Digital Multimodal Transport by Rail in Azerbaijan's Logistics System: The Strategic Significance of the Middle Corridor

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Abstract. Against the backdrop of accelerating globalization, the expansion of international trade volumes, and the intensification of transport and logistics flows between Europe and Asia, the establishment of efficient, flexible, and competitive logistics systems has become a strategic priority for transit countries. In this context, the Trans-Caspian International Transport Route (the Middle Corridor) plays a pivotal role as an alternative East–West transport linkage, enhancing countries' capacities in international trade and transit. [1].

The aim of this study is to evaluate the role of rail transport in Azerbaijan's logistics system within digital multimodal transport chains, to scientifically analyze its impact on the transit potential of the Middle Corridor, and to determine the effects of the application of digital technologies on the efficiency, transparency, and international competitiveness of transport processes. The research was conducted on the basis of synthetic-analytical methods, a systematic literature review, as well as statistics derived from digital monitoring data and electronic document circulation. Within the analytical framework, the impact of real-time monitoring technologies equipped with GPS and IoT sensors, electronic documents (e-CMR, e-TIR), and digital coordination platforms on operational efficiency, security, and time optimization in transit transport was assessed. [2].

Empirical findings indicate that increasing the level of digital integration enhances the operational efficiency of transport processes, reduces time losses within the logistics chain, and strengthens compliance with international standards. The implementation of electronic document management and real-time monitoring systems contributes to the expansion of Azerbaijan's transit potential and provides a strategic impetus for the development of the non-oil sector, particularly in export and transport services. Furthermore, the adoption of digital solutions reinforces the coordination of international cooperation, facilitating optimized information exchange and operational synchronization within regional and global logistics networks, notably along the TRACECA and Trans-Caspian corridors.

Furthermore, the implementation of digital multimodal transport systems not only enhances resource efficiency but also supports environmental sustainability.

Through optimal route selection and the monitoring of energy consumption, it becomes possible to reduce operational costs and minimize carbon emissions. Ultimately, the systematic adoption of digital multimodal transport models ensures network efficiency, transparency, and competitive advantages, thereby significantly strengthening the position of Azerbaijan's economy within the global logistics system. [3].

Keywords: Middle Corridor; digital logistics; multimodal transport; rail transport; Azerbaijan's transit corridors; digitalization of transport operations.

1 Introduction

The expansion of international trade has necessitated the functional and technological modernization of transport and logistics systems. In recent years, geopolitical shifts affecting global supply chains have significantly increased interest in alternative transport corridors along the Europe–Asia routes [4]. In this context, the Middle Corridor has emerged as a reliable and flexible transport route. Azerbaijan's advantageous geographical location, the availability of a well-developed railway infrastructure, and its access to the Caspian Sea are among the key factors defining the country's strategic role within this corridor [5]. The application of digital technologies to railway freight transportation along this corridor has further reinforced these advantages.

The development of the Middle Corridor is closely linked to the diversification of global supply chains and the advancement of alternative logistics routes across the Eurasian region. As the role of multimodal transport has expanded within the contemporary international trading system, the digitalization of logistics infrastructure has become a strategic competitive factor. In this context, digital platforms, electronic document circulation, and real-time monitoring technologies serve as key instruments that enhance the transparency of transport operations and the efficiency of their management. Multimodal transport models, in turn, create synchronized linkages among different modes of transport, reducing transit time and enabling the optimization of operational costs. From this perspective, the Middle Corridor can be regarded not only as a physical infrastructure initiative but also as an integrative logistics platform grounded in digital governance mechanisms [6,7].

In the contemporary global economic system, the optimization of logistics routes is assessed not only through the development of physical infrastructure but also through the level of digital integration. The implementation of digital logistics platforms ensures the timeliness of information flows across international transport corridors, while also enabling the forecasting of transit operations and the effective management of associated risks. For this reason, the Middle Corridor has evolved into an integrative transport system characterized by advanced digital coordination capabilities, thereby becoming one of the key components of an alternative and sustainable logistics architecture across the Eurasian region.

Statement of the Problem. It is well known that, in traditional international transportation, delays in documentation procedures, inconsistencies in information exchange, and operational risks constitute significant concerns [8]. The involvement of several

countries and the use of multiple modes of transport along the Middle Corridor make these challenges even more pressing. In this regard, a key issue of scholarly interest is the evidence-based assessment of how the implementation of digital multimodal railway transport within Azerbaijan's logistics system will influence the efficiency and competitiveness of the Middle Corridor.

2 Main Section

Multimodal Railway Transport and Digitalization. Multimodal transport refers to the movement of goods using two or more modes of transport within a single organizational framework [1]. This model enables enhanced coordination within the logistics chain, optimization of transportation costs, and the reduction of time losses. For long-distance transport, railways are considered the primary mode due to their high capacity and reliability. Digitalization, through the use of electronic transport documents (e-CMR, eTIR), automated information systems, and real-time monitoring, further enhances the efficiency of multimodal transport [2].

