

American Journal of Economics and Business Management

Vol. 9 Issue 3 | **pp.** 155-163 | **ISSN:** 2576-5973

Available online @ https://www.globalresearchnetwork.us/index.php/ajebm

Article

Mechanism for Managing Environmental and Economic Risks in Railway

PhD Rakhimov Khasan Shukurjonovich*[1]

1. Associate Professor, Department of Economics, Namangan State Technical University

* Correspondence: hasanboyrahimov1990@gmail.com

Abstract: This study examines environmental and economic risks in the railway transport system from the perspective of industrial economics. The research identifies inefficiencies in resource utilization, weak integration of environmental factors into economic planning, and limited adaptability of management systems to modernization processes. The study analyzes structural weaknesses in regulatory frameworks, financing mechanisms, infrastructure policies, and strategic planning within the railway sector. To address these challenges, the research proposes an integrated management mechanism based on ESG principles, including green KPIs, environmental auditing systems, green financing instruments, and technological modernization through electrification and renewable energy integration. Analytical calculations indicate that implementing these mechanisms can reduce operational costs by approximately 20–23%, improve energy efficiency, and enhance environmental sustainability while strengthening the competitiveness and long-term development of the railway transport network.

Keywords: Environmental risk; Railway transport management; Industrial economics; ESG framework; Green transport; Energy efficiency.

Citation: Shukurjonovich R. K. Mechanism for Managing Environmental and Economic Risks in Railway. American Journal of Economics and Business Management 2026, 9(3), 155-163.

Received: 19th Dec 2025
Revised: 30th Jan 2026
Accepted: 20th Feb 2026
Published: 08th Mar 2026

Copyright: © 2026 by the authors. Submitted for open access publication under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/4.0/)

Environmental and economic risks emerging in the railway transport system are primarily associated with inefficient utilization of sectoral resources, the incomplete integration of technogenic consequences into economic calculations, and the limited adaptability of the management system to modernization processes [1], [2]. From the perspective of industrial economics, these risks represent systemic problems that affect the production infrastructure of the railway network, energy consumption, the cost structure of transport services, investment potential, and overall competitiveness[3].

Analytical assessments indicate that the existing management mechanisms—serving as a central component in the governance of large-scale industrial infrastructure—have gradually lost their functional flexibility[4]. Current management practices are predominantly focused on optimizing operational expenditures, while the criteria that determine the environmental efficiency of capital investments are largely absent from contemporary planning procedures[5]. Consequently, despite the introduction of technical modernization, digitalization, and energy-saving systems, the profitability level of network operations and the payback period of capital investments have not produced the expected outcomes.

Another significant source of the problem lies in the fact that ecological risks within the current management structure are not treated as strategic threats but rather as secondary costs [6]. In international practice, particularly within transport economics platforms developed based on ESG standards, parameters such as carbon emissions, waste recycling, the degree of technological obsolescence, and energy consumption coefficients are evaluated as independent elements of the cost structure [7]. In the railway system of Uzbekistan, however, the absence of such indicators in economic calculations and the "blind" determination of expenditures further intensify weaknesses in the formation of competitive transport services.

This situation also exerts a negative influence on the macroeconomic functions of the transport network. Inefficient resource utilization and elevated environmental emissions undermine the efficiency of industrial logistics, export capacity, and regional cross-border transit services [8]. One of the most critical criteria in industrial economics—the stability and continuity of the production function—cannot be maintained under conditions characterized by high-risk, technologically outdated, and cost-intensive railway infrastructure [9]. In other words, these risks increasingly manifest not only as environmental concerns but also as factors that disrupt the continuity of economic cycles.

In addition, the absence of internal organizational mechanisms that ensure resource efficiency, as well as the insufficient integration of innovations into management decision-making at the institutional level, represents a notable structural weakness [10]. Within existing investment projects, evaluation criteria for capital investments from the perspective of environmental and economic returns have not been adequately developed. As a result, the attractiveness of "green investments" remains extremely limited [11]. This, in turn, restricts private sector participation in the development of transport infrastructure and leads to an increasing dependence on continuous budgetary subsidies [12].

