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MECHANISMS FOR FORMING INVESTMENT RESOURCES FOR THE SUSTAINABLE INNOVATIVE DEVELOPMENT OF THE RAILWAY TRANSPORT NETWORK

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ABSTRACT

Railway transport remains one of the most capital-intensive branches of national infrastructure, and its capacity to modernize technologically depends directly on the volume, structure, and continuity of investment resources. This article examines the mechanisms through which investment resources can be formed and mobilized to support the sustainable innovative development of a railway transport network, using the experience of Uzbekistan as an illustrative case. The study combines a systematic review of international and national literature with a comparative analysis of financing instruments applied in railway modernization, including state budgetary allocation, retained earnings and internal reinvestment, sovereign and multilateral borrowing, public-private partnerships, leasing of rolling stock, and green and infrastructure bonds. The results indicate that a diversified, multi-channel model of investment resource formation, anchored by a stable regulatory environment and risk-sharing arrangements between the state and private investors, provides the most resilient basis for financing innovative railway projects. The article proposes a structural model for combining public and private capital sources and outlines policy measures capable of increasing the inflow of long-term investment into railway infrastructure. The findings are intended to be of practical value for transport-sector policymakers, railway operators, and researchers working on infrastructure finance in transition and emerging economies.

KEYWORDS

Railway transport, investment resources, innovative development, public-private partnership, green bonds, infrastructure financing, sustainable development, Uzbekistan.

Introduction

Transport infrastructure occupies a central place in the architecture of national economic growth, and among its branches, railway transport carries a particular strategic weight because of its capacity to move large volumes of freight and passengers over long distances at comparatively low external cost. Railways form the backbone of trade corridors, connect production centers with markets, and serve as an instrument through which a country expresses its position within regional and global logistics networks [1]. At the same time, the technological base of railway transport — traction rolling stock, signaling and control systems, track and electrification infrastructure — requires continuous renewal,

since obsolescent assets translate directly into higher operating costs, lower average speeds, and constrained network capacity.

The question of how investment resources for such renewal are formed, mobilized, and allocated has therefore become one of the defining problems of transport economics. Railways are simultaneously public-interest assets, subject to social and regional-development obligations, and commercial enterprises expected to operate efficiently and, increasingly, to attract private capital. Reconciling these two roles requires investment mechanisms that go beyond simple budgetary allocation and instead combine several sources and instruments — state investment programs, retained earnings of the railway operator, borrowing from international financial institutions, leasing arrangements for rolling stock, public-private partnerships, and, more recently, green and sustainability-linked financial instruments [8], [9], [11].

The relevance of this problem is particularly pronounced for countries undergoing structural transformation of their transport sector, such as Uzbekistan. Over the past decade, JSC "Uzbekiston Temir Yullari" (Uzbekistan Railways) has pursued a strategy of sustainable development built on the introduction of innovative technologies, optimization of the network structure, and an expanded inflow of investment for modernization [1]. The national rail network extends across roughly 4,700–7,000 kilometers depending on the measurement basis used, of which more than 70 percent is already electrified, with a target of reaching 85 percent electrification by 2030 [4], [6]. Even so, international assessments note that a large share of rolling stock — on the order of 90 percent — requires renewal, and that the rail mode's share in overall inland transport activity remains modest relative to road transport, at approximately 3 percent of network length but carrying a disproportionately important share of freight [4], [5]. These figures illustrate both the scale of investment needed and the structural imbalance that innovative financing mechanisms are meant to address.

Despite the recognized importance of the topic, the existing literature on railway investment financing tends to separate into two loosely connected strands. One strand, dominated by international financial institutions and development-bank publications, addresses financing instruments in general terms — public-private partnerships, green bonds, blended finance — without close reference to the specific institutional conditions of a given railway operator [3], [9], [10]. The other strand, more sector-specific, documents the operational and financial performance of particular railway companies but pays comparatively less attention to the architecture of investment mechanisms as such [5], [12]. This article aims to connect these two strands by systematizing the mechanisms available for forming investment resources for railway transport and by examining how they interact within the specific case of Uzbekistan's railway network.

Accordingly, the objective of the study is to identify and structure the principal mechanisms for forming investment resources capable of supporting the sustainable innovative development of railway transport, and to propose a model for combining these mechanisms that is applicable to transition economies with an actively modernizing rail sector. The specific tasks of the research are: (a) to review the theoretical and applied literature on investment mechanisms in the transport and railway sectors; (b) to analyze the structure of sources currently used to finance railway modernization in Uzbekistan; (c) to compare this structure with international practice in public-private partnerships and green finance for railways; and (d) to formulate recommendations for diversifying and strengthening the investment resource base of the railway sector.

