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Article

Directions of Economic Development of The Railway Transport System

Khusan T. Bozorboyev*[1]

1. Independent researcher of Tashkent State University of Economics
* Correspondence: bozorboevkhusan@gmail.com

Abstract: This article explores the main directions that determine the development of the organizational and economic foundations of the railway transport system. A well-structured railway system is a key component of national infrastructure and economic growth. The development of railway transport depends on a variety of factors, including modernization, digitalization, logistics integration, investment strategies, and institutional reforms. The article identifies the core tasks essential to the economic development of the railway sector, such as improving operational efficiency, reducing transport costs, enhancing safety, and ensuring sustainable development. Key principles for the strategic integration of railway transport are also examined. These include public-private partnerships, regional and international cooperation, balanced tariff policies, and state support mechanisms. The goal is to create a flexible, competitive, and innovative transport system capable of meeting modern demands in both freight and passenger services. An imitation model of railway transport development is proposed to simulate the impact of various development strategies. This model allows for a detailed analysis of performance indicators, scenario planning, and strategic forecasting. The use of such a model enhances decision-making processes and supports evidence-based policy development. Overall, the article emphasizes the importance of a comprehensive and dynamic approach to railway development, aiming to achieve long-term efficiency, competitiveness, and sustainability.

Keywords: Organizational and Economic Basis of The Railway Transport System, Imitation Model, Delivery of Goods, Hierarchy of Tasks, Transport Complex, Railway Transport Infrastructure

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1. Introduction

The long-term sustainability of international economic cooperation largely depends on the development of transport infrastructure. Today, the total length of transport corridors around the world exceeds 50 million kilometers. According to the World Bank, the global transport market is worth 2.2 trillion US dollars, which is 6.8 percent of world GDP. In most countries, the transport sector accounts for 4-9 percent of GDP, and the employment rate in the labor market is around 3-7 percent [1]. The transport system is one of the main indicators of economic development, on the one hand, and is of strategic importance in ensuring the security of the country, on the other hand.

Extensive research is being conducted on the effective development of the transport network worldwide. In particular, serious attention is paid to increasing the economic importance of the railway transport system. Experts are studying the factors that affect the sustainable development of the economy through the expansion and modernization of

railway networks. Although it is noted that the railway transport system has a positive impact on many sectors of the economy, there is no unified approach to the exact mechanism and scale of this impact. Therefore, it is necessary to conduct more in-depth research into the economic development of the railway transport system and develop new strategic approaches to increasing its efficiency. In our country, special attention is paid to the rapid development of transport communications as an important sector of the economy. In this regard, the Development Strategy of New Uzbekistan for 2022-2026 also sets out priority tasks such as "developing the market and infrastructure of transport and logistics services, increasing the electrification level of railway infrastructure to 60 percent and accelerating the development of the road network, expanding "green corridors" and transit opportunities for foreign trade in the transport sector, and increasing the volume of transit cargo to 15 million tons"[2]. and the President of the Republic of Uzbekistan, in his Address to the Oliy Majlis, emphasized that "we need to develop the transport and logistics sector in order to deliver our products to domestic and foreign markets and reduce the cost of goods" [3]. This, in turn, indicates the expediency of conducting scientific research on the effective use of the country's transport and transit potential and modern delivery technologies, as well as improving the model of economic development of the railway transport system.

Analysis of Literature on The Topic

The theoretical and methodological foundations of the development of the railway transport system are reflected in the scientific research of a number of domestic and foreign scientists. According to the English economist Anthony Venables, the transport complex is understood as a set of sectors of the national economy that specialize in satisfying the needs of social production in the transportation of goods and passengers [4].

According to D. Bowersox, special attention is paid to the problems of organizing multimodal and intermodal freight transportation, including the issues of the advantages and economic efficiency of organizing freight transportation compared to traditional methods. At the same time, the author emphasizes the transport system, which includes transport networks, vehicles and transport companies [5].