The digital management of multimodal transport enables the automation of decision-making processes within the logistics chain. In particular, Big Data and artificial intelligence–based analytical models facilitate the forecasting of cargo flows, route optimization, and the efficient allocation of operational resources. This approach enhances the flexibility of logistics systems, expanding their ability to adapt to changing market conditions. [8].

Azerbaijan's Role in the Middle Corridor. The Middle Corridor is an international transport and logistics route connecting China and Central Asian countries with the South Caucasus and Europe via the Caspian Sea (Fig. 1).

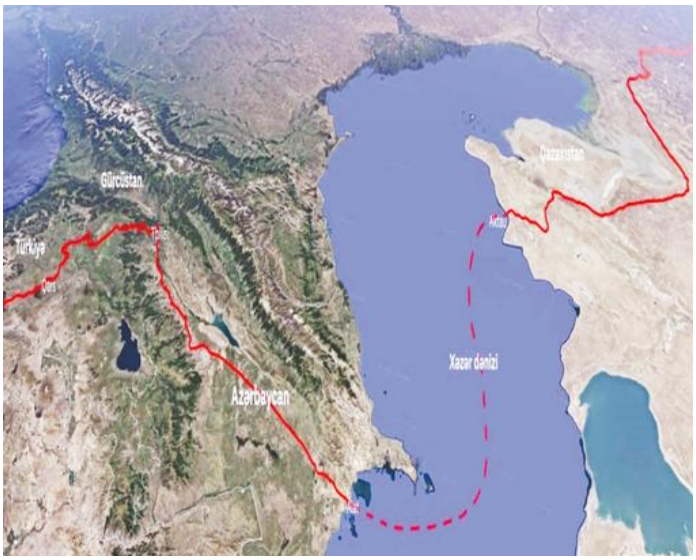

Fig.1. Map Illustration of the Middle Corridor.

Digital multimodal railway transport within Azerbaijan's logistics system enhances the efficiency of the Middle Corridor (Trans-Caspian International Transport Route), reinforcing it as a strategic, fast, and secure route between China and Europe. As a key transit hub of the Middle Corridor, Azerbaijan connects East–West trade flows via the Caspian Sea and supports logistics diversification across Eurasia. In this regard, the Middle Corridor serves as a critical transit route that forms a highly integrated transport and logistics system in the region. The route extends from China through Kazakhstan, the Caspian Sea, Azerbaijan, and Georgia, reaching European markets via Turkey. Consequently, its institutional structure is expressed as a complex infrastructure model based on the integration of maritime, rail, and road transport. Compared to the Northern Route, its lower geopolitical risk is considered one of its main competitive advantages. Additionally, reduced transit times enhance the operational efficiency of international trade, positively impacting the overall performance of the logistics chain.

Azerbaijan's role as a transit hub within this system has been significantly strengthened in recent years through both infrastructure and institutional reforms. Notably, the commissioning of the Baku–Tbilisi–Kars railway, the operational launch of the Alat International Sea Trade Port complex, the construction of modern highways, and the optimization of customs procedures have all facilitated an increase in transit flows. According to 2022 statistics, the volume of cargo transported along the Middle Corridor reached 1.5 million tons, demonstrating the region's enhanced logistics potential. Nevertheless, limited shipping capacity along the Trans-Caspian route, inconsistencies in tariff policies, and delays in administrative procedures remain key challenges that hinder the corridor's full operational efficiency.

In the future, enhancing the corridor's efficiency will require the implementation of digital logistics solutions, strengthened institutional coordination among participating countries, and the continuous modernization of infrastructure. In this regard, the Middle Corridor has the potential to serve not only as an economic but also a geopolitical pillar of the emerging transport architecture in Eurasia. Currently, this initiative is actively being developed as a unified digital platform under the name "Digital Transport Corridor." It is designed to integrate interactions with various state agencies—customs, phytosanitary, and border control—streamlining administrative processes. One such project, "Test Customs," has already begun operations at the Kazakhstan–China border. It enables transit declarations to be processed automatically within just 20 minutes, significantly accelerating the container transport process.

This corridor has emerged as an alternative route for East–West cargo transport across the Eurasian region and has significantly increased its strategic importance in recent years. The demands for diversification, security, and logistical resilience in global trade have transformed the Middle Corridor into a vital geoeconomic platform. Acting as one of the central hubs of the Middle Corridor, Azerbaijan plays a natural bridging role between East and West, enabling the connection of Central Asian countries with the Caucasus and European markets via the Caspian Sea. Such a geographical advantage positions Azerbaijan not only as a transit country but also as a regional logistics hub. One of the main pillars of Azerbaijan's role in the Middle Corridor is its well-developed railway infrastructure. It is well known that the Baku–Tbilisi–Kars railway is considered one of the key components of the Middle Corridor's land segment.

