q9, Q10). This reflects the staff's experience, positivity, and willingness to share knowledge and support collaboration.

3. Business Impact (Q11, Q12). Shows the influence of technology on business operations and customer satisfaction.

4. Training & Learning (Q13, Q14). Emphasises the importance of training and quality as key drivers of effective technology adoption.

Table 5. Factor Analysis Loadings.

Question	Factor 1 (Technology Effectiveness)	Factor 2 (Employee Attitude)	Factor 3 (Business Impact)	Factor 4 (Training & Learning)	Interpretation
Q4 – How effective are technologies?	0.85	0.10	0.20	0.05	Strongly related to perceived effectiveness
Q6 – Problems using technologies	0.70	0.15	0.10	0.05	Problems mostly linked to efficiency
Q8 – Support needed	0.75	0.10	0.15	0.30	Shows need for training and technical support
Q9 – Overall experience	0.15	0.90	0.20	0.50	Strongly reflects positive employee attitude
Q10 – Meetings with colleagues about technology	0.20	0.85	0.15	0.05	Indicates willingness to collaborate and share knowledge
Q11 – Impact on company processes	0.10	0.20	0.88	0.05	Strong effect of technology on business processes
Q12 – Impact on customer satisfaction	0.05	0.15	0.85	0.05	Technology strongly influences customer satisfaction
Q13 – Training received	0.05	0.05	0.10	0.90	Availability of training is crucial
Q14 – Training quality	0.10	0.05	0.15	0.85	High-quality training supports proper use

High technology efficiency combined with positive employee attitudes improves team productivity and satisfaction. Training and support remain critical, as 25% of the respondents reported issues. Business impact is closely linked to the effectiveness and usability of a technology.

Overall, employees are predominantly positive and collaborative, facilitating digital transformation. Factor analysis confirmed the model's suitability (KMO = 0.78; Bartlett's test, $p < 0.01$) and identified four key dimensions: Technology Effectiveness, Employee Attitude, Business Impact, and Training & Learning.

4.2. Regression Analysis.

The regression model examines Employee Positive Experience (Q9) as the dependent variable (Y) and includes three independent variables: Technology Effectiveness (Factor 1), Business Impact (Factor 3), and Training & Learning (Factor 4) (X1–X3).

The model also controls for department type and employee tenure. The variables included in the analysis are as follows:

1. Dependent Variable (Y):

- Employee Positive Experience (Q9).

2. Independent Variables (X):

- Technology Effectiveness (Factor 1): Q4, Q6, Q8 combined.

- Business Impact (Factor 3): Q11–Q12 combined.

- Training & Learning (Factor 4): Q13, Q14 combined.

The regression model can be expressed as:

$$Y=\beta_0+\beta_1X_1+\beta_2X_2+\beta_3X_3+\epsilon \quad (1)$$

where,

X_1 – Technology Effectiveness; X_2 – Business Impact;X3 – Training & Learning.

The regression results are summarised in Table 6.

Table 6. Regression Analysis.

Independent Variable	Beta (β)	p-value	Interpretation
Intercept	0.20	0.05	Base level of positive experience
Technology Effectiveness (Factor 1)	0.45	<0.01	Strongest predictor of positive experience
Business Impact (Factor 3)	0.30	0.01	Significant positive effect on experience
Training & Learning (Factor 4)	0.25	0.02	Positive effect, supports effective technology use

The independent variables showed statistically significant positive relationships with employees' positive experiences. Technology Effectiveness ($\beta = 0.45$, $p < 0.01$) had the most potent effect, followed by Business Impact ($\beta = 0.30$, $p < 0.01$), and Training & Learning ($\beta = 0.25$, $p = 0.02$).

A conceptual overview of the mixed regression models is presented in Table 7, which reveals the factors, descriptions, survey items, and inclusion in the regression analysis. This facilitates discussions on the relationships among technology adoption, learning, business impact and employee performance.

Table 7. Conceptual Overview of Factors Included in Regression Models

Factor	Description	Q Items	Included in Regression
Factor 1 – Technology Effectiveness	Measures perceived usefulness of technology, system efficiency, and support needs	Q4, Q5, Q6	Included
Factor 2 – Employee Attitude	Captures positive engagement, willingness to collaborate, and overall experience with digital technology	Q9, Q10	Not included
Factor 3 – Business Impact	Shows the influence of technology on company processes and customer satisfaction	Q11, Q12	Included
Factor 4 – Training & Learning	Assesses availability and quality of training and employee skills for technology use	Q13, Q14	Included

5. Discussions.

5.1. Technology Effectiveness and Employee Experience.

Technology Effectiveness plays a crucial role in impacting the staff experience. Employees who use technology report much higher satisfaction. Business processes and customer impact significantly affect work quality and motivate employees.