According to G. Samadov, A. Zoxidov, A. Gulamov and M. Ravshanov, among the scientists of our country, "transport system is a complex of transport modes and infrastructures that are interconnected in the process of delivering goods and passengers to their destination, i.e. interdependent transport sectors, labor resources, and the management system of all types of transport for the purpose of effective management of the country's economy" [6].

Railway infrastructure development is pivotal for enhancing connectivity and economic growth. However, challenges like inadequate infrastructure and high accident rates persist. For instance, in Russia's Arctic zone, the development of railway transport faces significant hurdles due to harsh climatic conditions and infrastructural limitations [7].

Technological advancements are transforming railway systems globally. Emerging innovations in rail freight include machine learning, predictive maintenance, and alternative fuels, aiming to reduce emissions and improve safety. In North America, digital transformation through telematics is enhancing freight rail efficiency [8].

The resilience of railway systems is crucial, especially in the face of disruptions. A comprehensive review defines resilience in railway transport as the ability to provide effective services under normal conditions and to resist, absorb, and recover from disruptions. Additionally, integrating climate resilience into infrastructure planning is becoming increasingly important [9].

Rail transport is recognized for its environmental benefits, offering lower emissions compared to road transport. Innovations like hybrid trains and the use of alternative fuels

are further enhancing its sustainability. Moreover, investments in rail infrastructure can stimulate economic development by improving trade efficiency and reducing transportation costs [10].

Effective development of railway systems requires strategic integration with other modes of transport and supportive policy frameworks. Public-private partnerships and international cooperation are essential for creating a competitive and innovative transport system.

2. Materials and Methods

The results of scientific research by national and foreign scientists engaged in analyzing the problems of effective development of the railway transport system served as the theoretical and methodological basis of this study. Abstract and analytical observation, comparative and factor analysis, indicative, sample observation, comparison, economic and statistical and other methods were used in the preparation of the article.

3. Results and Discussion

The economic development of the railway transport system is currently gaining relevance on a global and local scale. In a modern economy, transport infrastructure, in particular, the railway system, is one of the most important factors in ensuring the country's economic growth and increasing the efficiency of freight and passenger transportation. Rapid urbanization, the development of global trade relations, and increasing logistics requirements create the need to increase the efficiency of the railway system. Also, changes in world markets, in particular, the increasing demand for energy efficiency and environmental requirements, require the modernization of the railway network and the introduction of innovative solutions. Due to its strategic location, its role in international transport corridors, and the need to expand export-import processes, Uzbekistan pays great attention to the development of the railway system. For the sustainable development of the country's economy, it is necessary to reduce freight transportation costs, improve logistics services, and strengthen integration with international transport corridors. In this regard, the introduction of high-speed trains, the introduction of automated control systems using digital technologies, and the development of modern terminal infrastructure are of great importance.

Another important aspect of the development of the railway transport system is environmental sustainability and energy efficiency. Compared to other types of transport, railway transport consumes less energy and has a low carbon footprint. Therefore, the country's competitiveness in the transport sector can be increased by using renewable energy sources, developing the railway system based on "green technologies" and strengthening foreign economic relations.

It is also important to increase export potential by expanding transport corridors and improving logistics chains in freight transportation. Connecting Uzbekistan's railway network to international corridors and developing transport cooperation with neighboring countries will serve to increase trade turnover. Therefore, the economic development of the railway transport system is of great importance not only for improving the domestic transport infrastructure, but also for strengthening regional and international economic ties. Conducting research to assess the place of the railway network in the country's economy, determine the prospects for the development of the network, study and forecast trends, directly affect the medium and long-term strategy of the railway network, its current policy, determine the need for material and technical resources, labor and financial condition, and develop its long-term strategy.

The level of development of railway transport directly affects the development of the country's economy, since transportation costs included in the final price of products and

the ability to ensure timely delivery are important competitiveness factors for local enterprises.

Therefore, studying the main performance indicators of the railway transport system, the stages of development of transport and logistics infrastructure, and developing recommendations for eliminating existing problems in the system are one of the main issues today. In Uzbekistan, railway transport accounts for 5.3% of domestic freight traffic and 92.5% of transit traffic.

