

TRANSFORMATION OF THE ORGANIZATIONAL AND ECONOMIC MECHANISM OF RAILWAY TRANSPORT DEVELOPMENT IN THE CONDITIONS OF THE DIGITAL ECONOMY

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Abstract: The article examines the transformation of the organizational and economic mechanism of railway transport development in the context of the digital economy. The study explores how digital technologies—such as big data, artificial intelligence, and automation—reshape management structures, operational efficiency, and financial models within the railway sector. Special attention is given to the integration of digital platforms, intelligent transport systems, and data-driven decision-making processes. The paper identifies key challenges, including infrastructure modernization, cybersecurity risks, and investment constraints, while highlighting opportunities for improving service quality, reducing costs, and increasing competitiveness. The results demonstrate that the transition toward a digital economy requires a comprehensive transformation of institutional frameworks, economic tools, and governance approaches in railway transport systems.

Key words: Digital economy; railway transport; organizational mechanism; economic mechanism; digital transformation; intelligent transport systems; innovation; efficiency; infrastructure modernization; data analytics.

Introduction

Railway transport plays a crucial role in national and global logistics systems, ensuring mobility of goods and passengers. In recent decades, the emergence of the digital economy has significantly influenced traditional industries, including railway transport. Digitalization introduces new opportunities for optimizing operations, improving service quality, and enhancing competitiveness. However, the transition to a digital environment requires not only technological upgrades but also a transformation of the organizational and economic mechanisms governing railway systems. Existing models, often characterized by rigid hierarchies and outdated financial structures, are insufficient to meet modern demands. Therefore, this study aims to analyze the transformation processes and identify key directions for development.

In January address of President Sh. Mirziyoyev to the Parliament and people of Uzbekistan in 2020, great attention was given to the issues of digital development. It was in this year that the fundamental documents were adopted, which laid the normative and legal foundation for further digital reforms. On April 28, 2020, under No. PP-4699, the President of Uzbekistan adopted a resolution "On measures for the wide implementation of the digital economy and e-government" [1], The President's decree of October 5, 2020, "On the approval of the Strategy "Digital Uzbekistan-2030" [2] and measures for its effective implementation" was a logical continuation of the aforementioned efforts.

Railway transport has historically been one of the most fundamental components of national and international transport systems, playing a decisive role in ensuring economic growth, regional integration, and social mobility. As a backbone of freight and passenger movement, railways contribute significantly to industrial development, trade expansion, and environmental sustainability due to their relatively low carbon footprint compared to other modes of transport.

In the context of globalization and increasing competition among transport modes, railway systems are under growing pressure to improve efficiency, reliability, and service quality. At the same time, the rapid development of the digital economy is reshaping traditional industries by introducing new technologies, business models, and management approaches. The digital economy is

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characterized by the widespread use of information and communication technologies (ICT), data-driven decision-making, and the integration of digital platforms into economic activities. These changes create both opportunities and challenges for railway transport systems.

The transformation driven by digitalization goes beyond the mere adoption of new technologies. It requires a fundamental rethinking of the organizational and economic mechanisms that govern railway transport [5]. Traditional management models in the railway sector are often centralized, hierarchical, and characterized by limited flexibility. Such structures can hinder innovation and slow down decision-making processes in a rapidly changing environment. Therefore, the shift toward digital systems necessitate more adaptive, decentralized, and data-oriented organizational frameworks. From an economic perspective, the digital economy introduces new principles of value creation, cost management, and resource allocation. Railway companies must adapt to changing market conditions by implementing innovative financial instruments, optimizing operational costs through digital tools, and adopting customer-oriented pricing strategies. The use of advanced analytics allows for more accurate demand forecasting, efficient asset utilization, and improved investment planning. Moreover, digital transformation in railway transport is closely linked with the development of intelligent transport systems (ITS), smart infrastructure, and integrated logistics networks [6]. Technologies such as artificial intelligence, big data analytics, the Internet of Things, and cloud computing enable real-time monitoring and control of railway operations, predictive maintenance of rolling stock and infrastructure, and enhanced safety systems. These innovations contribute to increased operational efficiency and reduced risks.

However, the transition to a digital economy also presents several significant challenges. These include the need for substantial capital investments in infrastructure modernization, the development of digital competencies among the workforce, and the establishment of robust cybersecurity systems to protect critical transport infrastructure. In addition, institutional barriers, regulatory constraints, and resistance to organizational change can slow down the transformation process. Given these conditions, the study of the transformation of organizational and economic mechanisms in railway transport becomes particularly relevant. It is essential to identify the key directions, principles, and tools that can ensure the successful adaptation of railway systems to the digital economy. This includes analyzing best practices, evaluating the effectiveness of implemented technologies, and developing recommendations for policymakers and industry stakeholders.

