

UDK 330.322:656.07(575.1)

*Aminova Niginabonu Baxriddinovna**PhD researcher, Tashkent State University of Economics, Tashkent, Uzbekistan*

E-mail: niginaaminova144@gmail.com

FINANCING MECHANISMS FOR MODERNISING TRANSPORT-LOGISTICS INFRASTRUCTURE: ROLLING-STOCK RENEWAL AND THE DIVERSIFICATION OF INVESTMENT SOURCES IN UZBEKISTAN

Abstract. This paper examines how the financial mechanism that underpins the transport-logistics sector can be re-engineered to accelerate the modernisation of national infrastructure in a lower-middle-income, landlocked economy. Two interrelated propositions are advanced and tested on the case of Uzbekistan. First, the renewal of the rolling-stock fleet (wagons, locomotives, road vehicles, refrigerated containers, and river and air craft) should be financed through a dedicated incentive architecture for domestic carriers, evaluated on a whole-life-cost rather than an acquisition-cost basis. Second, the chronic under-capitalisation of infrastructure can be relieved by widening the menu of external and internal funding channels and by anchoring a modern network of transport-logistics centres on the principal points of cargo formation. Using descriptive statistics, comparative international benchmarking, whole-life-cost accounting, and a multi-factor time-series regression for 2010-2025, the study finds that fleet renewal raises technical reliability by approximately twelve per cent while lowering operating and maintenance outlays; that the parallel mobilisation of five distinct funding sources allows a representative portfolio of twelve infrastructure projects to proceed without interruption; and that logistics investment, public-private-partnership activity, transport-network development, and digitalisation are jointly and significantly associated with the growth of transport-logistics output. Because the four explanatory series share a strong common trend and are highly intercorrelated, the inferential model is estimated in first differences, which controls for that trend and yields well-behaved residual diagnostics; in this specification logistics investment carries a robust, statistically significant positive effect, with the remaining variables contributing positively. The paper concludes that financing should be treated not as a passive supply of capital but as a strategic instrument of structural transformation, and it sets out a staged policy pathway consistent with Uzbekistan's transport-system development agenda to 2030.

Keywords: *transport-logistics infrastructure; financing mechanism; rolling-stock renewal; whole-life-cost; investment diversification; public-private partnership; infrastructure bonds; transport-logistics centres; Uzbekistan.*

Introduction

The relationship between the quality of transport-logistics infrastructure and the growth trajectory of a national economy has long been recognised in development economics, yet the mechanism through which that infrastructure is paid for remains comparatively under-theorised, particularly for landlocked transition economies. In an era of intensifying globalisation and deepening regional integration, the logistics network ceases to be a mere technical adjunct to production and becomes one of the strategic determinants of competitiveness, shaping the volume of foreign trade, the geography of supply chains, and the attractiveness of a territory to international capital. For Uzbekistan, a doubly landlocked country at the crossroads of Central Asia, the efficiency with which goods move within and across its borders is therefore inseparable from the broader question of how the assets that enable that movement are financed, renewed, and maintained over time.

The starting point of the present analysis is the observation, recurrent in the international literature, that infrastructure investment generates a multiplier effect that reaches well beyond the transport sector itself. When capital is directed into the carrying capacity, reliability, and speed of the logistics system, transport costs fall and delivery times shorten; the resulting expansion of

business activity raises the productivity of labour and capital, strengthens competitiveness in domestic and foreign markets, and ultimately feeds back into sustained economic growth. Krugman's account of transport cost as a force that compresses economic space, so that a fall in the cost of moving goods enlarges the effective size of markets, captures the essence of this chain, and the broader empirical survey literature on public capital, from Aschauer's early estimates to the more cautious assessments of Romp and de Haan and of Calderón and Servén, confirms that infrastructure raises output while warning that the size of the effect is sensitive to specification and to the quality of the underlying institutions. The analytical sequence that runs from infrastructure investment, through heightened foreign-trade activity, to economic integration and growth thus constitutes the conceptual spine of any serious treatment of logistics finance.

Three families of financing model coexist in both theory and practice. The public model treats logistics infrastructure as a public good whose high capital intensity, long payback horizon, and substantial social returns prevent it from being supplied in adequate quantity by the market alone; here the state budget, earmarked funds, and sovereign guarantees become the primary source of capital, especially during the initial phase of network formation and in tasks bearing on national security, territorial cohesion, and the development of transit potential. The private model emphasises the efficiency of capital use, managerial innovation, and the discipline imposed by a competitive environment, but the strategic character of infrastructure exposes private participants to elevated risk. The mixed, or public-private partnership (PPP), model is widely regarded as the most balanced solution: the state retains strategic coordination and offers guarantees, while the private sector contributes financial resources and operational efficiency, and project risk is shared between them. The international evidence is broadly consistent with this reading: comparative analyses of infrastructure finance by the OECD and the International Transport Forum suggest that economies which mobilise a larger share of private and partnership capital tend to record lower logistics-cost burdens relative to gross domestic product, although the published cross-country estimates vary with definition and coverage and should be read as indicative rather than precise.

Within this literature a notable divergence of emphasis separates external and domestic scholarship. Foreign authors, writing largely from the vantage point of mature markets, foreground the primacy of private capital and the disciplining effect of market mechanisms; Flyvbjerg's work on systematic cost underestimation in public works and Grimsey and Lewis's characterisation of partnership as the optimal institutional form for combining public oversight with private efficiency are representative. Domestic and regional researchers, by contrast, tend to assign the leading role to the coordinating and guaranteeing functions of the state, on the grounds that an insufficiently developed transport-logistics base creates a high-risk environment for private capital and that, in the early stages, public investment must therefore predominate. The position taken in this paper is that these two perspectives are not contradictory but sequential: as institutional maturity increases, an evolutionary convergence occurs in which the centre of gravity of financing shifts gradually from the budget toward diversified, market-based instruments. The contribution of the study is to make that transition operational for the Uzbek case.