The formation and deepening of environmental and economic risks in railway transport indicate that the current management mechanisms have weakened in their capacity to maintain a balance between internal resources, capital allocation, and environmental factors within the network [13]. From the standpoint of industrial economics, this condition highlights the necessity of developing a restructured system of mechanisms capable of organizing technological modernization in the transport sector, minimizing costs, and integrating environmental safety into a sustainable development strategy. This issue will be further elaborated in subsequent sections through practical solutions and innovative models.

In the process of forming a management mechanism aimed at reducing environmental and economic risks in railway transport, it is essential to conduct a systematic assessment of its current state. The effectiveness of any mechanism depends on the degree to which its structural components are integrated and oriented toward strategic objectives. Under current conditions, however, the existing management mechanisms remain fragmented, the level of intersectoral coordination is low, and an institutional platform consistent with international standards has not yet been fully established [14].

More specifically, the key elements responsible for resource management, environmental risk assessment, and investment decision-making operate separately and without structural interconnection. This situation negatively affects not only economic efficiency but also the sustainable development, competitiveness, and ecological transformation processes of the transport network. For example, the inability of technical operational policies to rely on metrics related to energy efficiency or SO_2 emissions, the lack of financial mechanisms supporting "green projects," and the absence of even theoretical planning for the integration of renewable energy sources into infrastructure clearly illustrate these systemic deficiencies.

Furthermore, the lack of a professional approach to environmental threats within the sector, the limited implementation of ESG requirements, insufficient human capital

capacity, and weak monitoring mechanisms further deepen the vulnerability of the existing management system [15]. The main structural components of the current mechanism and their operational challenges are presented in the analytical table below, highlighting key deficiencies within the system, integration problems, and the urgent need for reforms (Table 1).

Table 1. Elements of the Management Mechanism for Reducing Environmental and Economic Risks in the Railway Sector [1].

№	Elements	Content and Existing Problems
1.	Regulatory and Legal Framework	There are no clear mechanisms linking environmental and economic aspects; existing regulatory acts are not aligned with ESG requirements.
2.	Financing Mechanism	There are no dedicated funds aimed at eco-technologies, and the practice of "green" investments or green bonds has not yet been established.
3.	Technical Operation Policy	The technical fleet lacks an environmental passport; energy efficiency is not assessed, and technical maintenance is not conducted based on ESG criteria.
4.	Management and Monitoring System	There is no regular evaluation mechanism for waste management, SO_2 emissions, or environmental risk indicators.
5.	Infrastructure and Resource Policy	The level of electrification is low, dependence on diesel fuel remains high, and mechanisms for supplying renewable energy are weak.
6.	Human Resources and Institutional Solutions	There is a shortage of qualified specialists in environmental risk management, and ESG-oriented training programs have not been implemented in practice.
7.	Production and Service Structure	Hidden costs (such as energy losses and the absence of waste recycling systems) are not reflected in cost estimates.
8.	Strategic Planning	There are no clearly defined "green transport" objectives, international ESG index alignment, or a long-term environmental transformation strategy.

The table presented above indicates that although the main elements of a management mechanism intended to reduce environmental and economic risks in the railway sector formally exist, the interconnections among these elements remain weak, and their strategic coherence is almost absent. This situation limits the integrated and effective functioning of the mechanism, causing risk mitigation efforts to depend on localized solutions rather than systematic approaches.

First, an organic linkage between the regulatory and legal framework and the practical management system has not been established. Requirements related to ESG indicators—which allow environmental and economic safety criteria to be defined on a measurable and calculable basis—are not reflected in operational regulations and policy decisions. Within the financing mechanism, investment methods based on environmental efficiency (such as green finance, eco-subsidies, and grants) are either absent or remain at a purely theoretical level.