Methodology

This study employs a comprehensive methodological framework combining qualitative and analytical approaches to examine the transformation of organizational and economic mechanisms in railway transport within the digital economy. The research is grounded in a system approach, which allows railway transport to be analyzed as an integrated socio-economic and technological system. This approach makes it possible to identify interconnections between organizational structures, economic processes, and digital technologies, as well as to assess their combined impact on system performance.

Results and Analysis

It should be noted that the modernization of the economy and the growing export potential of Uzbekistan require the expansion of transit corridors, which provide access to prospective international markets for the Republic's exported products. In this regard, given the strategic importance of the development of the transportation industry, great importance is attached to the development of transportation infrastructure on a national scale, taking into account its integration into the international transport system

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The conducted research demonstrates that the transformation of the organizational and economic mechanisms of railway transport under the conditions of the digital economy is multidimensional and systemic in nature [7]. The results reveal that digitalization not only improves operational efficiency but also fundamentally reshapes management structures, financial models, and the overall logic of value creation in the railway sector. Moreover, digital technologies enhance capacity utilization by improving traffic management systems. Intelligent algorithms optimize train scheduling and routing, reducing congestion and increasing throughput. As a result, railway networks can handle higher volumes of passengers and freight without requiring proportional increases in infrastructure investment.

An important trend identified in the study is the integration of railway transport into broader digital ecosystems. Railway systems are increasingly connected with other modes of transport, logistics platforms, and supply chain networks through digital interfaces. This integration enables the development of multimodal transport solutions, where passengers and goods can move seamlessly across different transport systems. Digital platforms provide end-to-end visibility of logistics processes, improving coordination and reducing delays. Additionally, customer-oriented digital services—such as mobile applications, online booking systems, and real-time tracking—enhance user experience and increase the competitiveness of railway transport compared to other modes.

Despite the positive outcomes, the analysis reveals several significant challenges that hinder the transformation process. One of the primary constraints is the high level of capital investment required for digital infrastructure development. Many railway systems, particularly in developing economies, face financial limitations that slow down the adoption of advanced technologies. Another critical issue is the shortage of qualified personnel with digital competencies. The successful implementation of digital systems requires specialists in data analysis, cybersecurity, and information technology, which creates additional pressure on human resource development. Cybersecurity risks also represent a major concern. As railway systems become more digitized and interconnected, they become more vulnerable to cyber threats. Ensuring the protection of sensitive data and critical infrastructure is therefore a key priority. Institutional and organizational resistance to change further complicates the transformation process. Traditional management cultures and regulatory frameworks may not be well-suited to support innovation and flexibility, leading to delays in implementing digital initiatives.

The "Strategy for the Development of the Transportation System of the Republic of Uzbekistan until 2035" envisages the following tasks [4]:

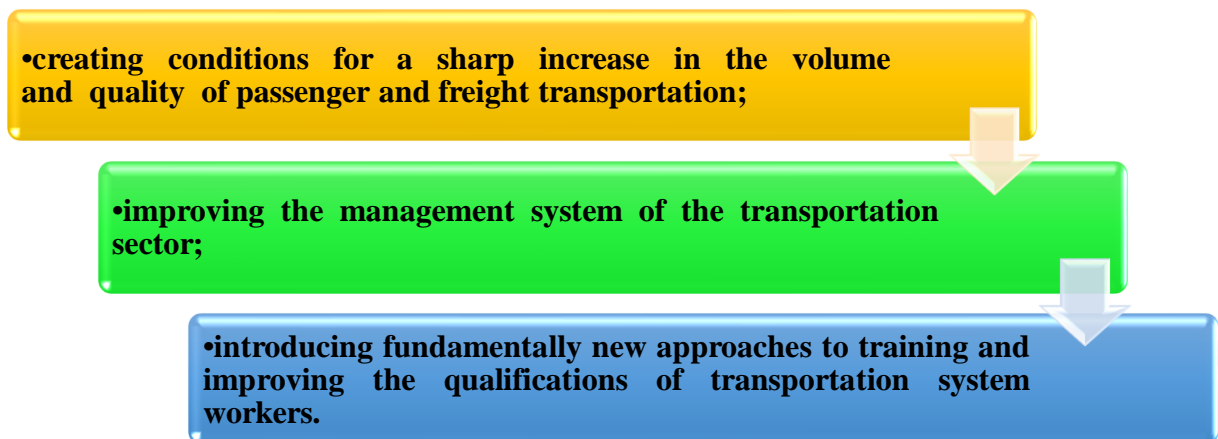


Figure 1. Priority tasks of "Strategy for the Development of the Transportation System of the Republic of Uzbekistan until 2035"

Source: Compiled by author.