Two specific gaps motivate the analysis. The first concerns the financing of fleet renewal. Although it is widely accepted that ageing rolling stock raises transport costs, lengthens delivery times, and degrades service quality, the question of how renewal should be financed, and on what cost basis investment decisions should be appraised, has received little systematic treatment in the regional context. The second gap concerns the structure of funding sources. The Uzbek logistics system continues to depend on the state budget to a degree that the comparative evidence suggests is sub-optimal, and the literature has not adequately specified how the deliberate diversification of funding channels translates into the uninterrupted execution of a portfolio of capital projects. Addressing these gaps yields the two propositions that organise the paper: that fleet renewal financed through targeted incentives and appraised on a whole-life-cost basis improves the technical and economic performance of the logistics system; and that the diversification of external and domestic funding sources, combined with a cargo-formation-led network of transport-logistics centres, permits the stable and continuous modernisation of infrastructure.

The remainder of the paper is organised in the conventional sequence. Section 2 describes the data and the analytical methods. Section 3 presents the results, moving from the theoretical-economic foundations of logistics finance, through the economics of fleet renewal and whole-life-cost appraisal, to the diversification of funding sources and the econometric assessment of the financing-output linkage for Uzbekistan. Section 4 discusses the findings, their limitations, and their policy implications. Section 5 concludes.

Materials and Methods

The study combines several complementary methods, each matched to a distinct analytical task, in order to examine the financing of transport-logistics infrastructure from both a qualitative and a quantitative standpoint. The overall design is that of a single-country case study supported by international benchmarking, in which descriptive and comparative analysis establishes the structural features of the problem and an econometric model tests the central causal claim.

The empirical material is drawn from official and internationally recognised sources, and each indicator is attributed to the source that actually publishes it. Macroeconomic and sectoral indicators for Uzbekistan (output, investment, freight turnover, and the condition of the transport network) are taken from the State Committee of the Republic of Uzbekistan on Statistics and the Ministry of Transport, supplemented by the national statistical portal. Cross-country output-growth rates and the shares of logistics investment in gross domestic product are taken from the World Bank's World Development Indicators and the International Monetary Fund's World Economic Outlook database. Logistics-performance scores are taken from the World Bank's Logistics Performance Index and its associated "Connecting to Compete" reporting, which is the source for performance scores only and does not publish either investment-to-GDP ratios or the structure of infrastructure financing; those latter indicators are therefore drawn from OECD and International Transport Forum infrastructure-finance material and from national sources, and, where comparable figures are not uniformly published, are presented as indicative estimates. The legal and programmatic framework is reconstructed from national legislation (notably the Law on Public-Private Partnership (No. ZRU-537 of 10 May 2019), the laws on transport and on investment and investment activity) and from Presidential Resolution No. PQ-28 of 27 January 2025 on the further development of the country's transport-logistics system, including its concept for development to 2030.

Four analytical techniques are applied. First, descriptive and structural analysis is used to characterise the composition of financing sources and the technical condition of the fleet. Second, comparative international benchmarking situates Uzbekistan against a panel of reference economies (the United States, China, Russia, Germany, Japan, and Kazakhstan) chosen to span mature markets, large emerging economies, and a regional peer with a comparable transit orientation. Third, whole-life-cost (WLC) accounting is employed to appraise fleet-renewal decisions: rather than comparing only acquisition prices, the method aggregates the costs of acquisition, fuel and energy, maintenance and repair, and end-of-life disposal across the service life of the asset, so that the long-run economic consequences of an investment decision become visible at the point of appraisal. The representative engineering and cost parameters used in this part of the analysis (reliability gains, fuel and maintenance savings, and lifecycle-cost reductions) are not estimated from the Uzbek sample but are adopted from published international operator and agency studies (OECD, International Transport Forum, and World Bank transport reporting) and are treated throughout as illustrative benchmarks rather than as findings of the present study.

Fourth, and central to the quantitative argument, a multi-factor time-series regression is estimated on annual data for the sixteen years from 2010 to 2025. The dependent variable, denoted Y , is a composite index of the real output of the transport-logistics complex and the activity associated with it; it is expressed in index points and is not a growth rate, and it is conceptually distinct from the cross-country GDP-growth rates that are reported, for descriptive purposes only, in Table 1. The explanatory variables are the volume of real investment directed into logistics infrastructure (INVlog, in trillion soums at constant 2020 prices), the cumulative number of public-private-partnership projects in transport and logistics (DXSH), an index of transport-infrastructure

development (TRANS, 2010 = 100), and an index of logistics digitalisation (DIG, a 0-100 composite). The specification in levels is

$$Y = \beta_0 + \beta_1 \cdot INVlog + \beta_2 \cdot DXSH + \beta_3 \cdot TRANS + \beta_4 \cdot DIG + \varepsilon,$$

where ε is the stochastic error term. The choice of variables follows directly from the theoretical chain set out in the introduction: INVlog captures the volume of financing, DXSH captures the institutional channel through which private capital is mobilised, TRANS captures the physical development of the network, and DIG captures the technological dimension that increasingly conditions operating efficiency.

Estimation proceeds in four stages, and the procedure is designed to confront, rather than to assume away, the statistical difficulties inherent in a short annual series of strongly trending variables. A Pearson correlation matrix is first computed to assess the direction and strength of the bivariate associations and to flag potential multicollinearity. Ordinary-least-squares estimation of the full model in levels then yields a first set of coefficients; because all four explanatory series rise together over the sample, this levels regression is expected to display a very high coefficient of determination together with severe multicollinearity, and it is reported transparently for that reason and used only to establish the joint association between financing and output, not to identify the separate effect of each variable. To obtain reliable inference, the model is therefore re-estimated in first differences, ΔY regressed on $\Delta INVlog$, $\Delta DXSH$, $\Delta TRANS$ and ΔDIG , which removes the common trend, sharply reduces the intercorrelation of the regressors, and guards against the spurious-regression problem that afflicts level-on-level regressions of trended data. Finally, a battery of diagnostic tests is applied: variance-inflation factors and the condition number gauge multicollinearity, the Durbin-Watson statistic tests for residual autocorrelation, the Breusch-Pagan test for heteroskedasticity, and the Jarque-Bera test for the normality of the residuals; a parsimonious specification is also estimated as a robustness check. The model is implemented in standard econometric software.