The current state of technical operation policy is primarily aimed at maintaining ongoing operations rather than eliminating technological obsolescence. As a result, repair costs, energy losses, and maintenance expenditures continue to increase. The absence of ESG-based technical assessment methods (for example, CO_2 emission accounting or methodologies such as LCOE and TCO) hinders the achievement of long-term economic efficiency in the sector.

[1] O‘rganilgan manbalar asosida muallif tomonidan shakllantirilgan.

In the management and monitoring system, digital platforms for assessing environmental and economic threats have not yet been introduced. This situation limits the possibility of using key indicators—such as the age structure of rolling stock, emission capacity, energy consumption, and maintenance returns—in strategic decision-making processes. The existing monitoring format relies primarily on regulatory and technical reporting and is not integrated with ESG reporting systems.

Significant problems also exist in infrastructure and resource policy. The level of electrification remains low, dependence on diesel fuel is high, and mechanisms for supplying renewable energy sources are insufficient. Consequently, the cost of transport services increases, financial burdens intensify, and environmental risks expand.

The sector also lacks sufficient capacity in terms of personnel policy and institutional solutions. There is a shortage of specialists with expertise in identifying environmental risks, evaluating projects based on ESG principles, and conducting technical deficiency analyses. The absence of ESG-oriented training programs further slows the implementation of systemic solutions.

Hidden costs—such as energy losses, the absence of waste recycling systems, and regional environmental risk points—are not reflected in the structure of production and services. This reduces the economic transparency of railway services for customers, logistics operators, and investors.

Most importantly, strategic planning has not been conceptually aligned with ESG transformation or the objectives of "green transport." Therefore, the implementation of modern reform mechanisms aimed at ensuring sustainable development in the sector requires a deep institutional restructuring of these weakly integrated components. A fundamental revision of the mechanism will be proposed in the subsequent sections of the dissertation based on scientific justification.

The systematic reduction of environmental and economic risks in railway transport requires not only identifying and describing existing problems but also establishing functional mechanisms capable of addressing them. At the current stage, the primary task is to institutionally define the structural elements of the management mechanism responsible for risk governance and to reformat them in accordance with practical conditions.

First, it is necessary to introduce a "green KPI" system as the central axis of the mechanism. Through this system, separate environmental and economic efficiency indicators should be developed for each technological process, infrastructure element, and unit of rolling stock. Parameters such as SO_2 emissions, energy consumption, service life, and the proportion of resource recycling should be evaluated in relation to overall operational outcomes. When integrated into the corporate governance system, these KPIs will establish a scientific and practical foundation for evaluating organizational efficiency.

The second important mechanism involves establishing an environmental auditing system and an "environmental passport" framework. By collecting data on air quality, noise levels, waste types, and energy sources for each station, depot, and mainline section, and presenting this information in digital format, it becomes possible not only to strengthen monitoring but also to support more informed decision-making in future planning processes. The implementation of such a system will facilitate a transition toward a preventive management model.

The financial foundation of the mechanism should consist of green bonds, eco-subsidies, and leasing systems. These instruments would enable the replacement of obsolete rolling stock and low-efficiency equipment with modern technologies characterized by reduced emissions. Currently, the primary barrier to technological renewal in the railway fleet lies in high costs and long investment payback periods. Therefore, attracting international institutions (such as EBRD or AIIB) or establishing

domestic green investment platforms could provide effective solutions. For projects demonstrating high environmental efficiency, interest-free loans or carbon credit systems could increase financial returns.

At the same time, one of the most important institutional components of the mechanism is the establishment of "green technology clusters" based on public–private partnerships. Through these clusters, it becomes possible to expand the local production, maintenance, and servicing of locomotives, electric locomotives, power units, and infrastructure equipment. The domestic production of energy-efficient equipment can reduce import costs while shortening investment payback periods. In addition, these clusters would integrate education, technical services, and technology transfer processes directly with sectoral specialization.

