

TRANSPORT AND LOGISTICS SYSTEM QUALITY ENGINEERING IN THE CONTEXT OF THE FIFTH INDUSTRIAL REVOLUTION

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ABSTRACT

The research aims to develop scientific and methodological recommendations for the application of digital technical tools in quality management of transportation and logistics services in the context of the Fifth Industrial Revolution using manufacturing engineering. For this purpose, service quality and transport performance are examined. To this end, it reviews and comprehensively analyzes leading international experience in service quality management among European, American, Japanese, and Chinese transportation and logistics companies in the context of the Fifth Industrial Revolution. As a result, an innovation is proposed for the provision of high-technology transportation and logistics services, consisting of supplementing this practice with engineering and technical support aimed at maximizing service quality. The research examines the modernization of transportation logistics as a factor in improving the technical quality of products and enhancing global competitiveness. A comprehensive set of digital technical tools for managing the quality of transportation and logistics services in the context of the Fifth Industrial Revolution using manufacturing engineering is developed. It is emphasized that logistics infrastructure affects product integrity, timeliness, and reliability of deliveries, and a company's ability to maintain declared product specifications in international markets. The engineering approach makes it possible to link logistics modernization with reduced quality losses, improved supply chain controllability, and stronger competitive advantages. The innovative scientific and practical developments presented in this article will facilitate the incorporation of logistics solutions into the overall architecture of quality management.



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1. INTRODUCTION

The technical quality of products in the global economy depends not only on how a product is manufactured but also on how it is transported, stored, and delivered to the end consumer. Therefore, the modernization of transportation logistics should be regarded as an element of the engineering quality assurance system rather than as an external service function. Violations of delivery schedules, temperature requirements, routing procedures, and cargo handling conditions can negate a product's technological advantages even after production, while logistics modernization can reduce quality losses during transportation, improve delivery accuracy, and decrease logistics downtime (Ju et al., 2025).

Industrial and manufacturing engineering is applied in the construction of high-technology transportation and logistics infrastructure facilities, but is not commonly used in the provision of transportation and logistics services, which constrains improvements in the quality of these services. The problem stems from the fact that, in connection with the Fifth Industrial Revolution, transportation and logistics services are undergoing technological modernization that periodically occurs in rapid leaps (Ashraf et al., 2025).

The accelerated introduction of smart automation tools into transportation and logistics service delivery creates a risk of declining service quality because smart automation systems may experience failures and be used inefficiently without adequate engineering support and comprehensive technical maintenance (Sun and Cai, 2024).

Transport and logistics services are used by the main sectors of the economy, the infrastructural sectors, and the population. The modern approach to quality management in the transport and logistics sector is predetermined by a gradual transition to the goals of the Fifth Industrial Revolution, associated with human-centrism and ecologization, which constitute the basis of digitalization. These aspects become the key social, environmental, and technological indicators of the quality of transport and logistics services. Accordingly, when promoting them in markets, operators of the transport and logistics sector focus on the fact that their offer is beneficial for those who are aware of and support sustainable practices (Drejeris et al., 2024).

Intellectual digitalization in the 2020s is a component of society and the economy's course towards the Fifth Industrial Revolution. It differs somewhat from digitalization peculiar to the Fourth Industrial Revolution, which was connected with the priority of the use of digital technologies to satisfy consumer demand and achieve manufacturers' goals (market positions, growth of revenue, and reduction of costs through automation). The Fifth Industrial Revolution links the strategies of development of companies from the main

sectors of the economy with the Sustainable Development Goals, focusing on continuous technological progress, given the necessity for adopting sustainable solutions at each stage of product value creation.

The quality of transport and logistics services in the conditions of the Fourth Industrial Revolution is based on such parameters as a high level of services and cost-effectiveness, connected with the application of digital technologies. In the conditions of the Fifth Industrial Revolution, these properties are supplemented by human-centrism (creation of a decent quality of life for labor resources and consideration of consumer expectations) and environmental friendliness (Lin et al., 2023). In the context of expected revenue and profit, cost-effectiveness remains the key priority, which ensures the sustainability of development and the sense of economic activities (Matevosyan et al., 2024).