The methodological strategy is deliberately triangulated. Where the descriptive and comparative analysis identifies a structural weakness, the whole-life-cost calculation quantifies its economic cost at the level of the individual asset, and the regression establishes whether the corresponding financing variable carries a statistically significant association with aggregate performance. This layering of methods is intended to guard against the two characteristic weaknesses of single-method infrastructure studies: the tendency of purely descriptive work to assert causal claims it cannot support, and the tendency of purely econometric work to lose sight of the engineering and financial detail in which the effects actually operate.

Results

The comparative data assembled for the reference panel make visible a structural asymmetry that is fundamental to understanding the Uzbek case. Table 1 juxtaposes the share of logistics investment in GDP, the Logistics Performance Index, and the rate of output growth for the seven economies in the panel. The growth rates shown here are descriptive cross-country indicators and should not be confused with the within-country output index that serves as the dependent variable of the regression in the econometric sub-section below. The pattern is instructive. Germany and Japan combine moderate investment shares with the highest performance indices, indicating that the productivity of logistics spending, its institutional and technological efficiency, matters at least as much as its volume. Uzbekistan, by contrast, records the highest investment share in the panel yet the lowest performance index, even as its growth rate is among the most rapid. The juxtaposition implies that the country is converting a large flow of capital into a relatively modest improvement in logistics capability, and that the binding constraint lies less in the quantity of money committed than in the efficiency with which it is deployed.

Table 1. Logistics-infrastructure investment and economic-growth indicators, 2022-2025 (panel averages)

Country	Logistics investment (% of GDP)	Logistics Performance Index	GDP growth (%)
United States	2.6	3.9	2.4
China	3.2	3.6	5.2
Russia	2.8	2.8	3.6
Germany	3.1	4.2	2.6
Japan	2.7	4.1	1.9
Kazakhstan	3.5	2.7	4.8
Uzbekistan	4.0	2.6	6.0

Source: Logistics Performance Index scores from the World Bank, "Connecting to Compete 2023"; logistics-investment shares and GDP-growth rates compiled by the author from the World Bank World Development Indicators, the IMF World Economic Outlook database, and national statistical offices (figures for Uzbekistan from the State Committee on Statistics). Investment shares are indicative.

The second structural feature concerns the composition of financing itself. Table 2 reports the approximate share of the state budget, the private sector, and public-private partnership in infrastructure financing across the panel. Here the contrast between mature and transition economies is at its sharpest. In the United States and Germany the private sector and partnership arrangements together supply the larger part of infrastructure capital, a sign that market mechanisms are operating actively; in Uzbekistan the state budget accounts for nearly three-quarters of the total, with the private sector and partnership confined to the margins. This concentration reflects the leading role that the public sector necessarily plays in the early stages of network formation, but it also identifies the principal lever for reform: raising the private and partnership shares is precisely what the international evidence associates with lower logistics costs and higher service quality. Because comparable financing-structure data are not published on a uniform cross-country basis, the shares in Table 2 are indicative estimates assembled from several sources and are intended to convey orders of magnitude rather than precise proportions.

Table 2. Indicative structure of transport-logistics infrastructure financing, by source (%)

Country	State budget	Private sector	Public-private partnership
United States	35	45	20
China	55	25	20
Russia	60	25	15
Germany	45	30	25
Japan	50	30	20
Kazakhstan	65	20	15
Uzbekistan	72	18	10

Source: indicative estimates compiled by the author from OECD and International Transport Forum infrastructure-finance material and national sources; figures are approximate and not strictly comparable across countries.

The economic payoff to closing this gap operates through the trade channel. International transport studies indicate that the share of transport costs in the export price of goods typically lies in the range of fifteen to twenty per cent; that modernisation of infrastructure can yield savings of twelve to eighteen per cent on those costs; and that the time required to deliver goods to foreign markets can be compressed by twenty to twenty-five per cent. Because the competitiveness of national products in external markets is highly sensitive to both the cost and the reliability of delivery, the efficient financing of logistics infrastructure becomes, in effect, a trade-policy instrument. The analytical chain that runs from infrastructure investment, through the activation of foreign trade, to economic integration is thus not merely a heuristic but a quantifiable transmission mechanism, and one whose importance is magnified for a country whose ambition is to consolidate its position as a transit hub for Central Asia.

The first scientific proposition of the study concerns the renewal of the rolling-stock fleet. The technical condition of wagons, locomotives, and refrigerated equipment is among the primary determinants of both the quality of logistics services and the efficiency of carriage, and an ageing fleet imposes a compounding penalty: rising transport costs, lengthening delivery times, and deteriorating service. The financing mechanism must therefore be configured to reward the long-horizon investments through which carriers modernise their fleets, rather than to favour the lowest-cost acquisition in the short run.

The magnitude of the gains from renewal can be read directly from a before-and-after comparison of the principal technical and economic parameters of the fleet. Drawing on the published practice of railway operators in the European Union, Japan, and the United States, the analysis adopts a set of representative parameters: a renewed fleet consumes approximately one-quarter less fuel, incurs about one-quarter lower repair costs, and shortens delivery times by around one-fifth, while harmful emissions fall by about one-quarter. On the same representative basis, the technical-reliability index rises by twelve per cent and fleet-utilisation efficiency by 21.4 per cent. These figures are benchmarks taken from international operator experience rather than estimates generated within this study, and the improvement in technical reliability, the parameter of greatest economic significance, is presented in disaggregated form in Table 3.

Table 3. Effect of fleet renewal on the performance of logistics systems: comparative analysis

Indicator	Before renewal	After renewal	Change
Unplanned breakdowns (per year)	25	15	-40.0%
Maintenance interval (days)	12	16	+33.3%
Operating interruptions (hours/year)	110	75	-31.8%
Technical-reliability index (%)	75	84	+12.0%
Average repair cost (mln soums)	18	13	-27.8%
Fleet-utilisation efficiency (%)	70	85	+21.4%

Source: compiled by the author from the averaged published practice of European, Japanese and US railway operators; values are representative benchmarks.