Analysis has shown that the implementation of qualitatively new approaches to the organization and management of transportation has led to a certain increase in freight and passenger traffic. Freight transportation by all modes of transportation increased by 6.1% in 2022 and amounted to 1.31 billion tons, while passenger transportation by all modes of transportation increased by 2.7%, amounting to 6.1 billion people [4].

The comparative analysis indicates that railway systems that actively adopt digital technologies demonstrate higher levels of efficiency, reliability, and customer satisfaction. These systems benefit from reduced operational costs, improved asset utilization, and enhanced service quality. In contrast, railway systems that lag in digital transformation tend to experience inefficiencies, higher maintenance costs, and lower competitiveness. This gap highlights the importance of strategic planning and investment in digitalization. Furthermore, the analysis shows that the success of transformation depends not only on technological adoption but also on the alignment of organizational and economic mechanisms with digital principles. Countries and companies that implement comprehensive and coordinated transformation strategies achieve more sustainable and long-term results.

Discussions

The findings of this study confirm that the transformation of the organizational and economic mechanisms of railway transport in the digital economy is not a linear or purely technological process. Rather, it represents a complex systemic shift that affects institutional structures, management paradigms, economic logic, and stakeholder interactions. The discussion of the results allows for a deeper interpretation of the implications, contradictions, and strategic priorities associated with this transformation. The transition from hierarchical to network-based organizational structures reflects a broader trend observed in digitally transformed industries. In the railway sector, this shift is particularly significant due to the traditionally rigid and centralized nature of management systems. The results suggest that digitalization facilitates decentralization by enabling real-time communication and coordination across multiple levels of operation. However, this transformation raises important questions regarding governance and accountability. While decentralized systems improve flexibility and responsiveness, they also require clearly defined roles, responsibilities, and control mechanisms to prevent fragmentation. Therefore, the effectiveness of new organizational models depends on achieving a balance between autonomy and coordination [8].

In modern conditions, the sectors of the economy face the task of determining a long-term development strategy and carrying out reforms for consistent development in all directions. The goal of the development strategy of the Republic of Uzbekistan until 2035 is to include our country among the 50 economically developed countries in the world. In this regard, one of the main tasks is the development of the market and infrastructure of transport and logistics services, increasing the level of electrification of railway infrastructure to 60% [4], accelerated development of the network of highways and expanding "green corridors" for external and transit opportunities in the transport sector, as well as increasing the volume of transit goods up to 15 million tons. As a result, in 2019, the Ministry of Transport of the Republic of Uzbekistan was established, and a Center for the Study of Transport and Logistics Development Issues was also created under the Ministry. The digital platform «Warehouses and Logistics Centers of Uzbekistan» (www.skladi.uz) was created by the Logistics Association of Uzbekistan with the support of the Ministry of Transport of the Republic of Uzbekistan.

In the field of railway transport, the following measures are considered expedient:

- gradual reduction of subsidies for passenger transportation at the expense of revenues from freight transportation and a transition to subsidies from the state budget, development of high-

speed passenger traffic, improvement of the quality of services provided and construction of a double-track viaduct;

- active implementation of advanced information and communication technologies to provide services to cargo owners and passengers online based on public-private partnerships;
- improvement of the regulatory framework, continuation of work on harmonization of intergovernmental standards and work on the conformity assessment system in the field of railway transport and transport infrastructure objects;
- creation of transport research institutes, including training and retraining of personnel in scientific, design work, and digital technologies development.

Moreover, the increasing reliance on data-driven decision-making alters the role of management. Managers are no longer only decision-makers but also interpreters of analytical outputs. This requires a transformation of managerial competencies, emphasizing digital literacy, analytical thinking, and strategic adaptability. From an economic perspective, the shift toward digital mechanisms represent a transition from static to dynamic models of resource allocation and value creation. The use of predictive analytics and real-time data significantly enhances the efficiency of financial planning and operational management. The findings indicate that digitalization contributes to cost reduction primarily through optimization rather than simple cost-cutting. For example, predictive maintenance reduces unnecessary repairs and minimizes downtime, while dynamic pricing improves revenue generation by aligning prices with demand patterns. At the same time, the study highlights a paradox: although digital technologies reduce long-term operational costs, they require substantial initial investments. This creates a financial barrier, particularly for railway systems with limited access to capital. As a result, the pace of digital transformation is uneven across regions and organizations. Additionally, the increasing role of digital platforms changes the nature of competition in the railway sector. Competition is no longer limited to traditional transport operators but extends to digital service providers and integrated logistics platforms. This necessitates a rethinking of competitive strategies and market positioning.