This line enables container and cargo transport between Asia and Europe to be carried out in a significantly shorter time. The Caspian Sea serves as one of the key logistics components of the Middle Corridor, with Azerbaijan positioned at its center. Moreover, the Baku International Sea Trade Port (BISTP) functions as the primary multimodal hub where maritime and land transport converge along the Middle Corridor. In addition, the application of digital technologies plays a crucial role in strengthening Azerbaijan's position within the corridor. Additionally, in this domain, electronic documentation, unified information platforms, real-time cargo tracking, and automated management systems enhance the efficiency of logistics processes. The Middle Corridor is considered one of the key factors contributing to Azerbaijan's economic development, particularly in the expansion of the non-oil sector. Revenues from transit transport, the export of logistics services, and the creation of new jobs positively contribute to the diversification of the national economy. Despite the expansion of Azerbaijan's role in the Middle Corridor, certain organizational challenges need to be addressed. These include the harmonization of legal and regulatory frameworks among regional countries, the optimization of logistics tariffs, and the full integration of digital systems. Future-oriented plans also involve increasing investments in transport and logistics infrastructure, deepening international cooperation, and implementing innovative logistics solutions. Steps taken in this direction reinforce confidence that Azerbaijan will become one of the leading transit hubs within the Middle Corridor. Furthermore, the Middle Corridor expands Azerbaijan's opportunities for integration into regional and global markets, further strengthening the country's position within the international trade system. Such a digital approach facilitates enhanced intercountry coordination along the corridor, reduces administrative barriers, and increases the transparency of transport operations. Moreover, the modern infrastructure of the Baku International Sea Trade Port (BISTP), along with its cargo handling capabilities and logistics terminals, ensures the continuity of transport operations along the Middle Corridor. These capabilities enhance Azerbaijan's competitive advantage as a transit country and facilitate an increase in cargo flow volumes. The integration of the railway network with port and road transport further improves the efficiency of multimodal transport. In this regard, railway transport serves as a key mechanism ensuring the stable and flexible management of cargo flows along the Middle Corridor. It is well known that, from a geopolitical perspective, Azerbaijan is recognized as a reliable partner for transport operations along the Middle Corridor, owing to its stability, balanced foreign policy, and active participation in international transport cooperation. This factor also plays a crucial role in ensuring the corridor's continuous operation.

The Baku–Tbilisi–Kars railway and the Baku International Sea Trade Port (BISTP) ensure Azerbaijan's status as one of the main transit hubs along the Middle Corridor [8]. This overall infrastructure enables the effective integration of rail and maritime transport modes. Furthermore, digital platforms implemented by national logistics operators enhance the coordination of transport operations and contribute to the reduction of transit times. [9].

At the present stage, the Republic of Azerbaijan, with its favorable geostrategic location in the Caucasus region at the intersection of the North–South and East–West international transport corridors, has, through consistently implemented construction

and infrastructure policies, become one of the leading transport and transit hubs in the Euro-Atlantic area. Considering its geographical location and modern infrastructure capabilities, at the current stage, the implementation of regional projects cannot be realistically achieved without the participation of the Republic of Azerbaijan [1]. Over the years, the phased implementation of infrastructure projects, the construction of the Alat terminal, the adoption of a multimodal transport approach, the establishment of the Transit Transport Coordination Council and the Azerbaijan Transport and Communication Holding, as well as complementary state programs, have collectively ensured the comprehensive development of the country's transport system. Transit transport is currently carried out not only along the East–West and North–South routes but also via the North–West and South–West corridors. Following the completion of recent works on the Baku–Tbilisi–Kars railway line in May 2024, its annual transport capacity has reached 5 million tons, further strengthening the role of the "Iron Silk Road" in East–West cargo transportation. [2;3;4].

As noted, the statistical data for 2024 demonstrate a consistent growth trend in transit transport across all major directions. According to analyses based on official data from the State Customs Committee, transit shipments along the East–West, North–West, South–West, and North–South international transport corridors accounted for 97.0% of the total transit volume in 2024. During this period, 32% of transit shipments were along the North–West route, 29% along the East–West route, 22% along the South–West route, and 14% along the North–South route. This distribution is also visually represented in the 2024 diagram below (Fig.1).

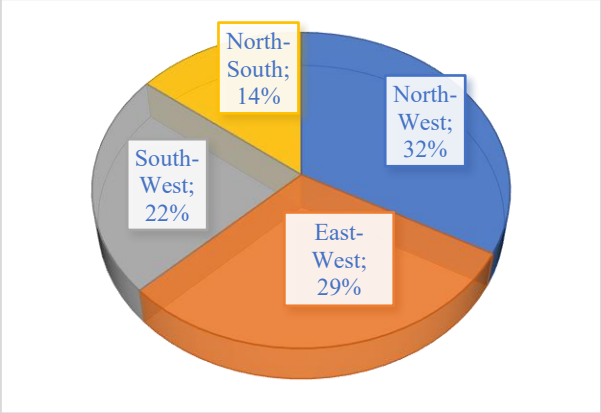

Fig. 2. Distribution of Transit Cargo Transport by Corridors, %

Source: State Customs Committee

As noted above, except for a 0.4% decrease recorded along the East–West transport corridor, transit shipments on other major corridors have shown a consistent upward trend. The relative decline in the East–West direction was mainly due to maintenance and modernization works on the Baku–Tbilisi–Kars railway line, which were fully

completed in May 2024. The volume of cargo transported along international corridors for 2022–2024 is illustrated in Diagram 2.