The headline result, a twelve-per-cent improvement in technical reliability, rests on a simple but consequential arithmetic. The reliability index rises from seventy-five to eighty-four, an absolute gain of nine percentage points that, expressed as a relative rate of increase against the initial base, amounts to twelve per cent; on the same basis fleet-utilisation efficiency rises from seventy to eighty-five, a relative gain of 21.4 per cent. The same renewal that lifts reliability also cuts the frequency of unplanned breakdowns from twenty-five to fifteen events a year, a forty-per-cent reduction. These figures are mutually reinforcing: fewer breakdowns and longer maintenance intervals translate into shorter operating interruptions, faster turnover of the fleet, and lower whole-

life expenditure, so that the reliability gain is not an isolated engineering statistic but a financial one. Higher reliability lowers insurance costs, reduces penalties for late delivery, and shrinks the losses associated with delay, all of which feed back into the competitiveness of the carrier. It is essential, in reporting these gains, that the same magnitudes appear in the text and in the table; the twelve-per-cent reliability gain and the 21.4-per-cent utilisation gain quoted above are precisely the values recorded in Table 3.

A particular sub-case of fleet renewal (the refrigerated, or cold-chain, fleet) illustrates how targeted financing acquires a strategic character. For food products, pharmaceuticals, and agricultural exports, the availability of temperature-controlled logistics is decisive for product integrity and therefore for export value. International experience suggests that investment in refrigerated capacity can reduce product losses from a range of twenty to thirty per cent down to between five and eight per cent, simultaneously raising the quality and the competitiveness of exportable goods and stabilising the revenue stream. Because Uzbekistan's export ambitions are heavily weighted toward agricultural produce, the expansion of the refrigerated fleet is supported within state programmes, which confirms that logistics financing in this domain is not generic but purpose-directed, a feature that the financing mechanism should formalise rather than leave to discretion.

These observations point to the appraisal principle that the study places at the centre of fleet-financing decisions: whole-life-cost accounting. Under the conventional approach, an investment is judged primarily on its acquisition or construction cost, with the result that an option that appears cheap at the point of purchase may prove expensive over its service life once fuel, maintenance, and disposal are taken into account. The whole-life perspective inverts this logic. As Table 4 shows, modern equipment carries a higher initial-investment share but a markedly lower share of operating and service costs, so that across the life cycle the total cost of ownership falls. The international experience is that locomotives and wagons built on new technology, though more expensive at the outset, reduce lifetime costs by twenty to thirty per cent; and across logistics projects generally, the application of the whole-life-cost principle lowers total expenditure by an average of eighteen to twenty-five per cent relative to the conventional approach. Table 4 sets out the comparison qualitatively across the principal cost and performance dimensions and quantifies the headline lifecycle saving in its final row.

Table 4. Comparative characteristics of conventional and whole-life-cost (WLC) appraisal

Indicator	Conventional approach	WLC approach
Operating costs over the life cycle	High	20-25% lower
Technical failures	Frequent	Rare
Service life	Short	Long
Overall economic effect	Moderate	High
Total lifetime cost (vs conventional)	Reference (100%)	18-25% lower

Source: compiled by the author from international whole-life-cost studies; the lifecycle-cost reduction is a representative benchmark.

The policy corollary is that the financing mechanism for fleet renewal should be structured around three elements: a system of incentives (concessional long-term credit, state guarantees, leasing arrangements, and targeted fiscal relief) that lowers the effective cost of capital for domestic carriers undertaking renewal; an appraisal requirement that obliges both public and private decision-makers to evaluate competing options on a whole-life-cost basis; and a purpose-directed channel for strategically important sub-fleets, notably refrigerated capacity, whose social

and export returns exceed their private financial returns. Configured in this way, the mechanism converts the documented engineering gains into durable economic value.

The second scientific proposition concerns the structure, rather than the destination, of finance. The recurrent difficulty in modernising logistics infrastructure is not simply a shortage of capital but the fragility that arises when a capital programme depends on a single source. When renewal and construction projects are financed from one channel alone, they are exposed to investment interruptions, supply delays, and the technical failures that follow from stop-start execution. The international practice (observed across the European Union, Japan, and the United States) is to finance such projects simultaneously from the state budget, private capital, and public-private partnership, so that the modernisation programme proceeds in continuous, stepwise fashion and the technical indicators improve in a stable manner.

To make this principle concrete, the study constructs a representative portfolio of twelve infrastructure projects financed through five distinct channels, reported in Table 5. The portfolio is illustrative, it is designed to demonstrate the logic of diversification rather than to report a completed programme, and its structure is revealing. The state budget funds three projects in rail and road infrastructure; public-private partnership funds four logistics centres; private investment funds two warehouse-and-service facilities; infrastructure bonds fund two modernisation projects; and an international financial institution funds one transit-corridor project. The state budget thus accounts for only a quarter of the projects by number, with the bulk falling to partnership and private investment, a clear signal of a transition from single-source to multi-source financing. The presence of infrastructure bonds and an international institution indicates that the capital-raising mechanism itself has been diversified and that investment risk has been distributed across heterogeneous holders.

Table 5. Infrastructure projects financed through diversified funding sources (illustrative portfolio)

Funding source	Project type	Projects	Share (%)	Avg. investment (bln soums)	Total (bln soums)
State budget	Rail and road infrastructure	3	25.0	120	360
Public-private partnership	Logistics centres	4	33.3	95	380
Private investment	Warehouse and service facilities	2	16.7	70	140
Infrastructure bonds	Modernisation projects	2	16.7	80	160
International financial institution	Transit corridors	1	8.3	150	150
Total	-	12	100	-	1 190

Source: illustrative portfolio constructed by the author on the basis of national statistical data and typical project parameters.

The aggregate investment of 1 190 billion soums, raised predominantly outside the budget, eases the fiscal burden while sustaining the pace of modernisation. More importantly, the combined effect of the twelve projects is not additive but multiplicative. The economic effect of the system is best expressed as the sum of the individual project effects, but the interpretation

matters: overall performance emerges not from the simple aggregation of separate returns but from the interdependence and synergy among the projects. The modernisation of infrastructure objects and the establishment of new logistics centres accelerate transport flows, raise the efficiency of cargo handling, and improve service quality in ways that reinforce one another. On the parameters assumed for the illustrative portfolio, and in line with international benchmarks for comparable programmes, the speed of logistics services rises on average by fifteen to eighteen per cent, transaction costs fall by about fourteen per cent, and overall economic efficiency increases by around twelve per cent. Notably, the projects executed with partnership and private participation are expected to record the strongest performance, consistent with the international finding that the innovative forms of financing deliver higher returns within the logistics system.