By institutionalizing these mechanisms as an integrated system, the contradiction between environmental risks and economic weaknesses can be effectively addressed. Each mechanism contributes to balancing environmental impact with economic efficiency. As a result, production costs can be reduced, service quality improved, and service life cycles extended. When legal, technical, financial, and information systems operate in harmony, the full effectiveness of the mechanism becomes evident.

Institutional reforms aimed at reducing environmental and economic risks in railway transport require a systematic, integrated, and strategic approach. In this process, the management mechanism should be viewed not merely as a regulatory basis, technical framework, or financial instrument, but as a multi-level and cross-sectoral functional structure. In particular, the formation of a mechanism aligned with ESG (Environmental, Social, Governance) criteria plays a decisive role not only in ensuring environmental sustainability but also in enhancing efficiency in industrial economics, increasing investment attractiveness, and strengthening the competitiveness of freight transport services.

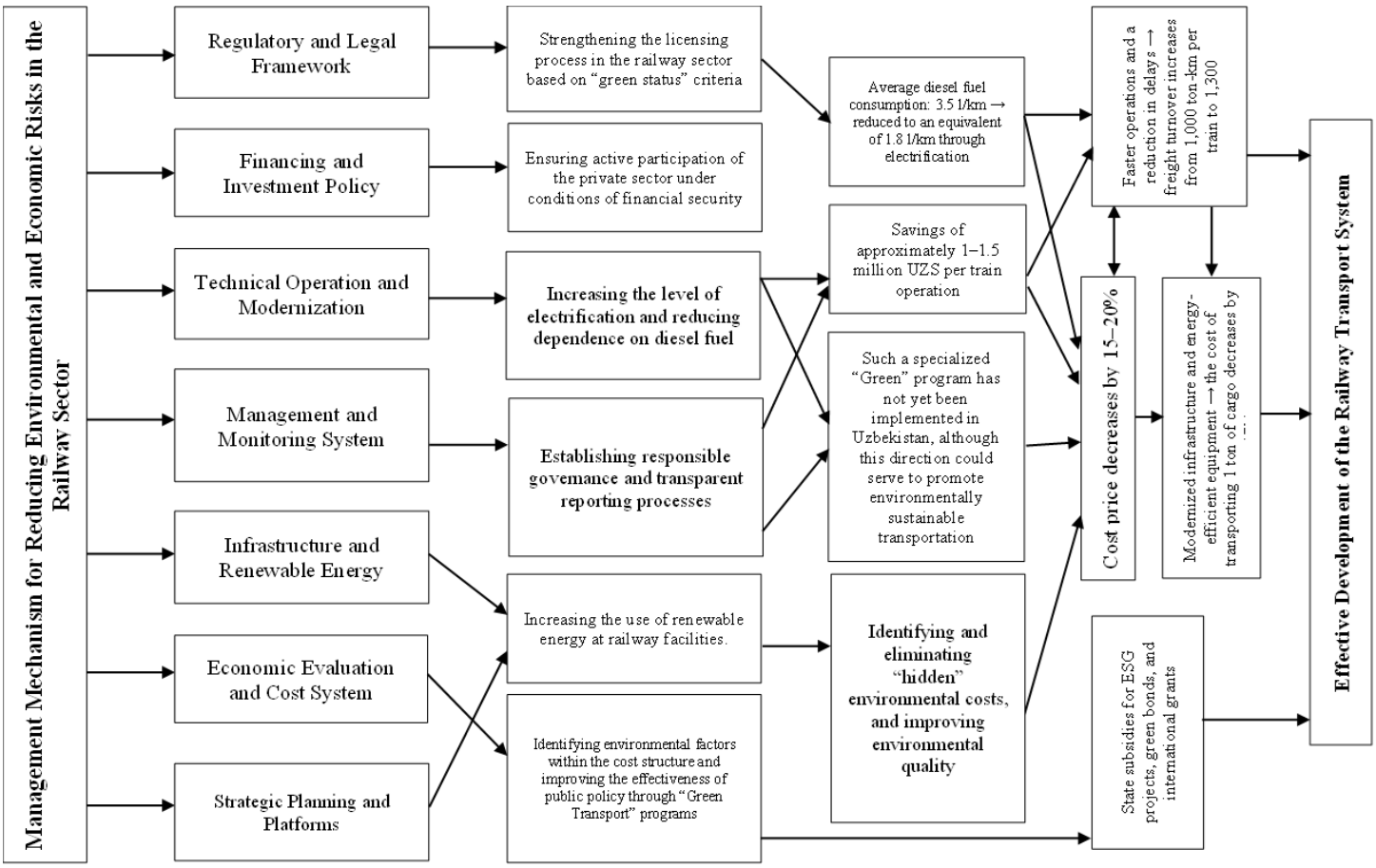
The proposed conceptual mechanism is structured around eight core elements, each performing a specific function while maintaining mutual coherence with the others. The mechanism encompasses components ranging from regulatory and legal frameworks and financing policies to infrastructure development, management systems, technical operations, and strategic planning. Through these elements, it becomes possible to implement "green transport" objectives in practice, reduce SO_2 emissions, optimize energy expenditures, and integrate waste management into economic efficiency calculations.