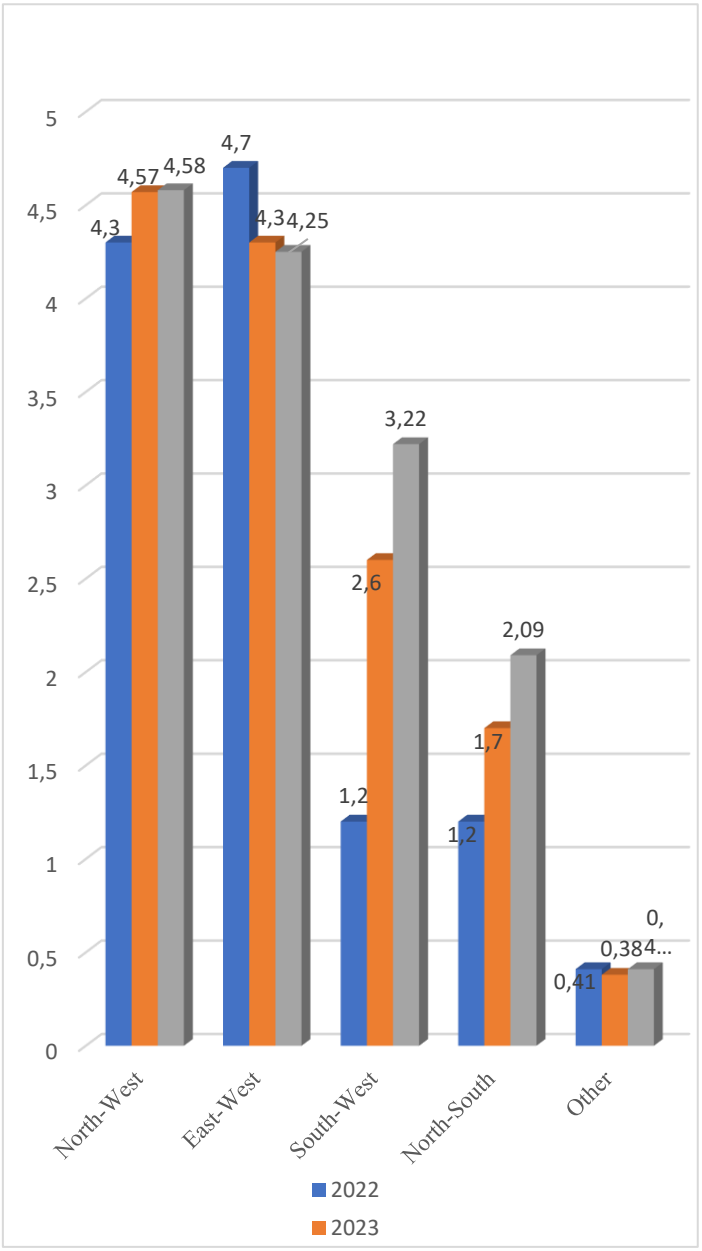

Fig. 3. Volume of Cargo Transported via International Corridors, million tons

Source: State Customs Committee

In the structural composition of transit cargo transported along international transport corridors by mode of transport, road transport accounts for 50%, while rail transport constitutes 48%. The remaining 2% corresponds to transit shipments carried out by air transport. In practice, maritime transport also actively participates in transit operations. However, since the segments of transport to and from ports are performed by road or rail, these shipments are statistically recorded under the shares of those respective modes. In this context, the current situation can be illustrated as shown in Diagram 3.

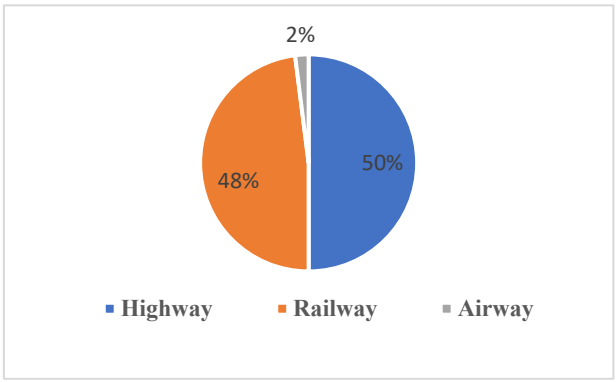

Fig. 4. Distribution of transit cargo by transport modes, in % (for the year 2024)

Source: State Customs Committee

Regarding the volume of transit cargo transported by various modes of transport, 12 million tons were carried in 2022, 13.4 million tons in 2023, and 14.5 million tons in 2024.

The volume of cargo transported along the Trans-Caspian International Transport Route (Middle Corridor) has demonstrated rapid growth in recent years amid structural changes in the global logistics system. In this context, the diversification of global supply chains and the increasing demand for alternative routes have further elevated the corridor's strategic importance. Comparative analysis of various international analytical reports indicates that transport volumes along this route approximately doubled between 2018 and 2024.