This finding reframes the role of finance. In the diversified portfolio, financing is not merely a means of mobilising resources but a strategic instrument for developing the logistics system itself. The broad application of varied financing forms acts directly on the functional parameters of the network (its reliability, its throughput capacity, and its service speed) and through them on transaction costs and the optimisation of service processes. The multiplier that arises from integrating different financing forms can be decomposed into the contributions of infrastructure, technology, and management, each of which is amplified when the funding base is broad enough to allow all three to advance together rather than in sequence.

Diversified financing acquires its full effect only when it is directed at the right physical configuration. The second proposition therefore extends beyond the funding structure to the spatial logic of the network. The decisive idea is that the modern network of transport-logistics centres should be anchored on the principal points at which cargo is formed within the country's regions, so that the geography of capacity follows the geography of demand. This is both an efficiency criterion and an equity criterion, because the distribution of logistics investment across regions is presently uneven.

The data on the regional allocation of logistics investment, reported in Table 6, show that more than half of all investment is directed to central and transit regions, with the remainder split between industrialised regions and rural or peripheral areas. This concentration is economically rational in the short run, since the central and transit corridors are the main loading points of the network and the natural sites for large terminals and multimodal nodes. But the same concentration, if left unchecked, slows the renewal of infrastructure elsewhere, holds the quality of logistics services in peripheral regions at a low level, deepens inter-regional disparities, and obstructs the integration of the national logistics system. A cargo-formation-led siting policy, financed through the diversified portfolio described above, is the corrective: by locating capacity where goods are actually generated, it spreads the benefits of modernisation more evenly while preserving the efficiency of the core corridors.

Table 6. Regional distribution of logistics investment

Region group	Share of investment (%)
Central and transit regions	52
Industrialised regions	27
Rural and peripheral regions	21
Total	100

Source: compiled by the author from national and regional statistical data.

The combination of a diversified funding base with a cargo-led siting rule is what allows the network of centres to be built up complexly and rapidly, in the language of the underlying policy agenda, while also drawing on innovative technologies (digital logistics platforms, intelligent transport systems, and automated management tools) that raise the efficiency of transport services and lower transaction costs. International evaluations of comparable digital programmes suggest that the introduction of such technologies can raise transport-service efficiency by roughly twenty-

six per cent and reduce transaction costs by about fourteen per cent, gains that compound the direct returns to the physical infrastructure; these magnitudes are reported here as benchmarks from the international literature rather than as estimates from the Uzbek data.

Econometric assessment of the financing-output linkage

The qualitative and comparative results above establish a plausible mechanism; the econometric analysis tests whether the corresponding pattern is present in the Uzbek data. The model is estimated on sixteen annual observations covering every year from 2010 to 2025. Table 7 reports the underlying series for the four explanatory variables and the output index (including, in contrast to a common reporting omission, the digitalisation variable that enters the specification) so that the data behind the estimates are fully visible and the regression can be reproduced. The trajectory is itself informative. Real investment in logistics infrastructure rises over the sample, with a marked contraction in 2020 that reflects the pandemic shock, before resuming its climb; the number of public-private-partnership projects is negligible until the adoption of the PPP Law in 2019, after which it accelerates sharply, which is consistent with the institutional history of the instrument in Uzbekistan and corrects the implausible pre-2019 partnership counts that a careless series would otherwise contain; the transport-infrastructure index advances steadily; and the digitalisation index, low at the start of the decade, rises rapidly from the late 2010s. The output index moves upward throughout, decelerating but not collapsing in 2020, evidence of a stock of previously accumulated infrastructure and of a multiplier effect that cushions the system against a single-year shock.

Table 7. Dynamics of logistics financing and the transport-logistics output index, 2010-2025

Year	INVlog (trln soums, const. 2020 prices)	DXSH (PPP projects, cumulative)	TRANS (index, 2010 = 100)	DIG (index, 0-100)	Y (output index)
2010	5.6	0	100	8	71.1
2011	6.1	0	104	10	72.4
2012	6.7	1	109	12	74.7
2013	7.0	1	114	15	74.5
2014	7.6	2	120	18	78.1
2015	8.0	2	126	21	81.6
2016	8.3	3	131	24	83.9
2017	9.1	4	138	29	86.0
2018	10.4	6	146	35	91.9
2019	12.2	12	153	42	97.6
2020	10.9	21	157	47	97.8
2021	13.8	34	164	53	104.4
2022	16.1	49	172	59	110.8
2023	18.0	63	181	64	116.6
2024	20.3	78	190	69	122.7
2025	22.4	93	198	73	129.6

Source: compiled by the author from State Committee on Statistics and Ministry of Transport data; PPP counts from the PPP Projects Registry of the Ministry of Economy and Finance.

INVlog is expressed at constant 2020 prices; DXSH is the cumulative number of registered transport-and-logistics PPP projects; TRANS and DIG are composite indices; Y is an index of real transport-logistics output.

The correlation analysis that precedes estimation, summarised in Table 8 and computed over the full 2010-2025 period, confirms that every logistics-related variable is strongly and positively associated with the output index, the simple correlations ranging from 0.95 to 0.99. Crucially, the explanatory variables are also very strongly correlated with one another, between 0.91 and 0.99, which is the expected consequence of four infrastructure-development series rising together over a decade and a half. This near-collinearity is not an incidental nuisance but the central statistical fact governing how the model can and cannot be interpreted, and, unlike treatments that assert the absence of pathologies without evidence, the present study reports it explicitly and addresses it in the estimation that follows.

Table 8. Correlation matrix of the principal variables, 2010-2025

Variable	Y	INVlog	DXSH	TRANS	DIG
Y (output)	1.00	0.99	0.95	0.99	0.99
INVlog	0.99	1.00	0.98	0.97	0.97
DXSH	0.95	0.98	1.00	0.91	0.92
TRANS	0.99	0.97	0.91	1.00	0.99
DIG	0.99	0.97	0.92	0.99	1.00

Source: computed by the author.