The integration of advanced technologies such as artificial intelligence, IoT, and big data analytics is a key driver of efficiency improvements [9]. The discussion of results confirms that these technologies enable a shift from reactive to proactive and predictive management models. This transformation enhances system reliability and safety, which are critical factors in railway transport. However, the effectiveness of technological integration depends on the compatibility of legacy systems with new digital solutions [10]. In many cases, outdated infrastructure limits the full potential of digital technologies, requiring additional investments in modernization.

Increasing the volume of product exports in the country requires a revision of the quality of all transport services provided on a national scale, indicating the need for it to comply with global standards. In this regard, the importance of exporting goods highlights the importance of exporting transport services, which is necessary for the country's strategic socio-economic development and further improvement of the use of the transit potential of the transportation system, etc. Railway transport constitutes the basis of the country's transportation complex and has significant economic, political, and security value, being tasked with transporting a large part of the freight traffic over long distances and meeting the needs of transportation in relation to foreign countries. Undoubtedly, over time, rail transport will become the most economically efficient way over long and medium distances. In transportation over medium distances, railway transport competes with automobile and maritime transport, and railway transport is considered more effective in transporting large-sized and heavy goods.

The transformation of railway transport in the digital economy also has significant institutional implications. Existing regulatory frameworks are often not adapted to the requirements of digital systems, creating barriers to innovation and implementation [11]. For example, issues related to data

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ownership, privacy, and cybersecurity require new regulatory approaches. The absence of clear standards and guidelines can slow down the adoption of digital technologies and increase risks for operators. Furthermore, public policy plays a crucial role in supporting digital transformation. Government interventions—such as investment programs, subsidies, and public-private partnerships—are essential for overcoming financial constraints and stimulating innovation. The study suggests that successful transformation is often associated with strong institutional support and coordinated policy measures.

When implementing blockchain technology in the supply chains of railway transportation, the situation becomes as follows:



Figure 2. Expecting results of implementing blockchain technology in the supply chains of railway transportation

Source: compiled by author.

Thus, transparency is achieved, work is accelerated and simplified, and the possibility of obtaining reliable and useful information arises. From the perspective of the transportation industry, the digital environment should provide integration into the global digital transportation system, transition to electronic paperless document management using the best international and domestic standards and practices, and ensure maximum utilization of transportation infrastructure. One of the main tasks in the conditions of digital transformation in rail transport is to ensure equal access of all clients and partners to the railway infrastructure to meet the needs of clients for quality transportation of goods and provision of services. Since the railway infrastructure is distributed and clients and partners of JSC "UTY" are located in different regions, timely and efficient information transmissions essential.

Conclusion

The conducted research demonstrates that the transformation of the organizational and economic mechanisms of railway transport in the context of the digital economy is a complex, multidimensional, and strategically significant process. It is not limited to the implementation of individual digital technologies but involves a fundamental restructuring of management systems, economic models, and institutional frameworks. The study confirms that digitalization serves as a key driver of efficiency, enabling railway systems to optimize operations, improve service quality, and enhance competitiveness. The introduction of data-driven decision-making, predictive analytics, and intelligent transport systems significantly increases the reliability and performance of railway transport. At the same time, the transition toward digital platforms and integrated logistics ecosystems allows railway companies to strengthen their position within the broader transport and supply chain networks.

Development and implementation of a new regulatory methodology for organizing train flows is necessary to accelerate delivery times of goods to the landfill of the Republic, to increase the attractiveness and comfort of railway transport. In order to increase the competitiveness of domestic corridors and redirect transit goods from alternative to domestic railways, it is necessary to establish railway communication through Afghanistan with Pakistan, as well as through Kyrgyzstan with China, and to create logistics clusters at Galaba station (Uzbekistan) and Peshawar station (Pakistan), Kashgar (China) and Andijan (Uzbekistan) for organizing intermodal transportation (by rail and road transport), which will attract interest in cargo transportation in this direction from both shippers and transport companies of Afghanistan and Kyrgyzstan. Implementation of the proposed measures will contribute to the formation of a world trade zone at the intersection of Uzbekistan's transit corridors, stimulate the development of all modes of transport, and create conditions for redirecting major world trade markets to Central Asia, with the implementation of a balanced, mutually beneficial, constructive foreign policy, increasing the republic's transport and transit potential, and creating favorable conditions for foreign trade. This, in turn, opens up opportunities to integrate into the global community and develop cooperation within the transport business. The use of electronic trading platforms provides an opportunity to provide customers with reliable information, create new channels for the sale of transport services and accelerate financial reporting, leading to a reduction in manual labor of workers, a maximum increase in the share of electronic document circulation between customers and UTJSC, an increase in the share of sales volume and the share of railway transportation in the market of transport services.

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