In 2018, the total cargo turnover along the Middle Corridor was estimated at approximately 7 million tons; this figure increased to 9 million tons in 2020 and reached 12 million tons in 2022. Transit cargo volumes amounted to 13.4 million tons in 2023 and 14.5 million tons in 2024. According to projected estimates, this indicator exceeded 16 million tons in 2025. Thus, the average annual growth rate is approximately 11–12%, which is considered one of the highest growth rates among international transport corridors. The main drivers of this growth are as follows:

- Expansion of trade relations between China and Europe;
- Increased demand for alternative routes amid rising geopolitical risks;

- Digitalization of multimodal transport;
- Optimization of transit capabilities across the Caspian Sea;
- Availability of investments directed toward the transport and logistics infrastructure of Azerbaijan and other regional countries.

According to analytical reports from international financial institutions, cargo turnover along the Middle Corridor is projected to reach 25–30 million tons by 2030. This growth outlook is associated with the diversification of East–West logistics routes across the Eurasian region. [10, 11].

It would be inaccurate to limit Azerbaijan's role in the Middle Corridor solely to its geographical location. In recent years, through institutional reforms and digital logistics initiatives, the country has made significant contributions to shaping a regional transit management model. In particular, the implementation of unified information exchange systems, the expansion of electronic customs platforms, and the development of multimodal coordination mechanisms have driven a transformative process of critical importance within Azerbaijan's transport and logistics ecosystem. [12].

The Role of Maritime Logistics in the Trans-Caspian Segment. The Trans-Caspian segment is considered a critical logistics link within the multimodal structure of the Middle Corridor. Ro-Ro and ferry transport across the Caspian Sea ensure the continuity of land transport routes and strengthen logistics synchronization among regional countries. The implementation of digital port management systems in this segment enables the automation of cargo handling operations and the optimization of vessel rotations. In particular, the integration of port logistics centers with the railway network is one of the key factors ensuring the seamless movement of containers. This approach reinforces the Middle Corridor's function as a sustainable multimodal logistics platform. [13, 14].

Strategic Impacts of Digital Transformation. At the present stage, the digital transformation of the transport sector is regarded not merely as a process of technical modernization but also as a strategic management tool and a key factor for sustainable economic development. In this context, the digitalization initiatives implemented within Azerbaijan's railway system hold particular significance among national priorities. These processes not only facilitate the rapid integration of the country's transport and logistics network into global markets but also optimize internal management mechanisms, improve service quality, and minimize time and resource losses. In recent years, systematic reforms have been carried out in Azerbaijan's transport and logistics sector, with notable progress achieved in the modernization and digitalization of railway infrastructure. Within this framework, the digital development strategy adopted by Azerbaijan Railways CJSC has established the transformation process as a priority, ensuring the consistent implementation of various innovative technological solutions.

In recent years, Azerbaijan Railways (ADY) has been implementing systematic and phased reforms aimed at integrating information technologies into transport and logistics operations. In particular, under the digital transformation program initiated in 2020, more than 40 innovative technological solutions have been introduced to manage and monitor passenger and freight transport and to enhance service qualityIn the freight transport segment, the implementation of the Freight Tracking System (FTS) platform

has significantly expanded the digital monitoring capabilities of logistics operations. Through this system, the movement of cargo wagons along routes, as well as loading and unloading stages, is continuously tracked, with data updated in real time, 24/7. As a result, the planning and coordination of transit shipments are conducted in a more transparent and flexible manner, thereby strengthening integration processes within international transport corridors. In particular, such digital tracking solutions provide substantial functional advantages for the management of shipments along the TRACECA corridor and the Middle Corridor. [15].

Comparative analysis indicates that the implementation of digital freight tracking systems reduces time losses within the logistics chain. For instance, according to statistical data published by the Community of European Railways (CER), countries equipped with such systems experience average cargo delivery times that are approximately 20–25% shorter. Azerbaijan's advancement toward these technological standards enhances its competitiveness in the regional transit and logistics sector and strengthens its position within international transport corridors.

In the freight transport segment, the electronic platform developed by ADY Express, a subsidiary of Azerbaijan Railways (ADY), enables the entire ordering process to be conducted in a fully digital environment. Through this platform, approximately 90% of cargo transport orders are accepted online, significantly enhancing the efficiency and transparency of logistics operations. The system integrates information on block train routing, the technical status of wagon fleets, and the status of customs declarations. At the same time, its integration with electronic TIR carnets, CMR documents, and e-customs applications accelerates documentation processes and improves operational efficiency for Europe–Asia–oriented shipments.

Furthermore, the "Single Window – Digital Transit" platform, implemented jointly by Azerbaijan Railways (ADY), the Baku International Sea Trade Port, Azerbaijan Caspian Shipping Company, and Azəravtoyol, facilitates the coordination of multimodal transport through a unified digital system. As a result of this integration, border and transit procedures for cargo along the East–West and North–South international transport corridors have been automated, significantly reducing process execution times. Notably, transit times along the Middle Corridor have decreased from 14 days to 9 days, clearly demonstrating the effectiveness of digital solutions in optimizing the logistics chain. Since 2022, Azerbaijan Railways (ADY) has begun implementing Big Data– and artificial intelligence–based analytical platforms in collaboration with international technology partners. Within this framework, projects carried out jointly with IBM and Oracle have enabled the optimization of train schedules, analysis of congestion zones, and the regulation of planned maintenance processes based on predictive models. The implementation of predictive maintenance mechanisms has allowed for the early detection of approximately 30% of potential failures, thereby minimizing the risk of accidents and enhancing operational reliability. [16].