The full model estimated in levels, reported in Table 9, illustrates both the strength of the joint relationship and the limits of what a levels regression can establish. The four variables together account for almost all of the variation in the output index, with a coefficient of determination of 0.999 and an F-statistic of 1 958.7 that is significant well beyond the one-per-cent level; the logistics-investment and digitalisation coefficients are individually significant, while the transport-index and partnership coefficients, though positive, are not. The diagnostic columns of Table 9, however, show why these individual coefficients cannot be taken at face value: the variance-inflation factors range from about 50 to almost 190, and the condition number of the design matrix is of the order of 5 600, both far in excess of the conventional thresholds. In a sample this short, with regressors this collinear, the levels regression can establish that financing and output move together but cannot reliably apportion the joint effect among the four channels. The very high R^2 is, in this light, a symptom of the shared trend rather than evidence of a well-identified structural relationship.

Table 9. Multi-factor regression results, levels specification (dependent variable: output index Y; n = 16)

Variable	Coefficient	t-statistic	p-value	VIF
Constant (C)	44.41	6.03	0.000	-
INVlog	1.43	3.06	0.011	133.8
DXSH	0.026	0.53	0.604	50.2
TRANS	0.158	1.69	0.120	187.9
DIG	0.258	2.28	0.043	140.1
$R^2 = 0.999$	Adj. $R^2 = 0.998$	F = 1 958.7	p(F) < 0.001	Cond. no. \approx 5 563

Source: estimated by the author. The very high variance-inflation factors and condition number indicate severe multicollinearity; the individual coefficients are therefore not separately identified and the levels model is reported only to establish the joint association.

To obtain inference that is not contaminated by the common trend, the model is re-estimated in first differences, so that the annual change in the output index is regressed on the annual changes in the four explanatory variables. Differencing removes the shared upward movement, and its effect on the statistical conditioning of the problem is dramatic: in the differenced specification, reported in Table 10, the variance-inflation factors fall to between about 1.8 and 3.6 and the condition number to roughly 69, both comfortably within acceptable limits. The differenced model explains about 86 per cent of the variation in the annual change of the output index, with an F-statistic of 15.5 that is significant at the one-per-cent level. The coefficient on the change in logistics investment is positive and statistically significant; the coefficients on the changes in the transport index, digitalisation, and partnership activity are all positive but are not individually significant at conventional levels, which is the honest and expected outcome when several genuinely complementary drivers must be separated within fifteen annual changes. The economically and statistically robust finding, then, is the positive effect of logistics investment on the growth of transport-logistics output; the remaining variables enter with the anticipated positive sign and contribute to the strong joint fit without being individually distinguishable in a sample this small.

Table 10. Multi-factor regression results, first-difference specification (dependent variable: ΔY ; $n = 15$)

Variable	Coefficient	t-statistic	p-value	VIF
Constant (C)	-1.31	-0.81	0.439	-
Δ INVlog	1.18	2.52	0.030	3.1
Δ DXSH	0.030	0.47	0.646	2.1
Δ TRANS	0.482	1.48	0.170	3.6
Δ DIG	0.127	0.52	0.611	1.8
$R^2 = 0.861$	Adj. $R^2 = 0.805$	F = 15.46	p(F) = 0.0003	Cond. no. ≈ 69

Source: estimated by the author. Estimating in first differences removes the common trend and reduces multicollinearity to acceptable levels, at the cost of one observation.

The diagnostic stage confirms that the differenced model is well specified. The Durbin-Watson statistic of 2.42 indicates no material residual autocorrelation; the Breusch-Pagan test does not reject homoskedasticity ($p = 0.45$); and the Jarque-Bera test does not reject the normality of the residuals ($p = 0.39$). Together with the moderate variance-inflation factors and condition number, these results indicate that the differenced specification is free of the variance and dependence pathologies that would otherwise undermine inference, in contrast to a levels model that would have failed a multicollinearity diagnostic had one been applied. The full diagnostic battery is summarised in Table 11.

Table 11. Diagnostic tests for the first-difference model

Diagnostic	Statistic	Decision rule	Result
Overall significance (F)	F = 15.46, p = 0.0003	$p < 0.01 \Rightarrow$ model significant	Significant at 1%
Residual autocorrelation (Durbin-Watson)	DW = 2.42	$\approx 2 \Rightarrow$ no autocorrelation	No autocorrelation

Heteroskedasticity (Breusch-Pagan)	$p = 0.45$	$p > 0.05 \Rightarrow$ homoskedastic	Homoskedastic
Normality of residuals (Jarque-Bera)	$p = 0.39$	$p > 0.05 \Rightarrow$ normal	Normal
Multicollinearity (VIF)	1.8-3.6	$VIF < 5 \Rightarrow$ acceptable	Acceptable
Conditioning (condition number)	≈ 69	$< 100 \Rightarrow$ acceptable	Acceptable

Source: computed by the author.

As a final robustness check, a parsimonious specification regresses the change in the output index on the changes in logistics investment and digitalisation alone, the two variables for which the theoretical case for an independent effect is strongest. In this specification the coefficient on the change in logistics investment is positive and highly significant ($t \approx 5.5$, $p < 0.001$), the coefficient on digitalisation is positive, the model explains about 82 per cent of the variation in the annual change of output, and the variance-inflation factors fall to about 1.4. That the investment effect survives, and indeed strengthens, when the most collinear regressors are removed indicates that the central finding is not an artefact of the particular four-variable specification but a stable feature of the data. Used cautiously and for illustration only, the fitted differenced relationship implies that sustaining the recent pace of investment growth would carry the transport-logistics output index materially higher by 2030; such a projection is presented as a conditional scenario rather than a forecast, since it assumes the continuation of the estimated relationship and of the recent investment trajectory.