Analysis of digital tools allows for determining the structure of technological support of service quality management at the stage of formation of the Fifth Industrial Revolution. The purpose of this paper was to classify and assess the features of using digital tools for managing the quality of transport and logistics services in the conditions of the Fifth Industrial Revolution. We studied transport and logistics companies and identified which leading practices allow revealing the most effective digital tools in the management of provided services. Also, we evaluated the correspondence of the structure of these tools to the concept of the Fifth Industrial Revolution.

The novelty of this research lies in the proposed innovation for addressing the identified problem: supplementing the provision of high-technology transportation and logistics services with engineering and technical support aimed at maximizing service quality. The research aims to develop scientific and methodological recommendations for the use of digital technical tools in quality management of transportation and logistics services in the context of the Fifth Industrial Revolution through the application of manufacturing engineering.

2. CONCEPT OF SERVICE QUALITY AND TRANSPORT PERFORMANCE

The research is conducted in accordance with the scientific concept of industrial and manufacturing engineering in the transportation and logistics sector, as presented in the literature by Hatika et al. (2026), Vadivukarasi et al. (2026), Wang et al. (2026), and Yang et al. (2026), which provides a solid theoretical foundation for this research.

The quality management mechanism currently applied to transportation and logistics services is described in the published works of AlQadi et al. (2025), Chen et al.

(2025), Nicoletti and Appolloni (2025), and Shen et al. (2025). It primarily includes nontechnical tools aimed at expanding the range of available transportation and logistics schemes, improving the convenience of accessing electronic transportation and logistics services (from online ordering to remote tracking of goods deliveries), and developing the communication capabilities of artificial intelligence underlying online consultants and chatbots used by transportation and logistics companies.

Lin et al. (2023) analyzed strategic aspects of the Mobility 5.0 program, promoted by governments, professional communities, and the academic environment, as the basis for integrating the provisions of the industrial revolution into the management of transport and logistics activities. The scholars note that the key components of this program are wireless charging technology, used for electric cars, which ensures effectiveness, speed, and convenience; air mobility, achieved with the help of drones, for quick and convenient delivery of cargoes and/or monitoring of transport movement; planning of processes and distribution of infrastructure based on big database analysis; green energy, ensuring reduction in CO₂ emissions from the activities of transport and logistics companies; digital solutions based on the Internet of Things, contributing to constant monitoring of the quality of deliveries; digital information systems of traffic jam management, relying on computer vision, big data analysis, machine learning, etc.

Rihawi (2025) provided insights into the effects of digital logistics solutions on the effectiveness of transport and logistics companies' activities and customer satisfaction with such parameters of quality as speed and precision in completeness of goods. The scholars note that these results could be achieved with the help of such digital tools as VoiceCommand (a digital information and robotized system for selecting products with the help of voice) and SmartCheck (a digital monitoring and information system for constant audit of stock, which allows avoiding mistakes due to human factor).

Cichosz et al. (2020) identified the list of barriers and stimuli for implementing digital tools into the activities of network companies that provide transport and logistics services around the world. According to the authors, network companies include all subjects of this market, given the existence of branches and subsidiaries in countries where they conduct their economic activities. The key barriers include difficulties in mastering digital technologies in companies that use services of small contractors, which cannot ensure digital readiness of employees; labor resources' reluctance to use digital smart solutions; lack of coordination between the departments that implement IT in the work of network transport and logistic companies; financial difficulties, which include problems with receipt of loans for purchase and/or development of digital solutions and

absence of skilled personnel with the high level of digital readiness. According to the researchers, the main stimuli for the implementation of digital technologies are personnel's reluctance to develop and master new digital technologies and strategic support of companies' course towards digitalization.