Furthermore, the mechanism envisages not only technical and financial solutions but also the restructuring of economic evaluation and cost accounting systems in accordance with ESG requirements. Through the impacts generated by each element, as well as the resulting efficiency levels and analytical calculations, it is theoretically possible to reduce costs within the railway network by 15–20 percent, enhance cost transparency, minimize environmental risks, and improve service quality.

Figure 1 below presents the structure of the management mechanism designed to reduce environmental and economic risks in the railway sector, including the interconnections among elements, economic outcomes, and strategic impacts in a systematic format (Figure 1).

The analysis of the structure and functional relationships within the proposed mechanism model demonstrates that reducing environmental and economic risks in railway transport cannot be achieved solely through technological modernization. Instead, it requires the coordinated functioning of the organizational and economic components that constitute the system. This mechanism not only systematizes existing problems but also provides practical pathways for addressing them from both economic and institutional perspectives.

First, the energy efficiency components of the mechanism—such as the transition from diesel-based operations to electrified networks, the integration of renewable energy sources into infrastructure, and the implementation of energy-saving operational regimes—serve to reduce the main unconventional pressures within the cost structure.



Picture 1. Management Mechanism for Reducing Environmental and Economic Risks in the Railway Sector [2].

Taking into account that the average diesel fuel consumption is 3.5 l/km, reducing it to an equivalent of 1.8 l/km through electrification can generate savings of approximately 1–1.5 million UZS per train operation. The annual equivalent of these savings across the entire railway network may exceed 100 billion UZS.

Direct savings in energy costs can be expressed as follows:

$$\Delta E = (C_d - C_e) * P_d * D * N \qquad (2.2)$$

Here:

ΔE – Annual direct fuel savings obtained from electrification (UZS

C_d – Diesel fuel consumption (l/km);

C_e – Electrical energy equivalent (kWh/km);

P_d – Price of 1 liter of diesel fuel (UZS/km)

D – Average travel distance (km/train);

N – Annual number of train movements.

[2] Formulated by the author based on the analyzed sources.