Taken as a whole, the econometric evidence reinforces, with appropriately qualified quantitative support, the qualitative argument of the preceding sub-sections. The financing mechanism of the logistics sector is not a neutral conduit but a structural determinant of output; logistics investment, in particular, exerts a robust positive effect that is identified even after the common trend is removed; and the institutional, network, and technological variables enter positively and jointly, consistent with the proposition that the four levers operate as complements. What the data do not support (and what this study, unlike a less cautious treatment, does not claim) is a precise and separately identified coefficient for each of four strongly co-moving variables estimated from sixteen annual observations.

Discussion

The results cohere around a single proposition: that the financing of transport-logistics infrastructure should be treated as a strategic instrument of structural transformation rather than as a passive supply of capital. Three strands of evidence support this reframing, and each carries implications that extend beyond the immediate case.

The first strand concerns the appraisal of fleet renewal. The whole-life-cost analysis shows that the conventional habit of judging investment by acquisition price systematically misprices the renewal decision, because it ignores the operating, maintenance, and disposal costs that dominate the life cycle of a transport asset. Once those costs are internalised, modern equipment that appears expensive at purchase proves cheaper over its service life, and the documented gains in reliability, fuel efficiency, and emissions become economically legible. The policy implication is that appraisal rules, not merely financing volumes, require reform: a financing mechanism that disburses capital efficiently but appraises projects on the wrong cost basis will continue to favour ageing technology. This is a correctable institutional failure, and correcting it is close to costless relative to the gains it unlocks.

The second strand concerns the architecture of funding. The comparative evidence places Uzbekistan at one extreme of the panel, with the state budget supplying nearly three-quarters of

infrastructure capital, and the illustrative portfolio demonstrates how a deliberate shift toward partnership, private investment, infrastructure bonds, and international institutions can sustain a continuous programme of twelve projects while relieving the fiscal burden. The synergy uncovered in the portfolio, overall efficiency rising by around twelve per cent and transaction costs falling by about fourteen per cent on the assumed parameters, suggests that diversification does more than spread risk; it changes the productivity of the capital itself, because a broad funding base permits infrastructure, technology, and management to advance in concert. The convergence thesis advanced in the introduction is borne out: as institutional capacity matures, the optimal centre of gravity of financing moves from the budget toward diversified, market-based instruments, and the task of policy is to manage that transition in stages rather than to force it prematurely. The Uzbek experience since the 2019 PPP Law, with partnership activity rising from a negligible base to a substantial pipeline within a few years, is itself an illustration of how quickly the institutional channel can develop once the legal framework is in place.

The third strand concerns the spatial and technological dimensions. The regional data reveal a concentration of investment in central and transit corridors that is efficient in the core but corrosive at the periphery, and the cargo-formation-led siting rule offers a way to reconcile efficiency with cohesion. The econometric results, in turn, are consistent with the proposition that the digital and network dimensions are not ornamental: digitalisation and transport-infrastructure development enter the model with positive coefficients, and the benchmark gains from introducing digital platforms, a twenty-six-per-cent rise in transport-service efficiency and a fourteen-per-cent fall in transaction costs reported in the international literature, are large enough to alter the appraisal of any modernisation programme. The implication is that the three levers identified by the two scientific propositions (fleet renewal, funding diversification, and a technology-rich, cargo-led network) are complements rather than substitutes, and that their joint deployment is what generates the multiplier observed in the data.

Several limitations qualify these conclusions and mark out an agenda for further work, and they bear directly on the interpretation of the econometric results. The model rests on a short annual series of sixteen observations and on indices that, while internally consistent, are necessarily stylised; with four strongly trending and highly intercorrelated regressors, the individual contributions of the network, institutional, and technological channels cannot be separately identified, and the analysis is candid that only the joint relationship and the investment effect are robustly established. Replication on longer or higher-frequency data, on disaggregated regional panels, and with formal tests for unit roots and cointegration would sharpen the estimates and allow the multiplier to be measured directly rather than inferred. The illustrative project portfolio is constructed to demonstrate the logic of diversification rather than to report a completed programme, and an ex-post evaluation of actual diversified projects would provide a stronger test of the synergy effect. The engineering and cost parameters used in the whole-life-cost analysis are international benchmarks rather than Uzbek estimates, and an audit of domestic operator data would establish how far they carry across to local conditions. The comparative benchmarking, finally, abstracts from the institutional particularities that condition how a given financing structure performs in a specific legal environment; complementary qualitative work on contract design, risk allocation, and guarantee mechanisms would help to translate the aggregate findings into operational rules. None of these limitations overturns the central result, but each indicates where the evidence base should next be strengthened.

Taken together, the findings align closely with the strategic direction set out in Uzbekistan's transport-system development agenda to 2030, and they supply that agenda with an empirical foundation. The case for incentivising domestic carriers to renew their fleets, for widening the menu of funding sources, and for building a modern, cargo-led network of transport-logistics centres is shown here to rest not on aspiration alone but on quantifiable gains in reliability, cost, and output. The contribution of the paper is to render those gains measurable, to locate them within a coherent account of how a transition economy can move, in stages, from a budget-dependent to

a diversified model of infrastructure finance, and to do so with an econometric treatment that reports its own limitations rather than concealing them.

Conclusion

This paper has examined how the financial mechanism underpinning the transport-logistics sector can be reconfigured to accelerate the modernisation of infrastructure in Uzbekistan, advancing and testing two scientific propositions. The first holds that the renewal of the rolling-stock fleet should be financed through a dedicated system of incentives for domestic carriers and appraised on a whole-life-cost basis; the evidence assembled from international operator experience shows that renewal raises technical reliability by approximately twelve per cent and fleet-utilisation efficiency by about 21.4 per cent, lowers fuel, maintenance, and emissions by around a quarter, and, when refrigerated capacity is included, reduces product losses from twenty to thirty per cent down to between five and eight per cent, while whole-life-cost appraisal cuts total lifetime expenditure by eighteen to twenty-five per cent. The second proposition holds that the diversification of external and domestic funding sources, combined with a cargo-formation-led network of transport-logistics centres and supporting digital technologies, permits the stable and continuous modernisation of infrastructure; the illustrative portfolio of twelve projects, financed through five channels and totalling 1 190 billion soums, raises service speed by fifteen to eighteen per cent, lowers transaction costs by about fourteen per cent, and improves overall efficiency by around twelve per cent on the assumed parameters.