Zrelli and Rejeb (2024) presented a classification of digital applications integrated with the Internet of Things and digital sensors in the supply chain management and logistics, and stated that the use of these digital means ensures security and cost-effectiveness. Sozinova et al. (2023) considered the contribution and developed recommendations for the management of intellectual economic growth in the knowledge economy for the development of international trade in modern global markets. Moldabekova et al. (2021) dwelt on the features of digital technologies in logistics in the context of the Industry 4.0 concept and on differences between tools that were acceptable for Industry 4.0. These tools include computer vision, cloud computing, and big data analysis. Albrecht et al. (2024) studied robots, which have been actively used since the beginning of the Fourth Industrial Revolution. The focus on prioritizing the security of transport services, supported by the capabilities of digital innovative solutions, is emphasized by da Motta Reis et al. (2024).

Maxyutova et al. (2022) aimed at studying the problems of labor markets in Central Asian countries, which are largely predetermined by the influence of the Fourth Industrial Revolution in all spheres of the economy and social sector. This research confirmed the beliefs of most researchers that principles of the Fourth Industrial Revolution are aimed at supporting consumers and manufacturers, but ignore the interests of labor resources. Tiwari and Prasad (2024) justified approaches to building the models of smart management of transport flows based on machine learning, neural modeling, big data analysis, and mathematical methods. The authors' approach contains important recommendations that can be considered during the development of digital systems of management and monitoring of transport and logistics flows. Gundala and Domakonda (2024) substantiated the method of reducing the emissions of gasoline-alcohol-based nanofuels, which can be used in digital solutions based on machine learning.

3. METHODOLOGY FOR DEVELOPING A NEW APPROACH TO ENSURING SERVICE QUALITY AND TRANSPORT PERFORMANCE

The review of the available research literature on the topic revealed a gap associated with the insufficient examination and resulting uncertainty regarding the opportunities and technical frameworks for applying industrial and manufacturing engineering to the quality management of transportation and logistics services. The logic of this research envisages the assessment of the

digital tools for managing the quality of transport and logistics services. The order of this research is as follows.

- 1) Identification of the largest subjects of the market of transport and logistics services, which have potential for using the leading digital tools that can manage service quality in the context of the Fifth Industrial Revolution. This stage involves the use of the rankings method and comparative analysis, as well as qualitative evaluation.
- 2) Determination of the list of digital tools and assessment of the effectiveness of their influence on the management of transport and logistics services' quality. This stage involves analysis of corporate data regarding digital tools and the content analysis of scholarly sources to find the types of digital tools. Functional analysis was used to reveal the functional purpose of digital tools applied in the activities of the sector's subjects.
- 3) Assessing the correspondence of the applied digital tools to the paradigm of the Fifth Industrial Revolution. We tried to find out how their application allows companies to perform social and environmental responsibilities given in the provisions of the corporate strategy of development. Here, we used the comparative method to determine the factual achievement of the established corporate goals in the sphere of sustainable development, conforming to the principles of the Fifth Industrial Revolution.

Our approach is characterized by the focus on the assessment of each digital tool in the context of its effect on the achievement of the principles of the Fifth Industrial Revolution.

We considered the specifics of digital tools of the selected leading companies in the transport and logistics sector. The theoretical and empirical substantiation of the issues of improvement of the management of transport and logistics services' quality in the context of the Fifth Industrial Revolution, presented in the modern scholarly works, enabled us to establish the key digital tools used for this purpose.

4. NEW APPROACH TO ENSURING SERVICE QUALITY AND TRANSPORT PERFORMANCE

4.1 Quality Management of Transportation and Logistics Services in the Context of the Fifth Industrial Revolution

The global market of transport and logistics services is transforming under the influence of external and internal factors, which have different effects on the satisfaction of consumer demand and the market actors' functioning. During the COVID-19 pandemic and in the post-COVID period, market participants focused on the maximum

possible satisfaction of demand given the limited resources. There was a deficit of workforce due to reasons caused by the pandemic, a reduction in financial capital due to a decrease in revenue, and delays in transport at border crossings. Therefore, to organize the effective economic activities, companies of the transport and logistics sector strived towards a balance between offer and demand in the context of the use of digital technologies that helped solve resource problems.