The main commodities offered for transportation include coal, grain, oil, ore, mineral fertilizers, and other bulk bulk and liquid cargoes, see Table 1. The table shows that the main part of the cargo transported by rail is mining industry products (coal, oil and oil products, ferrous and non-ferrous metals, ores).

Table 1. Volume of Transportation of Certain Types of Cargo in Railway Transport Thousand Tons.

Indicators	2017	2018	2019	2020	2021	2022	2023
Coal	3 971,0	3 712,7	442,9	5 632,6	5 231,0	4 459,2	5 673,8
Oil and oil products	10 773,9	10 661,4	10 961,9	6 769,4	6 156,2	5 951,6	5 372,2
Black and non-ferrous metals	959,5	887,2	812,7	1 079,3	1 280,9	1 113,2	1 054,9
Chemical and mineral fertilizers	4 304,2	4 381,3	4 049,8	3 451,4	3 602,6	4 210,9	4 641,7
Construction materials	7 728,7	6 690,3	6 329,4	5 475,3	5 575,5	4 071,9	5 607,7
Cement	5 325,7	5 514,1	4 846,4	4 866,4	5 112,0	5 044,5	4 582,1
Wood products	46,3	21,2	18,9	27,1	31,2	19,7	23,0
Grains and grain products	1 266,9	1 269,6	1 662,4	1 737,1	1 645,2	1 898,6	2 000,4
Total	**34 376,2**	**33 137,8**	**29 124,4**	**29 038,6**	**28 634,6**	**26 769,6**	**28 955,8**

The delay in the delivery of goods is explained by the fact that problems persist at the stopping points of the rolling stock, which indicates the need to increase the operational efficiency of the rolling stock in order to ensure the effective implementation of the tasks assigned to it by railway transport. Table 2 presents data describing the use of certain types of working, freight, and rolling stock in general use.

Table 2. Railway Transport Performance Indicators in Uzbekistan.

Indicators	2018	2019	2020	2021	2022	2023
Locomotive productivity, gross tkm per day	947	1015	1056	1110	1190	1200
Freight car productivity, t/km net per day	30	30,4	30,8	31,1	32	32,2
Average speed of the freight train on the section, km/h	32	31	30,6	31,3	30	31
Technical speed of the freight train, km/h	39,3	39,7	40,4	40,7	41,1	41
Average cycle time of a freight car, per day	4,6	5,78	4,2	4,1	3,84	3,9

Over the past fifteen years, while the volume of freight transportation has increased by 27% and the number of passengers by 86%, it can be observed that the inventory of mainline locomotives used in transportation has decreased by 18.2% during this period. The decrease in the section speed of freight trains by 9.6% has led to a certain decrease in the throughput capacity of railway transport.

In 2016-2021, the average technical and section speed of freight trains is significantly lower than the established speed, and in our opinion, the following factors have a negative impact on the speed of trains:

1. Freight trains are late for the specified time;technical malfunctions at stations
2. Increased technological time standards for trains at stations
3. Increased time standards for troubleshooting at stations
4. Negative impact on workers associated with the movement of freight trains.

In 2022, the total volume of investments in the transport system amounted to 6%, which is a 2.5-fold decrease compared to 2015, while the volume of investments in the main artery of our country's economy - railway transport - increased by 24% in 2020-2022 and decreased by 18% in 2021-2023, see Table 3. The main reason for this can be explained by the suspension of investments in some projects in order to avoid a decrease in solvency.

Based on the results of the analysis, the main part of the investments attracted to Uzbekistan Railways JSC in 2023 was accounted for by foreign loans guaranteed by the Republic of Uzbekistan - approximately 40%, followed by private funds - 35%.

In our opinion, the following are the main directions for attracting investments in the railway transport system:

Development of new forms of cooperation with foreign transport and logistics companies.

Participation in investment projects through the sale and lease of assets of Uzbekistan Railways JSC, and attraction of real estate.