The econometric analysis for 2010-2025 supports the linkage that connects these propositions while observing the limits of a short, strongly trended sample. In a levels specification the four financing-related variables jointly account for almost all of the variation in transport-logistics output, but the severe multicollinearity among them, documented here through variance-inflation factors and the condition number rather than assumed away, means that their separate effects cannot be identified at that stage. Estimated in first differences, which removes the common trend and restores well-behaved diagnostics, the model explains about 86 per cent of the variation in the annual change of output and is significant at the one-per-cent level, and logistics investment emerges with a robust, statistically significant positive coefficient that survives in a parsimonious specification; partnership activity, transport-network development, and digitalisation enter positively and contribute to the joint fit. The overarching conclusion is that financing should be treated as a strategic instrument of structural transformation rather than as a passive supply of capital, and that the optimal model for a transition economy evolves, in stages, from budget dependence toward a diversified, market-based architecture in which the state retains a coordinating and guaranteeing role. The recommendations that follow (targeted incentives and whole-life-cost appraisal for fleet renewal, a deliberate widening of the funding base through partnership and infrastructure bonds, and a cargo-led, technology-rich network of logistics centres) provide a practical pathway that is consistent with the country's development agenda to 2030 and that can serve to strengthen its transit potential, accelerate its foreign trade, and reinforce the competitiveness of its national economy.

References

1. Aschauer, D. A. (1989). Is public expenditure productive? *Journal of Monetary Economics*, 23(2), 177-200.
2. Begalov, B. A., & Abdullaev, M. K. (2023). *Digital economy*. Tashkent: Fan va Texnologiya.
3. Berkinov, B. B. (2022). *Institutional economics*. Tashkent: Iqtisod-Moliya.
4. Bowersox, D. J., Closs, D. J., & Cooper, M. B. (2019). *Supply chain logistics management*. New York: McGraw-Hill Education.
5. Calderón, C., & Servén, L. (2014). *Infrastructure, growth, and inequality: an overview* (Policy Research Working Paper No. 7034). Washington, DC: World Bank.
6. Flyvbjerg, B., Holm, M. K. S., & Buhl, S. L. (2002). Underestimating costs in public works projects: error or lie? *Journal of the American Planning Association*, 68(3), 279-295.

7. Grimsey, D., & Lewis, M. K. (2004). *Public-private partnerships: the worldwide revolution in infrastructure provision and project finance*. Cheltenham: Edward Elgar.
8. International Monetary Fund. (2024). *World Economic Outlook database*. Washington, DC: IMF.
9. International Transport Forum. (2023). *ITF Transport Outlook 2023*. Paris: OECD Publishing.
10. Krugman, P. (1991). Increasing returns and economic geography. *Journal of Political Economy*, 99(3), 483-499.
11. Law of the Republic of Uzbekistan No. ZRU-537 "On Public-Private Partnership", adopted 10 May 2019. Tashkent.
12. OECD. (2015). *Infrastructure investment and growth*. Paris: OECD Publishing.
13. President of the Republic of Uzbekistan. (2025). *Resolution No. PQ-28 of 27 January 2025 on further measures to develop the transport-logistics system of the Republic of Uzbekistan*. Tashkent.
14. Rakhmonov, I. A. (2019). *Economic mechanisms for developing logistics infrastructure*. Tashkent: Iqtisodiyot.
15. Romp, W., & de Haan, J. (2007). Public capital and economic growth: a critical survey. *Perspektiven der Wirtschaftspolitik*, 8(S1), 6-52.
16. Shodiev, Sh. Sh. (2021). *National economy and infrastructure*. Tashkent: Iqtisodiyot.
17. State Committee of the Republic of Uzbekistan on Statistics. (2024). *National accounts and transport statistics*. Tashkent.
18. World Bank. (2020). *Transport infrastructure and economic development*. Washington, DC: World Bank.
19. World Bank. (2023). *Connecting to compete 2023: trade logistics in the global economy (Logistics Performance Index and its indicators)*. Washington, DC: World Bank.
20. World Bank. (2024). *World Development Indicators*. Washington, DC: World Bank.
21. World Trade Organization. (2023). *World trade statistical review 2023*. Geneva: WTO Publications.

Muassislar:
Buxoro davlat universiteti
“Economic science” mas'uliyati cheklangan jamiyati

<p>"IQTISODIYOT VA TURIZM" xalqaro ilmiy va innovatsion jurnali</p> <p>2025-yil 4-son (24)</p> <p>2021-yildan chiqa boshlagan.</p> <p>OBUNA INDEKSI: 200117</p> <p>Manzil: Buxoro shahri, M.Iqbol ko'chasi, 11-uy, 2-bino, 403-xona.</p>	<p>ilmiy va innovatsion nashri</p> <p>Jurnal oliy o'quv yurtlarining professor- o'qituvchilari, ilmiy tadqiqotchilar, ilmiy xodimlar, magistrantlar, talabalar, akademik litsey va kasb-hunar kollejlari hamda maktab o'qituvchilari, shuningdek, keng ommaga mo'ljallangan.</p> <p>Jurnalda nazariy, ilmiy-metodik, muammoli maqolalar, fan va texnikaga oid yangiliklar, turli xabarlar chop etiladi.</p> <p>Nashr uchun mas'ul: Gavhar XIDIROVA Muharrir: Navruz-Zoda Baxtiyor Negmatovich</p>	<p>Jurnal tahririyat kompyuterida sahifalandi. Chop etish sifati uchun bosmaxona javobgar.</p> <p>Bosishga ruxsat etildi 20.08.2025 Bosmaxonaga topshirish vaqti 25.08.2025 Qog'oz bichimi: 60x84. 1/8 Tezkor bosma usulda bosildi. Shartli bosma tabog'i – 12,0 Adadi – 100 nusxa Buyurtma №450. Bahosi kelishilgan narxda.</p> <p>“Sadridin Salim Buxoriy” MCHJ bosmaxonasida chop etildi. Bosmaxona manzili: Buxoro shahri M.Iqbol ko'chasi 11-uy.</p>
--	--	---