In addition, the extensive deployment of real-time video surveillance and GPS tracking systems enabled comprehensive monitoring of 4,500 kilometers of railway lines by the end of 2024. Trackside sensor networks, automated barrier systems, and speed control mechanisms have made a significant contribution to enhancing safety and stability in the operation of both passenger and freight trains.

Collaboration with international financial institutions plays a particularly important role in the digital transformation process. Under the "Modernization of Azerbaijan Railways" project, financed by the World Bank and the European Bank for Reconstruction and Development (EBRD), nearly USD 400 million has been allocated for digitalization initiatives and infrastructure modernization. At the same time, the implementation of pilot projects aimed at harmonizing digital platforms within the frameworks of TRACECA and the Trans-Caspian International Transport Route has strengthened the coordination of international transit connections.

In the near-term strategic development plans, the automation of document circulation based on blockchain technology, the establishment of fully automated logistics centers, the deployment of electric locomotives powered by green energy, and the testing of automatically controlled train systems are envisioned. The implementation of these technological innovations is expected not only to reduce operational costs but also to enhance Azerbaijan's competitiveness as an international transit country.

As a result of the systematic application of digital technologies, Azerbaijan Railways (ADY) serves as the leading driver of the country's transport sector. Improvements in service quality, operational efficiency, and safety in both passenger and freight transport further strengthen Azerbaijan's strategic role within the global logistics and transit network.

At the same time, prioritizing green energy within digital management has contributed to strengthening ecological sustainability. For instance, in 2023, carbon emissions decreased by approximately 9%, and the share of electrified railway lines reached 63%, reflecting the progress achieved in this area. Although these indicators remain lower compared to advanced European countries, they demonstrate higher growth dynamics relative to some of the region's major railway systems. Initiatives such as the installation of solar panels and the transition to alternative energy sources have further reinforced the environmental component of the digital management model.

Overall, prioritizing digitalization in the railway sector is of critical importance, as it accelerates transportation, reduces operational costs, and fosters a healthy competitive environment. Solutions such as real-time tracking technologies (GPS, IoT), electronic cargo documents (e-CMR, e-TIR), digital coordination of customs and border procedures, and automated planning of transit operations enhance the efficiency of the logistics chain and accelerate the movement of transit cargo across regions. This approach lays the foundation for a management model based on digital logistics capabilities and facilitates the integration of the national transport system into international standards. [17].

It is well established that one of the strategic priorities facing Azerbaijan Railways (ADY) is to strengthen the country's position as a regional transit hub. In this context, digitalization enables cargo shipments along the Middle Corridor to be conducted more efficiently, transparently, and with enhanced traceability. Azerbaijan's favorable geostrategic position—as a key transport bridge connecting East with West and North with South—provides a significant advantage for achieving this objective. However, at the current stage, the full realization of transit potential is achievable not only through the development of physical infrastructure but also through its integration with digital technologies and intelligent management systems.

As a result of implementing digital solutions, over 1 million tons of cargo transported along the Baku–Tbilisi–Kars railway are currently monitored through digital tracking systems, with plans to double this volume within the next three years. At the same time, the implementation of digital integration platforms along the Azerbaijani segment of the Trans-Caspian International Transport Route continuously enhances the country's regional logistics value. The impact of digital transformation on operational performance is also substantial. Specifically, the average speed of trains on the railway network increased from 65 km/h in 2023 to 82 km/h, surpassing the Commonwealth of Independent States (CIS) regional average of 76 km/h. Notably, in certain sections of the Baku–Tbilisi–Kars line, freight train speeds have reached up to 100 km/h, demonstrating the synergistic impact of infrastructure and management technologies.

Significant improvements have also been observed in safety indicators. Between 2018 and 2023, delays caused by technical malfunctions decreased from 38% to 9%, a result attributed to the implementation of advanced diagnostics, sensor monitoring, and predictive maintenance systems. This approach has contributed to reducing operational risks in railway transport and enhancing service reliability.

Azerbaijan's location at the intersection of international transport corridors allows for the full utilization of transit potential through its digitalized railway network. For example, the reduction of transit time along the Middle Corridor from 16 days in 2017 to 8 days in 2024 can be regarded as an effective outcome of integrating digital planning and coordination systems into the logistics chain.

Within this framework, Azerbaijan Railways' (ADY) cooperation with the International Union of Railways (UIC) and the Trans-Caspian International Transport Route (TITR) structures is of particular significance. Being selected by these organizations as a pilot country for the implementation of the "digital transit model" underscores Azerbaijan's growing influence and its status as a reliable partner within the international transport and logistics system.

The implementation of digital management systems not only enhances operational efficiency but also strengthens environmental sustainability. Through optimal route selection and efficient energy use, approximately 10,000 tons of fuel savings and a reduction of up to 28,000 tons of carbon emissions have been achieved annually, representing a significant milestone in the transition to a "green logistics" model.