The leading positions in the ranking of companies providing transport and logistics services in 2024 belonged to the following companies (FNC Americas LLC, 2025):

- 1) European companies: Bolloré Logistics (France) (10th position) (logistics and specialized services for the industrial sector; the company works in developing countries, including Latin America and Africa) and CEVA Logistics (France) (9th position) (logistics and global freight forwarding, activities in more than 160 countries) – since 2025, these two companies function as one entrepreneurial subject; DSV Global Transport and Logistics (Denmark) (4th position) (cargo delivery, wide geographical coverage); DB Schenker (Germany) (3rd position) (integrated logistics AI-based solutions and ground transportation in Europe); Kühne + Nagel International AG (Switzerland) (2nd position) (air transportation and sea freight, the company has branches and subsidiaries in more than 100 countries); DHL Global Forwarding (Germany) (1st position) (complex logistics solutions and sea freight around the world).
- 2) Nippon Express Co., Ltd, Japan (8th position) (complex transport solutions and sectoral logistics, Asia-Pacific region).
- 3) American companies: United Parcel Service, Inc. (7th position) (international sea freight and air transportation, freight forwarding, etc.); Expeditors International of Washington, Inc. (6th position) (complex logistics and cargo transportation with the use of innovative digital platforms of process management);
- 4) Chinese Sinotrans Limited (5th position) (international and domestic freight, customs brokerage, storing, freight forwarding, and complex logistics services).
- 5) All the above companies have their intellectual capital, presented by innovative digital technologies, which is formed independently or with the use of purchased technological solutions.

It is necessary to classify and assess the effectiveness of digital tools that ensure operations in the transport and logistics sector by the example of the activities of the above-mentioned leading companies.

CEVA Logistics (France), which is in the top 10 operators of the market, develops its own digital logistics solutions for contract logistics and forwarding services. Merging with Bolloré Logistics will allow expanding the presence in international markets. The main digital tools developed by the company include information and monitoring IT systems supported by industrial and manufacturing engineering and characterized by the following features:

- Monitoring of cargo at storage and on the way. The company's website allows tracking of cargoes.
- Forecasting of the optimization of the costs of logistics and transport services, performed based on big database analysis (access to information in regions and countries is enabled by digital information integration into the information systems of national operators), machine learning, and neural networks. Using this IT system, Bolloré Logistics can reduce total costs by approximately 30% (Tamanna, 2025). This indicator of reducing costs is similar to other companies, which is due to the desire to retain high competitive positions and cooperate with IT companies that offer unified digital platforms for the monitoring of data. To implement and start the exploitation of the CargoWise digital platform, CEVA Logistics worked with WiseTech Global (CEVA Logistics, 2020b) and used the services of IBM for the management of electronic exchange of data and application of cloud solutions (IBM, 2025).
- Safe placement, transportation, and delivery of cargoes for large industrial companies with optimization of routes. Capabilities of the IT system of CEVA Logistics include assessment of road conditions, analysis of weather, study and correction of delivery schedules in real time, detection of possible barriers to timely delivery, assessment of the options for reduction of fuel consumption and building more effective routes, and remote control of cargo protection. CEVA Logistics provides transport and logistics services to subjects from different sectors, which include project logistics during the construction of gigafactories; freight forwarding for the defense sector, aerospace industry, mining and processing industries, energy sphere, oil and gas sector, etc.
- Sustainable management of supply chains. Customer support in reducing the negative influence of supply chains on the environment is realized within the CEVA FORPLANET project, which allows purchasing products and packaging, given the focus on circularity and the use of transport solutions (e.g., electric transport) that allow reducing the carbon footprint (CEVA Logistics, 2020a).