2. Materials and Methods

The study is based on a qualitative and comparative research design that combines a structured review of the academic and institutional literature with a descriptive-analytical examination of secondary statistical and policy data. Sources were drawn from three categories: (i) peer-reviewed academic publications on transport and infrastructure financing, including studies addressing green and decarbonization-oriented financing instruments for rail and inland waterway transport [11] and reviews of financial mechanisms supporting environmental sustainability more broadly [13]; (ii) reports and working papers issued by international organizations and development institutions — the World Bank, the Organisation for Economic Co-operation and Development (OECD), the United Nations Conference on Trade and Development (UNCTAD), and the Asian Development Bank Institute (ADBI) — concerning transport-sector financing, public-private partnerships, and infrastructure investment policy in Uzbekistan and comparable economies [2], [3], [8], [9], [10]; and (iii) sector-specific data published by JSC "Uzbekiston Temir Yullari" and by industry and news outlets reporting on railway modernization projects, electrification progress, and recent international financing agreements [1], [4], [6], [7].

The analytical procedure followed three stages. In the first stage, a conceptual classification of investment resource-formation mechanisms was constructed, distinguishing internal sources (retained earnings, depreciation funds, asset optimization) from external sources (state budget allocation, sovereign and corporate borrowing, multilateral development-bank loans, public-private partnerships, leasing, and capital-market instruments such as green and infrastructure bonds). In the second stage, this classification was applied descriptively to the available evidence on Uzbekistan's railway sector in order to characterize the present structure of investment inflows and the constraints affecting each channel. In the third stage, a comparative analysis was carried out between the domestic structure identified and international practice in railway public-private partnerships and green-bond financing, drawing on documented experience from the World Bank's Public-Private Partnership Legal Resource Center and related comparative studies [8], [9], [10], [11]. This comparison served as the basis for the structural model and recommendations presented in the Discussion section.

The study does not employ primary econometric estimation; instead, it relies on a systems approach to infrastructure finance, treating the railway operator, the state budget, multilateral lenders, and private investors as interacting agents whose combined behavior determines the overall investment resource pool available for network modernization. This approach is consistent with methodologies used in comparable sector reviews of transport financing mechanisms in Central Asia [2], [4] and is appropriate for a topic in which the object of study is an institutional and financial architecture rather than a set of quantifiable causal parameters alone.

3. Results

The analysis of available evidence indicates that investment resources for the modernization of Uzbekistan's railway network are currently formed through a combination of five principal channels, each with a distinct scale, cost of capital, and degree of flexibility.

First, direct state budgetary allocation and state investment programs continue to represent a foundational source of financing, particularly for strategically important projects such as new line construction, electrification, and cross-border corridor development. The state's role is reinforced by the fact that JSC "Uzbekiston Temir Yullari" operates as a state-affiliated joint-stock company whose

reform strategy explicitly links continued state support to the optimization of the company's structure and the attraction of additional investment for network expansion [1].

Second, the railway operator's own funds — retained earnings, depreciation charges, and revenue from ancillary commercial activity — form an internal reinvestment channel. This channel has historically supported incremental modernization and has, in specific cases, been combined with external capital to complete complex infrastructure projects; the construction and operation of the Khairaton–Mazari-Sharif railway line in Afghanistan is documented as an example in which the company's own resources were combined with both foreign and domestic investment to reach international engineering standards [5].

Third, borrowing from multilateral development institutions constitutes an increasingly significant channel, particularly for projects involving digitalization and technological upgrading rather than physical construction alone. A recent illustration is the European Bank for Reconstruction and Development's loan of up to €38.4 million to support the digital transformation of Uzbekistan Railways, covering the introduction of modern dispatching, scheduling, and traffic-management software; this represented the EBRD's first public-sector digitalization project in the country and was framed explicitly as a contribution to operational efficiency, safety, and integration with regional trade corridors such as the Trans-Caspian route [7]. More broadly, the World Bank's policy assessment of Uzbekistan's transport and logistics sector identifies the mobilization of private capital for rail and road infrastructure as constrained by incomplete liberalization and underdeveloped financing instruments, and recommends the introduction of innovative financing and funding mechanisms, including public-private partnerships, as a priority area for reform [2], [9].