Based on actual values:

$\Delta E = (3.5 - 1.8) * 10000 * 500 * 15000 = 127.5\ bln\ sum$

If the maintenance cost for one diesel unit amounts to 25 million UZS and for an electric unit to 15 million UZS, the annual change in depreciation and maintenance costs can be determined as follows:

$$\Delta A = (A_d - A_e) * N \qquad (2.3)$$

Here:

ΔA – Difference in depreciation costs (UZS)

A_d – Annual maintenance cost of diesel equipment per train

A_e Annual maintenance cost of electric equipment.);

N – Annual train movements.

$$\Delta A = (25 - 15) * 15000 = 150 \text{ bln sum}$$

The environmental and economic benefits of avoiding pollution and penalties can be determined as follows:

$$\Delta C_{tej} = (E_d - E_e) * \tau * N \qquad (2.4)$$

Here:

ΔC_{tej} – Savings achieved by preventing pollution penalties (UZS

E_d, E_e: CO_2 – trash (gramm/t-km);

τ: 1 r CO_2 – Estimated compensation cost (UZS)

$\Delta C_{tej} = (42 - 20) * 1 * 15000 = 330000\ gramm = 330kg \approx 330000\ sum$

This reduces environmental compliance costs for each train operation.

The integral savings index can be determined as follows:

$$ITI = \frac{\Delta E + \Delta A + \Delta C_{tej}}{C_{bazaviy}} * 100\% \qquad (2.5)$$

Here:

C_{base} – Total annual operating costs (in the baseline scenario)

ITI – Cost reduction index through technological modernization.

If the total annual operating costs for 2024 amount to 1,200 billion UZS, then the cost reduction index achieved through technological modernization will equal 23.1%.

$$ITI = \frac{127.5 + 150 + 0.33}{1200} * 100\% \approx 23.1\%$$

Second, through the institutional instruments proposed within the mechanism—environmental passportization, an ESG audit system, "green KPIs," and a financial evaluation model—environmental risks in cost planning become grounded in clear economic calculations. As a result, hidden costs (such as waste disposal, service interruptions caused by technological obsolescence, and energy losses) become visible, creating opportunities for their systematic elimination.

Third, the attraction of "green" financial instruments within financing and investment policy—such as international grants, green bonds, and public–private partnership projects—reduces the investment pressure associated with technological renewal. The mechanism also proposes the formation of local "green technology" clusters and the development of service logistics in order to establish domestic value chains. This approach strengthens the internal industrial capacity of the sector and reduces external economic dependence.

Fourth, the integration of "green transport" objectives into the mechanism of strategic planning through institutional platforms aligns sectoral policy with ESG requirements. This, in turn, improves the ranking indicators of railway transport in international logistics systems and increases the attractiveness of the network for exporters and freight carriers.

From an environmental perspective, each operational component defined within the mechanism—reducing SO_2, NO_x, and PM emissions, transforming infrastructure toward carbon neutrality, decreasing the share of technologically obsolete rolling stock, and establishing a monitoring system based on environmental passports—contributes to lowering the level of ecological impact and improving public health, air quality, and the sustainability of the natural environment.

The application of this mechanism in railway transport will lead to:

- Reducing costs by 15–20%;
- Increasing freight turnover efficiency;
- Enhancing cost transparency;
- Introducing ESG reporting;
- Ensuring systematic assessment of environmental risks;
- Strengthening the international recognition of "green transport" status.

Thus, the formation of innovative management mechanisms aimed at reducing environmental and economic risks in railway transport is emerging as an important factor not only for improving sectoral efficiency but also for ensuring sustainable development within industrial economics. In particular, the transition to electrification, the use of energy-efficient technologies, the integration of renewable energy sources into infrastructure, and reliance on modern standards in technical operations are becoming decisive factors that enable the functional implementation of the mechanism. Such an approach contributes to optimizing the economic cost structure, reducing depreciation and maintenance expenses, and extending the service life cycle.

Increasing energy efficiency and thereby reducing dependence on diesel fuel creates an opportunity to eliminate one of the main inertial pressures within the cost structure. Calculations indicate that under conditions of transition from diesel to an electrified network, average savings of approximately 1–1.5 million UZS per train operation can be achieved. On an annual basis, this could generate economic efficiency of up to 250–300 billion UZS across the railway network. Moreover, reductions in technical maintenance and operational costs, along with fewer service interruptions, can significantly improve production stability and the logistics efficiency coefficient.

