

Cost Benefit Analysis of Multimodal Transportation Systems in Nigeria: A Financial Perspective on Long-term Sustainability

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Received: 30.10.2025 | Accepted: 20.11.2025 | Published: 26.11.2025

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DOI: [10.5281/zenodo.17718938](https://doi.org/10.5281/zenodo.17718938)

Abstract

Original Research Article

This study evaluates the impact of cost benefit analysis of multimodal transportation systems on the financial long-term sustainability of Nigeria's transport infrastructure. Recognizing the critical role that transport infrastructure plays in economic development, the research focuses on how the costs incurred and benefits derived from multimodal projects influence the sustained financial viability of the sector. Using annual data from 2003 to 2023, key variables such as budget execution rate (proxy for financial sustainability), project costs, and benefits generated were analyzed through the Autoregressive Distributed Lag (ARDL) modelling approach. The findings reveal a negative but statistically insignificant short-run effect of project costs on financial sustainability in Nigeria. Conversely, benefits derived from multimodal systems show a positive yet insignificant influence, indicating potential for enhanced revenue streams to support sustainability if properly harnessed. These results emphasize the necessity for improved cost controls, enhanced benefit realization strategies, and stable fiscal policies to promote enduring financial health in Nigeria's multimodal transport sector. The study contributes to existing literature by bridging financial analysis with multimodal transport sustainability within a developing country context, offering valuable insights for policymakers, infrastructure planners, and stakeholders aiming to optimize investment outcomes and secure sustainable transport development.

Keywords: Multimodal transportation, Financial sustainability, Transport infrastructure, Infrastructure investment, Nigeria, Economic development.

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1.1 Introduction

From a financial perspective, long-term sustainability means that a project or system can create and manage financial resources over time in a manner that guarantees steady service delivery, operational resilience, and minimum financial

pressure. In public infrastructure, especially transport, the phrase means looking at whether a system can keep running, be maintained, and develop without relying too much on subsidies or debt that can't be paid back. By 2030, governments throughout the world would need to spend more than \$2.7 trillion



Citation: Oyakegha, E. S., Irejeh, E. M., & Sile, A. A. (2025). Cost Benefit Analysis of Multimodal Transportation Systems in Nigeria: A Financial Perspective on Long-term Sustainability. *Global Academic and Scientific Journal of Multidisciplinary Studies (GASJMS)*, 3(11), 98-117.

a year on infrastructure to reach their sustainable development objectives. A big part of that will be for transport (Global Infrastructure Outlook, 2023). In Nigeria, nevertheless, infrastructure development has typically been short-term and reactive. The Budget Office of the Federation (2024) says that between 2015 and 2023, capital appropriations to transport made up just 5.2% of the national budget. This meant that transport was always underfunded. This financial instability makes transport investments less likely to last and shows how important it is to identify a long-term, financially stable solution. A transport infrastructure that is financially viable must be able to attract investment, recoup expenses quickly, and help the economy expand without making it less affordable or accessible (World Bank, 2024).

Multimodal transportation is the idea of combining diverse means of transportation, such as rail, road, air, and waterways, in a manner that makes them function together. This is a smart strategy to address Nigeria's transportation problems. The system is overstressed since over 90% of freight and passenger transit happens by road. This scenario leads to higher prices, longer wait times, and more accidents (National Bureau of Statistics, 2023). Multimodal integration might help with this problem by dispersing the load over more efficient and cost-effective options like rail and inland waterways. But building these kinds of systems demands careful financial preparation. The Infrastructure Concession Regulatory Commission (ICRC, 2023) says that Nigeria's transport system needs more than \$15 billion in investment to be improved via public-private partnerships and state help. In this situation, the financial outlook for long-term sustainability becomes significant. It is important to know the long-term financial effects, possible returns, and ways to pay for these kinds of investments. This is where you can use cost-benefit analysis (CBA) to make informed investment decisions and ensure the sustainability of transportation financing.

Cost-benefit analysis is a methodical way to figure out whether a project is worth doing by comparing the overall estimated expenses to the predicted benefits, both physical and intangible. In the transportation industry, CBA usually takes into

account building costs, maintenance expenses, time saved on travel, less congestion, environmental effects, and social and economic effects. Mackie and Worsley (2013) The European Commission (2023) says that well-designed multimodal transport systems may reduce logistics costs by 20–30% and carbon emissions by up to 40%. In Nigeria, where the logistics industry makes up around 14% of GDP but is still not very effective because of weak intermodal connectivity (PwC Nigeria, 2022), it is critical to do a CBA from a financial point of view. It not only tells us where to put our limited resources, but it also encourages fiscal discipline, accountability, and openness in funding infrastructure. A cost-benefit approach helps figure out whether expanding rail or waterways, for example, is a better long-term investment than relying too much on road networks. This makes the argument for multimodal systems that are financially viable and can handle future needs stronger.