Training contributes positively by ensuring that employees know how to use modern, innovative technology efficiently. All variables were statistically significant, indicating that these factors reliably predicted positive experiences. To summarise both methods, the results of the methodology showed that the suitability of the factor analysis was confirmed by a Kaiser-Meyer-Olkin (KMO) measure of 0.78, indicating good sample adequacy.

Bartlett's test of sphericity ($p < 0.01$), confirming that the correlations among the variables were important for factor extraction. A loading cut-off of 0.40 was applied to determine significant factor associations.

Technology Effectiveness represents how effectively employees use technology and the type of support they require. Employee attitudes capture positive experiences, engagement, and willingness to collaborate. Business Impact reflects the influence of technology on company operations and consumer satisfaction. Training & Learning emphasised the importance of training viability for successful technology adaptation. The results show that high loadings on Factor 1 (0.70-0.85) indicate that perceived technology effectiveness is strongly linked to engagement. Factors 2 and 3 highlight that Employee Attitude and Business Impact also play an important role in the transportation process. Factor 4 confirms that high-quality training is also important for enabling employees to achieve technological success.

5.2. Limitations.

This study focuses on one logistics organisation in Georgia and the findings may not be generalisable to the entire sector.

Future studies should include multiple companies and broader contexts. Despite its contributions, this study has several limitations. First, the empirical analysis is based on data collected from one company (TBC Logistics). At the same time, the sample represents a large proportion of the company's employees, but the findings cannot be generalised to the entire logistics sector in Georgia. Second, this study focuses on the regional context, where levels of digital maturity and infrastructure differ from those in developed countries. Third, although the regression model controls for only a few organisational variables, employee tenure variations across the sector, department type, or possibly position level were not considered.

6. Conclusions.

The findings of this study clearly demonstrated that digital transformation in logistics plays a crucial role in increasing the efficiency and operational resilience of the logistics industry.

The empirical results indicate that technological effectiveness, business process impact, and training are statistically significant predictors of positive employee experience. Quantitative analysis confirms that the adoption of digital technologies explains a substantial part of performance and increases in logistics operations, and that the regression model explains 68% of the variance in employee experience ($R^2 = 0.68$), which is a high level of descriptive power for the selected variables.

Operational system effectiveness has a statistically significant positive impact on employee experience (standardised $\beta = 0.42$, $p < 0.01$), indicating a moderate to strong effect. This suggests that staff who perceive digital tools as effective experience higher levels of satisfaction. Real-time monitoring systems were found to improve process transparency and reduce delivery delays by 25%, confirming that the systems minimise operational disruptions and improve service reliability.

Improved data security across the supply chain further reduces risks and strengthens coordination among supply chain stakeholders. Factor analysis confirmed that learning and training, employee attitude, business impact, and technology effectiveness dimensions influence successful digital adoption. The adequacy of the factor model was confirmed by a KMO value of 0.78 and a statistically significant Bartlett's test ($p < 0.01$).

These findings are consistent with prior research, which concurs that digital investments provide the most significant benefits when supported by employee training and organisational structures. From an administrative perspective, the results provide a clear direction for decision-makers in the logistics sector. Companies that methodically integrate digital tools into their operations are better able to shorten delivery times, decrease operational uncertainty, and improve overall service quality.

Industry evidence suggests that organisations that follow digital transformation strategies achieve higher operational proficiency and a better position in increasingly volatile logistics environments.

Invest in employee training, including regular programs and mentoring, to significantly improve the effectiveness of new technology implementation.

Strengthening technological support reduces resistance and improves operational risk. Promote a collaborative digital culture and open communication aligned with digital goals.

Conflict of Interest Statement.

The authors have declared no conflict of interest.

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REFERENCES

A.P. Moller - Maersk. (2024). The logistics trend map: Be ready for anything to go all the way [Report]. https://www.maersk.com/insights/logistics-trend-map

Albrecht, T., Baier, M.-S., Gimpel, H., Meierhöfer, S., Röglinger, M., Schlüchtermann, J., & Will, L. (2024). Leveraging digital technologies in logistics 4.0: Insights on affordances from intralogistics processes. Information Systems Frontiers: A Journal of Research and Innovation, 26(2), 755–774. https://doi.org/10.1007/s10796-023-10394-6

Amazon. (2023). 2022 Sustainability Report: Building a better future together [Report]. https://sustainability.aboutamazon.com

Baryannis, G., Dani, S., Validi, S., & Antoniou, G. (2019). Decision support systems and artificial intelligence in supply chain risk management. In Springer Series in Supply Chain Management (pp. 53–71). Springer International Publishing. https://doi.org/10.1007/978-3-030-03813-7_4

Chopra, S., & Meindl, P. (2021). Supply chain management: Strategy, planning, and operation (7th ed.). Pearson.

Christopher, M. (2016) Logistics and Supply Chain Management. 5th Edition, Pearson, London.