Another strategic advantage of the proposed mechanism is the possibility of reducing emissions, controlling atmospheric pollution, and complying with carbon standards related to SO_2 and NO_x emissions. This approach requires technical modernization that meets international environmental assessment standards. The introduction of environmental passports for locomotives within the rolling stock, environmental impact assessments, identification of emission boundary zones, and reporting on energy consumption throughout the service life cycle create the institutional basis for systematically addressing these environmental challenges.

Furthermore, modernization of the transport network in accordance with ESG requirements and the introduction of a "green KPI" system in corporate governance will contribute to improving financial transparency, strengthening international credit ratings, and expanding external investment attractiveness. Through green finance instruments—such as green bonds, eco-subsidies, and public–private partnership projects—the institutional foundation for restructuring the technical base and infrastructure can be significantly reinforced.

In conclusion, the transition to electrification and energy efficiency can reduce the cost of transport services by 20–23 percent, minimize operational expenses, eliminate potential conflicts with environmental regulatory frameworks, and create opportunities for international environmental certification based on ESG platforms. The step-by-step implementation of this mechanism will establish a sustainable platform for the strategic development of railway transport. Moreover, its implementation will generate profound positive changes not only in the transport sector but also in related structures of the industrial economy, including logistics, energy systems, and technological infrastructure.

REFERENCES

[1] Law of the Republic of Uzbekistan, "On Transport," No. PQ-706, Aug. 9, 2021.

[2] Law of the Republic of Uzbekistan, "On Railways," No. PQ-766-I, Apr. 15, 1999.

[3] The World Bank, "World Development Indicators." [Online]. Available: http://data.worldbank.org/indicato

[4] Sh. V. Nasimov, Ways to Increase the Competitiveness and Efficiency of Railway Transport in Freight Transportation, PhD dissertation abstract in Economics, Tashkent, 2024.

[5] G. A. Samatov, I. B. Rustamova, and F. R. Galimova, Methodological Manual for Practical Classes in Logistics. Tashkent: Editorial Department of Tashkent State Agrarian University, 2013.

[6] E. A. Kamalova, Improving the Logistics Management of Cargo Transportation, PhD dissertation abstract in Economics, Tashkent State University of Economics, Tashkent, 2019.

[7] M. N. Irisbekova, "Prospects for the development of international transport corridors in the Republic of Uzbekistan," Society and Management, no. 3, pp. 45–47, Tashkent, 2011.

[8] J. S. Fayzullayev, Improving the Efficiency of Managing an Integrated Transport-Logistics System, PhD dissertation abstract in Economics, Tashkent, 2021.

[9] A. A. Gulamov, Improving the Methodology for the Economic Evaluation of the Fixed Capital of a Railway Company (on the Example of JSC 'Uzbekistan Railways'), Doctoral dissertation abstract in Economics, Tashkent, 2020.

[10] A. A. Zokhidov, "Alternative transportation corridors in Central Asia: factors, interdependence, and integration problems," Central Asia and the Caucasus, vol. 15, no. 1, pp. 149–159, 2014.

[11] H. S. Rakhimov, "Assessment of the economic efficiency of transport infrastructure development," International Journal of Research in Management & Business Studies (IJRMBS), vol. 6, no. 3, 2019.

[12] H. S. Rakhimov, "Improving the economic activity of transport infrastructure," in Archive of Conferences, vol. 10, no. 1, pp. 47–49, 2020.

[13] JSC "Uzbekistan Railways," "Official website." [Online]. Available: www.uty.uz

[14] Association of International Road Carriers of Uzbekistan, "Official website." [Online]. Available: www.aircuz.uz

[15] State Committee of the Republic of Uzbekistan on Statistics, "Official website." [Online]. Available: http://www.stat.uz