Economic indicators also confirm the positive impact of digitalization. In 2023, revenue from freight transport at Azerbaijan Railways (ADY) increased by 22% compared to the previous year, reaching 612 million AZN, with a significant portion of this growth attributed to the implementation of digital management tools.

In conclusion, the digital transformation implemented in Azerbaijan's railway sector extends beyond mere modernization of transport infrastructure. It plays a critical role in accelerating economic development, deepening regional integration, and strengthening the country's strategic position within the global transit and logistics system. Existing international experience and comparative indicators demonstrate that the adoption of advanced digital models further reinforces Azerbaijan's role as a leading logistics hub in the region.

Digital transformation in the development of global logistics systems encompasses not only the application of information technologies but also the fundamental modernization of transport management processes. In this context, Azerbaijan has adopted the implementation of digital logistics as a core strategic priority. [18]. Specifically, Azerbaijan is implementing measures to establish a unified digital system based on the "one-stop shop" principle, which aims to transition transport operations to an electronic environment. This approach enables the management of data on a single platform, streamlines operational processes, and reduces bureaucratic obstacles. [18].

Furthermore, digital transformation serves as a key factor in enhancing the efficiency of transport operations along the Middle Corridor. Within this framework, customs procedures and associated documentation processes are conducted electronically and at a faster pace, reducing time losses in the logistics chain and increasing the speed of cargo movement. Such digitized systems not only ensure transparency for long-distance shipments along the Middle Corridor but also enhance the route's international competitiveness. Digital transformation in the development of global logistics systems is not limited to the application of information technologies; it also represents a fundamental modernization of transport management processes. The integrated management of rail, maritime (Baku International Sea Trade Port), and road transport via a unified digital platform accelerates documentation (e-CMR) and customs procedures while minimizing human involvement. Digital tracking systems enable real-time monitoring of cargo, thereby reducing transit times and lowering costs.

The modernization of Azerbaijan's digital logistics infrastructure serves as an important driver for the intensification of interregional collaboration and the institutionalization of integrative coordination mechanisms. Turkish experts emphasize that the effective exchange of information and the implementation of digital tracking systems are essential for accelerating corridor operations and optimizing associated costs, thereby assigning particular priority to this issue. Such an approach reinforces not only national-level efficiency but also enhances coordination and connectivity among all countries involved in transport operations along the Middle Corridor. Moreover, digital transformation enhances the resilience and security of transport routes while simultaneously reducing logistical costs and enabling more efficient management of processes at each stage of transportation through comprehensive digital monitoring. Such an approach creates favorable conditions both for attracting investment and for improving the overall quality of logistics services in the region. The adoption of digital solutions along the Middle Corridor minimizes administrative barriers, increases the transparency of information flows, and facilitates more effective risk management. [3]. All these factors collectively enhance the corridor's competitiveness among international transport routes and thereby contribute to supporting Azerbaijan's long-term logistics strategy.

It is well established that cargo flows between Asia and Europe are primarily carried out through the East–West and North–South international transport corridors. In addition, the North–West and South–West directions, which have evolved on the basis of these principal routes, have increasingly gained practical significance, a trend that is also corroborated by relevant statistical indicators. However, in recent times, the Middle Corridor has gained particular relevance in terms of its existing advantages and

alternative transport options. From this perspective, the aforementioned route is regarded by both international organizations and individual states as a strategic and promising transport corridor. he UN's SPECA program, the Asian Development Bank (ADB), the CAREC initiative, China's Belt and Road project, as well as organizations such as the Organization of Turkic States, recognize the growing role of the Middle Corridor in regional and global logistics systems. Although currently approximately 3–5% of China–Europe freight is carried via this route, given the disruptions observed along the Northern Corridor and the evolving geopolitical and geoeconomic context, transit volumes along the Middle Corridor are projected to rise to 15–20% in the medium term, or even higher. [1].

The implementation of digital technologies has yielded the following outcomes:

- Acceleration of border-crossing procedures;
- Implementation of electronic documentation (e-CMR, eTIR)
- Real-time cargo tracking;
- Automation of information exchange within the logistics chain.

International studies in this area indicate that the implementation of digital platforms enhances the coordination of multimodal transport and facilitates the optimization of operational costs [11].

The increase in freight volumes along the Middle Corridor has had several positive impacts on the Azerbaijani economy. These effects can be systematized at both the macroeconomic and institutional levels as follows.

The increase in freight turnover leads to higher revenues generated from transit tariffs and logistics services. According to relevant estimates, each additional 1 million tons of transit cargo contributes approximately USD 50–70 million in additional income to the national economy. This process is accompanied by an increased contribution of the logistics sector to the state budget. The expansion of logistics services, port operations, railway transportation, and the development of logistics terminals play a significant role in fostering the growth of the non-oil sector. Consequently, the share of the transport and logistics sector demonstrates a growing trend and contributes to the diversification of the economy. The Middle Corridor also facilitates the deepening of economic integration among the countries of the region. Within this process, mechanisms of international cooperation play a crucial role. In particular, regional initiatives encompassing Central Asia and the Caucasus are aimed at strengthening coordination in the transport and logistics sector. [19].