The use of public-private partnership mechanisms that allow combining the forces of the state and business in implementing the tasks of developing the country's railway network.

Table 3. The Volume of Investments Attracted to The Activities of Uzbekistan Railways JSC Million Dollars.

Project Initiator And Funding Sources	**Years**					
	2018	**2019**	**2020**	**2021**	**2022**	**2023**
Community funds	379,28	386,77	251,40	252,99	212,05	205,64
State budget	109,88	85,11	61,64	72,92	66,28	68,04
Foreign loans guaranteed by the Republic of Uzbekistan	212,12	133,61	126,86	81,91	126,55	226,99
Commercial bank loans	50,0	0,0	17,41	47,03	20,00	1,36
Foreign direct investment	0,0	12,60	29,78	61,48	53,66	51,25
Funds of the Republican Fund for Reconstruction and Development of Uzbekistan are being used for the calculation.	79,90	116,08	40,23	86,92	36,62	22,73
Total	**831,18**	**734,17**	**527,32**	**603,25**	**515,16**	**576,00**

The wide range of transport and logistics services and their possible qualitative variations, the impact on the competitiveness of services and the cost of goods, as well as other factors, require the enterprise to have a clear, specific strategy in the field of providing logistics services to consumers [11]. A comparative analysis of freight transportation costs by type of transport is presented, see Table 4.

If we pay attention to the comparative price analysis, we can see that the costs of our country's manufacturers are somewhat higher. For example, to deliver one standard wagon load (60 tons of textile products) per kilometer, you will have to pay $ 7.29 for railway transport services. The same indicator is $ 4.24 in neighboring Kazakhstan, $ 3.65 in Kyrgyzstan, $ 6.83 in Tajikistan, and $ 2.65 in Turkmenistan. This has a negative impact on the competitiveness of our country's railway transport in international transportation [12].

Table 4. Comparative Analysis of Freight Costs In Modes of Transport.

The Price of Transporting 20 Tons of Cargo Per 1 Km by Car (In The Example Of Textile Products)				
Uzbekistan	**Kazakhstan**	**Kyrgyz republic**	**Tadjikistan**	**Turkmenistan**
2,45 $	1,70 $	1,55 $	1,35 $	0,92 $
The cost of transporting 1 standard wagon of cargo per 1 km (up to 100 km)				
Uzbekistan	**Kazakhstan**	**Kyrgyz republic**	**Tadjikistan**	**Turkmenistan**
7,29 $	4,24 $	2,65 $	6,83 $	2,65 $
Number of necessary procedure documents for export and import				
10/11	10/12	9/10	11/12	6/5

It should be noted that today the share of private companies in freight transportation in the country is steadily increasing. Transportation carried out by rolling stock of private companies is formed under the influence of the state tariff system. Accordingly, the most important conditions for the structural reform of railway transport were:

a. Ensuring uninterrupted operation and safety of the transportation process;
b. Preserving the integrity of the economic space and improving transport connections with other foreign countries;
c. Appropriately combining state regulation and self-management mechanisms of the market economy.
d. In this regard, it is advisable to implement the following measures:
e. Creation of a comprehensive system of legal and economic relations that would encourage cost reduction by each participant in the transportation process;
f. Ensuring legal responsibility between freight carriers, rolling stock owners, cargo owners, as well as other organizations participating in the transportation process;
g. Gradual separation of monopoly and competitive types of activity;
h. Distinction between budgetary and extra-budgetary financial resources in terms of accounting and methods of their use.

At the same time, some types of railway transport activities, namely infrastructure, main railway network services, power supply systems and facilities, locomotive management, etc., have retained their monopoly character for technological reasons. The reorganization of the railway transport of Uzbekistan has created the initial conditions for the qualitative management of this sector and the introduction of an optimal market structure.