Application of the information & monitoring system and the CEVA FORPLANET project enabled CEVA Logistics to achieve good results in quality management. The company raises the eco-friendliness of transport and logistics services for customers, focused on responsible management of supply chains due to digital smart optimization of costs and routes. In 2024, the company purchased and put into operation 1450 trucks working on alternative fuels with zero CO₂ emissions. 2024 also saw the commissioning of the unique vessel CMA CGM MERMAID (2,000 TEU), which allows reducing CO₂ emissions by 20% and is controlled by the information and monitoring system (CEVA Logistics, 2020a). This system is based on the integration of digital platforms developed by the world's leading IT companies and digital tools.

Nippon Express Co., Ltd uses digital support for the management and informatization of the provision of services, which includes the following aspects (Nippon Express Co., Ltd, 2025a):

- Electronic reporting on cargoes, provided by the freight forwarder and the shipping company. This contributes to responsible business by regulating the correct calculation of taxes on imports and exports of goods. For this purpose, Nippon Express Co., Ltd. uses a digital application, Global-Net AFR Service.
- Electronic management of all logistics and transport bases and freight forwarders. This is an integrated system, which ensures monitoring and transfer of data on the movement of transport and state of cargo from digital sensors and video cameras to the unified information system; it also includes the management of robotized lines, analysis of big databases, and development and selection of optimal routes.
- Electronic booking of consolidated cargoes from Japan, performed via a digital application of e-booking. Customers interact with the company in an automatic regime, which reduces the time required for direct communication. Chatbot, machine learning (algorithm of incoming order processing and putting data into the delivery schedule), big data analysis (using the information on transport vehicles capacity and cargo data, the system determines the most optimal conditions), and neural networks (forecasting the time of delivery given the schedule of consolidated cargoes transportation, external conditions, etc.) technologies are used.
- Electronic search and tracking of cargoes using the digital apps Track&Trace, e-NX, and SHUTTLE. These apps contain various information and are aimed at corporate and individual customers. The apps utilize such technologies as computer vision (recording and transferring data on cargoes), big data analysis, machine learning, chatbots, and neural networks. These digital tools are used in all

similar information systems for managing the processes of electronic tracking of cargoes.

- Electronic calculation of CO₂ emissions for the delivery of cargoes via different transport, which can be offered by the company (online calculator NX-GREEN).

Digitalization of services provided by Nippon Express Co., Ltd contributes to the quality policy, which is regulated by the corresponding standards and is confirmed by certification. The company's services have been certified since 1994 according to the ISO 9001 standard. An airline belonging to Nippon Express Co.,

Ltd. was certified according to the ISO 14001 standard (Nippon Express Co., Ltd, 2025c). Services according to these standards envisage optimization of routes, focus on alternative fuel, and optimization of placement of cargoes in transport (digital twin technology for remote modeling of the options of cargo placement is used).

4.2 Service Reliability Analysis

Application of digital smart solutions in the management of the parameters of the quality of transport and logistics services enabled Nippon Express Co., Ltd to reach significant results (Table 1).

Table 1. Results of management of quality parameters by Nippon Express Co., Ltd, based on the use of digital tools supported by industrial and manufacturing engineering

	Results	Value/dynamics of change		
		2020	2023	2024
1	Energy consumption (crude oil equivalent) (kiloliter)	328.8	- 5%	- 0.3%
2	CO ₂ emissions (Scope 1 and 2) (tons CO ₂)	791.4	- 5.3%	- 4.04%
3	Number of own environmentally clean transport means (Japan)	12.076	+ 6.1%	+ 1.6%

Source: Prepared by the authors based on Nippon Express Co., Ltd (2025b)

Nippon Express Co., Ltd utilizes such digital tools as a system of base management and optimization of routes; digital apps for monitoring and tracking of cargoes; digital apps for booking; digital apps for preparation and filing of electronic reporting and calculation of environmental footprint, depending on the selected type of transport.

Similar to the two previous analyzed companies of the transport and logistics sector, United Parcel Service, Inc. also employs digital tools of two categories. These are digital tools utilized within the company (monitoring, management, and building of routes within the corporate digital integrated platform of optimization and navigation) and the ones for customer support and processing of orders (remote orders, selection of optimal routes, calculation of payments, cargo tracking, and filing a complaint for violation of contracts). Also, within electronic communication, the company offers customers the ability to file data for cargo stickers. Among the main elements of service quality management in United Parcel Service, Inc., we can mention environmental friendliness, cost-effectiveness, compliance with the norms and requirements set for transport and logistics services, and quick reaction to changes.