Fourth, public-private partnership arrangements, while still at an early stage of application in the railway subsector compared with energy infrastructure, are identified by recent OECD analysis as a necessary complement to direct state financing, given that private-sector engagement in Uzbekistan's transport and energy infrastructure remains constrained by weak policy frameworks and limited financing instruments; the same analysis identifies blended finance, green bonds, and risk-sharing PPP structures as models that could help close the country's infrastructure investment gap [3].

Fifth, capital-market and leasing-based instruments — including green bonds and operating leases of rolling stock — remain the least developed channel within the domestic railway sector but represent, according to international practice, one of the fastest-growing sources of infrastructure finance globally. International reviews of decarbonization financing in rail transport document a substantial and growing body of literature (encompassing over 240 sources reviewed in one systematic study) on green bonds, blended finance, and risk-sharing structures specifically applied to rail and inland-waterway modernization, while noting that the successful use of such instruments depends on feasibility analysis, a sound regulatory framework, and continued government support through incentives and guarantees [11].

Table 1 summarizes the five channels identified, together with their principal characteristics as observed in the reviewed evidence.

Table 1. Principal channels of investment resource formation for railway transport modernization

Channel	Typical use	Cost / risk profile	Main constraint
State budget / investment programs	New line construction, electrification, strategic corridors	Low direct cost, high fiscal opportunity cost	Competes with other budget priorities; cyclical availability
Operator's own funds (retained earnings, depreciation)	Incremental modernization; co-financing of large projects	Lowest financial cost, limited volume	Insufficient scale for large-scale renewal
Multilateral / sovereign borrowing	Digitalization, rolling-stock renewal, corridor integration	Moderate cost, medium-term repayment obligation	Sovereign debt-capacity limits; conditionality
Public-private partnerships	Terminals, rolling stock leasing, station modernization	Risk-shared, requires strong regulatory framework	Weak PPP legislation and limited track record
Green bonds / capital-market and leasing instruments	Electrification, low-emission technology, energy efficiency	Market-dependent cost, requires transparency and reporting	Underdeveloped domestic capital market instruments

Taken together, the evidence shows that the current investment structure of Uzbekistan's railway sector is shifting from a model dominated by state allocation and internal reinvestment toward a more diversified structure that increasingly incorporates multilateral borrowing and, cautiously, elements of public-private partnership. This shift is consistent with broader national investment trends: over the past eight years, Uzbekistan has directed substantial capital toward complementary energy infrastructure, including more than €17.2 billion in solar and wind power projects that support the electrification of rail services and reduce the transport sector's exposure to fossil-fuel price volatility [6]. Nevertheless, green bonds and other capital-market instruments remain largely untapped within the domestic railway sector itself, representing an identifiable gap between the mechanisms available in international practice and those currently in active use.

4. Discussion

The results of the analysis support the argument that no single investment channel is sufficient, on its own, to finance the innovative modernization of a railway network at the scale required by a transition economy such as Uzbekistan. State budgetary allocation provides stability and aligns investment with national development priorities, but it is inherently constrained by fiscal capacity and competition with other public spending needs. Internal reinvestment by the railway operator is the lowest-cost source of capital but is limited in volume relative to the scale of renewal required, particularly given that a substantial share of rolling stock is reported to need replacement [4]. Multilateral borrowing has proven effective for targeted, technologically defined projects — as illustrated by the EBRD-financed digitalization program — but sovereign and quasi-sovereign debt capacity places an upper bound on how far this channel can be expanded [7].

Public-private partnerships and capital-market instruments therefore emerge, both from the literature and from the case evidence, as the channels with the greatest unrealized potential. International experience documented by UNCTAD demonstrates that PPP structures for railways can be strengthened by legal instruments such as the Luxembourg Rail Protocol to the Cape Town Convention, which is designed to provide sufficient security for private lenders and lessors of rolling stock even in the absence of a government guarantee, thereby opening the sector to a wider range of investors, including in developing economies [8]. At the same time, comparative reviews caution that PPPs are not universally appropriate for transport infrastructure: their success depends on rigorous feasibility studies, a coherent regulatory framework, and continued government support through incentives and, where necessary, financial guarantees, since railway projects are large-scale, long-horizon, and carry significant demand and construction risk [11].