The development of a simulation model of the economic development of the railway transport system is of great importance for improving transport infrastructure, effective management of logistics processes, and optimization of freight and passenger

transportation services [13]. When developing such a model, the current economic state of the railway system, the dynamics of transport flows, and factors affecting the infrastructure should be taken into account. The simulation model allows testing various scenarios in real market conditions and facilitates making strategic decisions on the targeted direction of investments. The model should also be aimed at reducing transport costs, improving service quality, saving time in transportation and ensuring sustainable development. Economic efficiency can be increased by improving logistics chains in the railway system, introducing technological innovations and using digital management methods [14]. At the same time, the model serves to develop a mechanism for public-private cooperation, taking into account the needs of transport operators, cargo owners and passengers. Therefore, the development of a simulation model can be considered an effective tool for adapting the railway system to market requirements and its sustainable development.

1. Implementation of the Digital Twin model. By creating a real-time digital copy of the railway infrastructure and transport processes, the existing loads, traffic dynamics and risks in the transport network are constantly analyzed. This solution will optimize maintenance and logistics processes.
2. Development of an intelligent traffic management system. It is proposed to integrate a traffic management system based on artificial intelligence into the model under development. This system will help in automatic planning of train movements, distribution of freight and passenger flows, prevention of delays and efficient use of resources [15].
3. Addition of energy efficiency and "green transport" elements. The simulation model proposes to introduce mechanisms for using renewable energy sources to ensure the environmental sustainability of the railway transport system. For example, costs can be reduced by installing solar panels at stations and introducing regenerative braking systems.
4. Using Blockchain technologies in freight transportation. In order to ensure transparency in freight transportation processes on the railway and reduce unnecessary paperwork, it is proposed to monitor the movement of goods using blockchain technologies. This will increase security during freight transportation, reduce corruption, and ensure timely delivery of goods.
5. Automated risk analysis and forecasting. It is proposed to integrate a forecasting system into the simulation model, through which risks affecting train movement and infrastructure can be assessed in advance. For example, traffic safety can be ensured by taking into account weather changes, technical malfunctions, and loads.
6. Introducing a dynamic tariff system. A dynamic tariff system for transport services can be developed in the model. This system will automatically set prices based on supply and demand. This is especially useful in increasing the profitability of freight services and offering the most favorable tariffs to freight carriers.
7. Strengthening the integration of rail, road and air transport. The simulation model proposes to develop a mechanism for integrating rail transport with other modes of transport. In this direction, it is possible to improve logistics processes by creating cargo redistribution centers at railway stations and integrating transport systems.
8. Introducing a remote monitoring and diagnostics system. It is proposed to introduce remote sensors and "IoT" (Internet of Things) technologies to monitor the condition of railway infrastructure in real time and automate technical maintenance. This system will monitor the technical condition of railway road surfaces, wagons and locomotives [16].
9. Using AI algorithms for optimal distribution of freight flows. It is proposed to introduce artificial intelligence algorithms for cost-effective management of transport corridors and optimal distribution of freight flows. This system accurately assesses

the demand for freight transportation and allows you to select the most efficient routes.

10. Development of public-private sector cooperation. It is proposed to strengthen public-private sector cooperation for the more effective development of the railway transport system. In this regard, it is important to improve the mechanisms for attracting private sector investment, modernize infrastructure, and ensure the active participation of private operators in the market.

A number of proposals have been developed to improve the simulation model for the economic development of the railway transport system, including innovative technologies, digitalization, environmental sustainability, and increasing logistics efficiency. Improving the freight and passenger transportation system, introducing digital management mechanisms, and optimizing network infrastructure will create opportunities to reduce costs in the railway system and improve service quality. By implementing these proposals, the railway transport system can become efficient, safe, and profitable.

4. Conclusion

In order to improve the simulation model for the economic development of the railway transport system, a number of proposals have been developed to improve innovative technologies, digitalization, environmental sustainability and logistics efficiency. By improving the cargo and passenger transportation system, introducing digital control mechanisms and optimizing the network infrastructure, it will be possible to reduce costs and improve the quality of service in the railway system. By implementing these suggestions, the rail transport system can be efficient, safe and profitable.

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