The three analyzed companies of the transport and logistics sector use digital tools according to the paradigm of the Fifth Industrial Revolution, which is confirmed by results in the context of the social, environmental, and economic goals.

Digital tools of the leading international participants in the transport and logistics services market have similar characteristics and functionality. This is because they work in the conditions of high competitiveness and strive towards satisfying consumer demands within standardized sets of services and digital means. Digital transformation is the basis for raising the standards of the quality of provision of services. However, it reduces opportunities for small and medium companies, which cannot make large investments in the purchase and/or development of digital platforms and apps for the transition of the main functions of quality management into an electronic form. The growth of demand for digital tools in the sphere of transport and logistics services led to certain liberalization of prices for digital devices and technological solutions, which contributed to their affordability for various categories of companies. Accordingly, the volumes of sales of digital technological solutions and devices increased. For example, global sales of digital twins in the logistics market equaled \$1 billion in 2020, \$3 billion in 2022, \$6 billion in 2024, and \$9 billion in 2025. The forecast for 2030 is \$137.7 billion (Tamanna, 2025). The market of digital sensors, which are used in the sector of transport and logistics services, also demonstrated positive dynamics: \$2 billion in 2020, \$2.812 billion in 2022, and it is expected to reach \$6.562 billion by 2030 (Grand View Research, Inc., 2025). Digital sensors are in high demand among companies in the transport and logistics sector. Large-scale implementation of digital tools ensures the improvement in satisfaction of customer expectations regarding standardization, ecologization, safety, and focus on social well-being of labor resources (improvement of labor conditions) and customers (customer focus).

Table 2. The influence of digital tools, supported by industrial and manufacturing engineering, on the enhancement of service quality management in United Parcel Service, Inc. in 2024

	Digital tools, supported by industrial and manufacturing engineering	Effect of industrial and manufacturing engineering on quality management
I	Digital tools supported by industrial and manufacturing engineering and used within the company	
1.1	Corporate digital integrated platform for optimization and navigation. Digital tools that are used and optimized through industrial and manufacturing engineering: machine learning, big data analytics, neural modeling, digital twins, and computer vision.	1. Reduction in distance covered by company drivers: 10–14 miles per day, 3650–5110 miles per year. The focus is on the protection of the transport fleet from wear and tear. 2. Saving money on services due to the optimization of routes. 3. Ecologization: - Decrease in CO ₂ emissions of the 1 st , 2 nd , and 3 rd categories: 2.1%. - Reduction in fuel consumption: 30M gallons of jet fuel. - Transition to alternative fuel, which was successfully realized due to digital modeling and selection of transport routes, given the location of charging stations.
II	Digital tools for customer use, improved through industrial and manufacturing engineering	
2.1	Digital cargo tracking applications with enhanced reliability and usability through industrial and manufacturing engineering	Standard consumer parameters (convenience, accessibility of interaction, safety of cargo movement)
2.2	Digital app for calculating costs, receiving invoices, and ordering cargo stickers with increased accuracy, thanks to industrial and manufacturing engineering	
2.3	Digital app for selecting the optimal route with enhanced flexibility, thanks to industrial and manufacturing engineering	Cost-effectiveness was ensured due to the selection of the most acceptable option of delivery
2.4	Digital application for filing complaints in cases of contract violations, combining economies of scale and personalization through industrial and manufacturing engineering	Customer focus. Automatic processing of complaints with further compensation

Source: Prepared by the authors based on United Parcel Service, Inc. (2025)

Thus, the review and comprehensive analysis of the leading international experience in managing the quality of services provided by European, American, Japanese, and Chinese transportation and logistics companies in the context of the Fifth Industrial Revolution revealed a significant contribution of digital tools supported by industrial and manufacturing engineering to improving a broad range of quality parameters of transportation and logistics services.