Green and sustainability-linked financing instruments occupy a related but distinct position. The literature on green bonds identifies them as an innovative financing channel that opened a dedicated funding stream for environmentally beneficial projects, including low-emission and energy-efficient transport infrastructure, but also notes that green-bond markets in many emerging economies remain constrained by insufficient investor protection, inconsistent reporting standards, and pricing uncertainty [13]. For a railway network such as Uzbekistan's, which already combines an electrification program with a large renewable-energy investment portfolio, the alignment between rail modernization and green finance appears structurally favorable: electrified, renewably powered rail transport is a natural candidate for green-bond-eligible projects, provided that a transparent framework for use-of-proceeds reporting and impact verification is established [6], [13].

A further point of comparison concerns institutional design. Comparative studies of green infrastructure banks and public-private partnership vehicles in Asia find that, despite differences in name and legal form, both types of institutions share a common core function: mobilizing private investment through risk-mitigating interventions, structuring innovative transactions, and providing independent, cost-effective oversight of infrastructure financing [10]. This suggests that, rather than treating PPPs, green bonds, and multilateral lending as separate and competing channels, the railway sector would benefit from an integrated institutional mechanism — for example, a dedicated infrastructure-financing unit or fund operating alongside the railway operator — capable of coordinating between state guarantees, concessional lending, private capital, and green-bond issuance within a single project-preparation and risk-allocation framework.

Based on this synthesis, the article proposes a three-tier structural model for forming investment resources for the innovative development of railway transport. The first tier consists of a stable core of state budgetary financing and the operator's own reinvested funds, directed primarily toward strategically essential and socially obligatory elements of the network. The second tier consists of concessional and market-rate borrowing from multilateral development institutions, targeted at clearly defined modernization and digitalization projects with measurable efficiency returns, following the pattern already established through the EBRD digitalization loan [7]. The third tier consists of private capital mobilized through public-private partnerships, rolling-stock leasing, and green or infrastructure bonds, applied to commercially viable and environmentally aligned projects such as electrification, terminal development, and energy-efficient traction technology, supported by a transparent regulatory and reporting framework consistent with the recommendations of international financing-mechanism reviews [3], [9], [11].

This model is consistent with, and extends, the sector-specific findings of prior empirical work on Uzbekistan Railways, which links well-designed investment mechanisms to improved operational efficiency, cost optimization, and long-term sustainability of the railway enterprise [12]. It also reflects the broader policy direction identified by the World Bank's assessment of Uzbekistan's transport and logistics sector, which recommends reducing the barriers that currently limit private financing and diagnostic capacity in the rail subsector [2].

The study is subject to several limitations. As a qualitative and comparative analysis based on secondary sources, it does not provide an econometric estimate of the relative efficiency or expected cost of capital of each financing channel, and the available public data on the exact volume and share of each investment source within Uzbekistan's railway sector remain fragmented across multiple institutional publications. Future research would benefit from a quantitative assessment of the marginal cost of capital across the proposed three-tier model, as well as from case-based analysis of specific PPP or green-bond pilot projects once such instruments are more widely applied in the domestic railway sector.

5. Conclusion

The sustainable innovative development of a railway transport network depends on the existence of a diversified and institutionally coordinated system for forming investment resources, rather than on any single dominant source of financing. The analysis presented in this article shows that Uzbekistan's railway sector currently relies primarily on state budgetary allocation, internal reinvestment, and, increasingly, multilateral borrowing, while public-private partnerships and capital-market instruments such as green bonds remain underdeveloped relative to their potential contribution.

The proposed three-tier model — combining a stable public and internal financing core, targeted multilateral borrowing for modernization and digitalization, and an expanded role for private capital through PPPs, leasing, and green financing instruments — offers a structured pathway for closing the sector's investment gap while distributing financial risk more evenly between the state, development institutions, and private investors. Realizing this model in practice will require strengthening the domestic legal and regulatory framework for public-private partnerships, developing transparent reporting standards compatible with green-bond issuance, and building institutional capacity for project preparation and risk allocation within the railway sector.

For policymakers, the practical implication is that reform priorities should focus less on increasing the volume of any single financing channel and more on building the institutional infrastructure that allows different sources of capital to be combined efficiently around specific, well-prepared projects. For researchers, the findings point to a clear need for further quantitative and case-based work examining the comparative cost, risk, and developmental impact of alternative investment mechanisms as they are progressively introduced into the railway sectors of transition economies.

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