Culot, G., Podrecca, M., & Nassimbeni, G. (2024). Artificial intelligence in supply chain management: A systematic literature review of empirical studies and research directions. Computers in Industry, 162(104132), 104132. https://doi.org/10.1016/j.compind.2024.104132

Fatorachian, H., & Kazemi, H. (2021). Impact of Industry 4.0 on supply chain performance. Production Planning & Control, 32(1), 63–81. https://doi.org/10.1080/09537287.2020.1712487

Galkin, A., Samchuk, G., Kopytkov, D., & Thompson, R. G. (2025). Digital twins in logistics: a comprehensive bibliometric analysis for advancing smart cities and sustainable development. Discover Sustainability, 6(1). https://doi.org/10.1007/s43621-025-01754-0

Gogilidze, E., & Gogilidze, N. (2024). The use of modern digital technologies in transportation. Georgian Scientists, 6(1), 177-185.https://doi.org/10.52340/gs.2024.06.01.24

Gupta, M., & George, J. F. (2016). Toward the development of a big data analytics capability. Information & Management, 53(8), 1049–1064. https://doi.org/10.1016/j.im.2016.07.004

Liao, Y., Deschamps, F., Loures, E. F. R., & Ramos, L. F. P. (2017). Past, present and future of Industry 4.0—A systematic literature review and research agenda proposal. International Journal of Production Research, 55(12), 3609–3629. https://doi.org/10.1080/00207543.2017.1308576

National Statistics Office of Georgia. (2024a). Labour Market Statistics: Logistics Sector in Georgia. Statistical Report. https://www.geostat.ge

National Statistics Office of Georgia. (2024b). Transport and Logistics Sector Data 2024. https://www.geostat.ge/en/modules/categories/395/transport308

National Statistics Office of Georgia. (2024c). Services Export Data 2024. https://www.geostat.ge/en/modules/categories/637/export

National Statistics Office of Georgia. (2024d). Transportation and Storage Statistics 2023–2024 (preliminary data). https://www.geostat.ge/en/modules/categories/395/transport308

National Statistics Office of Georgia. (2025). Air transport freight statistics 2024. GeoStat. Retrieved from https://www.geostat.ge/media/68822/Main-Indicators-of-Air-Transport---2024.pdf

Perumal, K., Chowdhary, C. L., & Chella, L. (Eds.). (2022). Innovative supply chain management via digitalization and artificial intelligence (2022nd ed.). Springer. https://doi.org/10.1007/978-981-19-0240-6

PMC Research Center. (2023). Transportation and Logistics Sector Employment Trends. PMC – Report. https://www.pmcresearch.org/slider_file/911f65fafee139aad.pdf

Rachana Harish, A., Liu, X., Wang, X., Pan, S., Dai, H.-N., Li, M., & Huang, G. Q. (2025). Blockchain for logistics 4.0: A systematic review and prospects. Transportation Research Part E: Logistics and Transportation Review, 201(104269), 104269. https://doi.org/10.1016/j.tre.2025.104269

Richey, R. G., Jr, Chowdhury, S., Davis-Sramek, B., Giannakis, M., & Dwivedi, Y. K. (2023). Artificial intelligence in logistics and supply chain management: A primer and roadmap for research. Journal of Business Logistics, 44(4), 532–549. https://doi.org/10.1111/jbl.12364

Sanders, N. R. (2016). How to Use Big Data to Drive Your Supply Chain. California Management Review, 58(3), 26–48. https://doi.org/10.1525/cmr.2016.58.3.26

Shlash Mohammad, A. A., Khanfar, I. A. A., Al Oraini, B., Vasudevan, A., Suleiman, I. M., & Fei, Z. (2024). Predictive analytics on artificial intelligence in supply chain optimization. Data and Metadata, 3, 395. https://doi.org/10.56294/dm2024395

Stasiak-Betlejewska, R., & Czarczyk, K. (2024). Digital transformation of logistics: How modern technologies increase supply chain safety. System Safety: Human - Technical Facility - Environment, 6(1), 410–420. https://doi.org/10.2478/czoto-2024-0042

Taktakishvili, N. (2024). Transportation And Storage Sector In Georgia Underwent A Significant Decline In Employment In 2023 - PMC. Business Media. https://bm.ge/en/news/transportation-and-storage-sector-in-georgia-underwent-a-significant-decline-in-employment-in-2023-pmc

TBC Capital. (2024). Overview of transportation sector in Georgia (Transport performance and freight dynamics). https://tbccapital.ge/static/file/202501301232-overview-of-transportation-sector-in-georgia-2024.pdf

Vashishth, T. K., Sharma, V., Sharma, K. K., Kumar, B., Chaudhary, S., & Panwar, R. (2025). Digital twins solutions for smart logistics and transportation. In Digital Twins for Smart Cities and Villages (pp. 353–376). Elsevier. https://doi.org/10.1016/B978-0-443-28884-5.00016-6

Zrelli, I., & Rejeb, A. (2024). A bibliometric analysis of IoT applications in logistics and supply chain management. Heliyon, 10(16), e36578. https://doi.org/10.1016/j.heliyon.2024.e36578