The Middle Corridor possesses several strategic advantages compared to the Northern Corridor and maritime routes. Comparative analysis indicates that this route is regarded as more efficient in terms of multimodal flexibility, the level of digital integration, and the relatively shorter logistics transit times. While transit along the Northern Corridor typically takes an average of 20–25 days and maritime routes require approximately 30–45 days, the corresponding duration along the Middle Corridor ranges from 12 to 18 days. This time advantage is considered a significant factor in ensuring the operational efficiency of global trade flows. At the same time, the high level of multi-

modal integration enhances the flexibility of logistics processes and facilitates the coordination among different modes of transport. Digital transformation affects the efficiency of the Middle Corridor in three principal dimensions:

1. Operational efficiency effect – real-time data exchange accelerates the speed of freight transportation within the Middle Corridor;
2. Economic effect – the optimization of logistics costs enhances the competitiveness of freight operations along the Middle Corridor;
3. Institutional effect – unified digital platforms strengthen intercountry coordination along the Middle Corridor.

Scientific modeling indicates that the full implementation of digital logistics systems has the potential to increase overall efficiency along the Middle Corridor by 25–30%. This, in turn, further strengthens the route's competitive advantage in the international logistics market. According to forecast models, the development of the Middle Corridor can be assessed under three scenarios.

Innovative development scenario – Under this scenario, full integration of digital platforms and modernization of infrastructure would result in freight turnover reaching 30 million tons;

Moderate development scenario – As a result of expanded regional cooperation and the development of logistics hubs, this scenario envisions a steady increase in freight turnover to the level of 22–25 million tons.

Minimal development scenario – Due to persistent regulatory and legal barriers and coordination challenges, growth under this scenario is limited to a rate of 5–6%.

Risks and constraints. Despite the development dynamics of the Middle Corridor, several structural risks exist that affect its operational efficiency. These risks include a lack of coordination in tariff policies, limited vessel capacity in Trans-Caspian transportation, discrepancies in regulatory and legal procedures, and the incomplete full integration of digital systems. In addition, the asynchronous information exchange between customs and border control mechanisms of different countries causes delays within the logistics chain. To overcome these constraints, regional institutional harmonization and the implementation of unified digital transit standards are considered essential [20, 21].

Furthermore, for the effective implementation of the digital transformation process, ensuring uniformity of technological standards and resolving interoperability issues among participating countries are of particular importance. The lack of technical compatibility among different platforms can cause delays in information flows, thereby limiting the operational efficiency of logistics operations. For this reason, the implementation of unified digital protocols is considered a crucial condition for ensuring the long-term efficiency of the Middle Corridor.

Formation of the digital logistics ecosystem and institutional integration. The formation of a digital logistics ecosystem requires the establishment of comprehensive institutional mechanisms that ensure the coordination of transport processes through a unified management platform. Within this ecosystem, real-time information exchange is carried out among railways, seaports, road transport, and customs authorities. Such integration enables the synchronization of logistics operations, optimization of transit

times, and reduction of management costs. At the same time, the institutional-level implementation of the digital ecosystem facilitates strengthened coordination among participating countries along international transport corridors and supports the establishment of unified logistics standards.

Future development directions. In the near term, the sustainable development of the Middle Corridor prioritizes the expansion of the digital ecosystem, the implementation of blockchain-based electronic document circulation systems, and the establishment of automated logistics centers. In addition, the establishment of a unified tariff policy among participating countries and the strengthening of institutional coordination for multimodal transportation can further consolidate the corridor's position within the global logistics system. Forecasts suggest that the implementation of digital management models could further reduce transit times by up to 20% and lead to a significant increase in freight turnover [22, 23].

3 Conclusion

The analysis demonstrates that freight transportation via digital multimodal railway systems constitutes one of the key structural pillars of Azerbaijan's logistics framework. The modernization of the digital railway network, together with the Baku–Tbilisi–Kars Railway and the Alat Free Economic Zone, positions Azerbaijan as a leading transport hub in the region. This integrated system enhances Azerbaijan's role in international trade, reinforcing the Middle Corridor as a competitive and sustainable transit route. In the next phase, the deepening of digitalization and the expansion of international cooperation will further drive the sustainable development of the Middle Corridor.

Statistical and comparative analyses indicate that freight volumes along the Middle Corridor have exhibited a steady growth trend in recent years, further strengthening the role of railway transportation within Azerbaijan's logistics system. The implementation of digital multimodal transportation has contributed to the optimization of logistics costs and the enhancement of efficiency in international trade flows.

In conclusion, multimodal railway transportation integrated with digital technologies makes a significant contribution to reducing transit times, optimizing logistics costs, and enhancing the competitiveness of the Middle Corridor. This process strengthens Azerbaijan's position within the international transport and logistics system, expands its transit potential, and provides a substantial contribution to the sustainable development of the non-oil sector.

A consolidated scientific assessment indicates that the implementation of digital multimodal logistics models generates structural qualitative changes within Azerbaijan's transport system. This model not only promotes an increase in transit volumes but also facilitates the application of intelligent decision-making mechanisms in the management of logistics operations. Consequently, the Middle Corridor

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