4.3 Digital Quality Loop of Transportation and Logistics Services

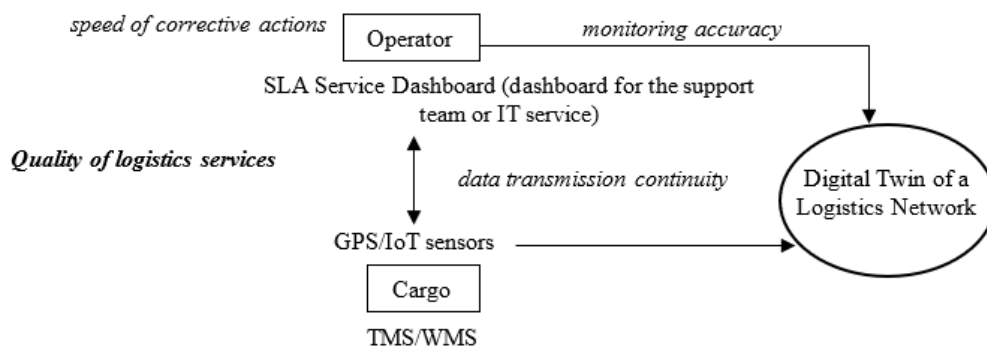
In transportation logistics, quality represents a loop that includes a “technological route” of cargo movement and a set of controlled parameters at each stage: temperature, humidity, vibration, transit time, and document status. Critical control points include dispatch, transit, warehousing, and delivery, as well as the indicators used to assess their performance, such as the share of regime violations, delays, and incidents.

To quantify quality changes in the transportation and logistics system, an index Q_{log} is proposed that links engineering parameters, such as the presence of sensors, automatic tracking, and route optimization algorithms, with quality outcomes, including the percentage of shipments without deviations, the reduction of claims,

and the stability of delivery times. The inclusion of the loop framework, the parameter matrix, and an illustrative calculation of this index demonstrates that logistics is not merely a “business process,” but a manageable technological quality system subject to design and optimization. In this regard, it is advisable to use the framework of the digital quality loop of transportation and logistics services illustrated in Figure 2.

Figure 2 presents the cargo, GPS/IoT sensors, TMS/WMS, a route analytics module, a digital twin of the logistics network, an operator, and an SLA service dashboard. The key idea of the authors’ framework is that the quality of logistics services is determined by data continuity, monitoring accuracy, and the speed of corrective decision-making.

Major international logistics operators, including DHL, UPS, and Maersk, use telematics, route optimization, digital twins of warehouses and flows, and predictive analytics to improve service quality. This makes it possible not only to track delivery status but also to manage deviations proactively. Such experience is particularly important in the context of Industry 5.0, where the quality of logistics services should be adaptive, transparent, and resilient to external disruptions.



Source: Prepared by the authors.

Figure 1. Digital quality loop of transportation and logistics services

5. DISCUSSION

The research contributes to the literature by Hatika et al. (2026), Vadivukarasi et al. (2026), Wang et al. (2026), and Yang et al. (2026) and further develops the scientific concept of industrial and manufacturing engineering in the transportation and logistics sector by clarifying the opportunities and technical frameworks for applying industrial and manufacturing engineering to the quality management of transportation and logistics services.

In contrast to the previous literature by AlQadi et al. (2025), Chen et al. (2025), Nicoletti and Appolloni (2025), and Shen et al. (2025), it has been substantiated that the nontechnical tools currently used to manage the quality of transportation and logistics services are insufficient to ensure a high level of service quality under the contemporary conditions of the Fifth Industrial Revolution. Therefore, the quality management mechanism for transportation and logistics services should be supplemented with digital technical tools supported by industrial and manufacturing engineering. In this research, we considered digital tools used in the management of transport and logistics services' quality by the largest actors of the market. The market of modern digital means (technologies, tools, and digital solutions) did not feature any radical innovations in the last 2-3 years. However, the ones that are used ensure stable growth. This shows that activities of the sectors of the digital economy that deal with the development of innovative digital solutions conform, on the whole, to technological expectations of the transport and logistics sector's subjects.

The strategic landmark of small and medium companies of the transport and logistics sector – digital transformations in quality management – is connected with the appearance of many more theoretical and empirical studies. To raise the intensity of this process, it is necessary to develop methodological approaches to the management of digital transition in the context of various types of activities in the sector. Creation of methodologies and guidelines for implementing digital smart tools is important for small and medium-sized companies of the transport and logistics sector and for

local, regional, and national authorities. Digital transformation of this sector is also important, similar to the digital transition of the transport sector, which is due to the optimization of their activities in the context of the reduction of negative impact on the ecosystems of territories (Kottala et al., 2025). Enhancement of the functioning of the sector's subjects will allow achieving the Sustainable Development Goals, in the part of support of employment for social protection of labor resources by raising their digital knowledge as the basis of the Fifth Industrial Revolution, and focus on environmental protection due to smart management of routes, logistics, and transport. This allows creating roadmaps for the digital transformation of transport and logistics companies.

An important measure for improving the digital transformation in the context of quality improvement in the transport and logistics sector, in the conditions of the Fifth Industrial Revolution, is customers accepting and acknowledging the principles of Industry 5.0. This requires comprehensive informing of the existing and potential customers about the influence of digital tools on the receipt of specific results in the context of support of social well-being, reduction of the environmental footprint, and protection of natural resources. Is it also possible to promote customers' responsible behavior during the selection of optimal routes to obtain the benefits of the economic and ecological character?

4. CONCLUSION

The primary result of this research is the development of a comprehensive set of digital technical tools for managing the quality of transportation and logistics services in the context of the Fifth Industrial Revolution through the application of manufacturing engineering. The authors' framework includes both internal corporate digital tools for optimization and navigation (machine learning, big data analytics, neural modeling, digital twins, and computer vision) and customer-oriented digital tools, including applications for cargo tracking, cost calculation, invoice retrieval, order placement, optimal route selection, and filing complaints in cases of

contract violations, all enhanced through industrial and manufacturing engineering.

Digital tools of quality management in the transport and logistics sector, used in conditions of the Fifth Industrial Revolution, are the basis for progress and allow achieving the goals of many stakeholders (companies, public authorities, customers, labor resources, and companies of adjacent sectors). The analyzed digital means, implemented by transport and logistics enterprises, are used primarily by large actors. Small and medium companies are not able to fully achieve the advantages that are accessible to market leaders. The reasons for this are financial deficit and problems with the level of personnel's digital readiness. Despite the growth of the IT market and the appearance of more affordable digital tools, small and medium-sized companies in the transport and logistics sector still face the problem of insufficiently effective digitalization.

This problem can be solved through a partnership with large market participants. The partnership can be realized at the national and international levels. This will raise the activities of various developing countries in the direction of presence in new markets and access to global opportunities of cooperation (Grigoryan et al., 2024).

Partnership can involve the following aspects:

- 1) Merging with large transport and logistics companies without losing legal and financial independence. This may involve functioning under a well-known brand, access to

technologies, and access to the goals of economic growth, social well-being, and reduction of environmental footprint. Small and medium companies can retain their customers and seek new potential ones. Large companies can count on certain additional income and strengthening of positions in regional markets.

- 2) Access to finances to support the creation of innovative digital solutions, which ensure new, unique parameters of the quality of transport and logistics services. Here, it is possible to register rights for new technologies and make their further transfer, which will contribute to the revenues of all parties.
- 3) Possibility to raise the digital readiness of labor resources through access to partners' resources in the sphere of knowledge and skills with digital tools.

Another option is integration with other small and medium companies and start-ups, which work in the transport and logistics sector and related industries.

The practical value of the authors' developments lies in the fact that their implementation will improve the reliability, convenience, accuracy of intelligent support, flexibility, economies of scale, and personalization of transportation and logistics services, thereby systematically and substantially enhancing their quality through industrial and manufacturing engineering.

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