Numerous global, regional, and local studies have investigated various facets of multimodal transportation and financial evaluation. Gwilliam (2022) pointed out the economic benefits of multimodal systems in Southeast Asia, where delivery times improved by up to 25% and logistical costs went down. Nuwagira and Kiggundu (2023) found in Uganda that combining rail and road transport lowered freight costs by 18% and made the supply chain more reliable. Nonetheless, the majority of research in Nigeria has been disjointed. Okeke and Abubakar (2021) concentrated on policy and governance within the transport sector, while Uzochukwu et al. (2022) examined modal shift options devoid of financial quantification. Additionally, there are few studies in Nigeria that use robust Cost-Benefit Analysis (CBA) methodologies that provide long-term financial insights. The Nigerian Economic Summit Group (NESG, 2023) observed an absence of thorough financial modelling in national transportation planning, resulting in mismatched project priorities. This study aims to address this significant gap by assessing the cost-benefit analysis of multimodal transport systems in Nigeria, particularly from a financial perspective that prioritises long-term sustainability. It attempts to provide scientific knowledge that facilitates prudent

investment choices, promotes fiscal discipline, and links infrastructure development with overarching national economic objectives.

1.2 Statement of the Research Problem

One of the central challenges confronting Nigeria's transportation sector is the persistent lack of financial sustainability, particularly in long-term infrastructure development and maintenance. Despite successive government interventions and policy frameworks, transport investments in Nigeria are often characterized by high initial capital outlay, limited cost recovery mechanisms, weak financial forecasting, and rising maintenance deficits (World Bank, 2023). These issues are further exacerbated by overreliance on public financing, poor asset management, and the absence of structured financial sustainability models. For instance, the Infrastructure Concession Regulatory Commission (ICRC, 2023) revealed that over 70% of Nigeria's publicly funded transportation projects face funding shortfalls or budget overruns within the first five years of operation. Without strategic financial planning and sustainable investment structures, the nation risks continued inefficiency, wastage, and eventual infrastructural decline.

While, multimodal transport systems offer the potential to optimise logistics, reduce operational costs, and foster environmental sustainability, the financial viability of such systems remains uncertain due to insufficient long-term economic evaluations. Currently, there is a critical gap in how transportation infrastructure is assessed and financed, particularly in terms of cost recovery, value for money, and lifecycle cost analysis. Many infrastructure decisions are based on short term political interests rather than rigorous financial analysis, leading to abandoned projects and underutilised assets. As noted by AfDB (2022), long-term sustainability in the transport sector demands an integrated financial perspective that evaluates not just immediate benefits but also recurring operational costs, return on investment, and broader socioeconomic impact. Therefore, the absence of a systematic financial evaluation framework, such as cost-benefit analysis tailored to Nigeria's multimodal transport context, raises significant concerns about the long-term

sustainability and financial prudence of transport investments. This paper study sought to fill this gap by offering a financial perspective on the long-term sustainability of multimodal transport systems in Nigeria.

1.3 Objectives of the Study

The study sought to ascertain the effect of cost-benefit analysis of multimodal transportation systems on the financial long-term sustainability of Nigeria's transport infrastructure. The specific objectives of the study are:

1. To assess the effect of the cost of multimodal transportation projects on the financial long-term sustainability of transport infrastructure in Nigeria.
2. To evaluate the effect of the benefits derived from multimodal transportation systems on the financial long-term sustainability of transport infrastructure in Nigeria.

1.4 Research Hypotheses

This study sought to address the following pertinent research hypothesis

H₀₁: The cost of multimodal transportation projects has no significant effect on the financial long-term sustainability of transport infrastructure in Nigeria.

H₀₂: The benefits derived from multimodal transportation systems have no significant effect on the financial long-term sustainability of transport infrastructure in Nigeria.

2.0 Literature Review

2.1.0 Conceptual Review

2.1.1 Cost-Benefit Analysis

Cost-benefit analysis (CBA) in transportation planning is a comprehensive evaluation of the economic consequences associated with infrastructure investment choices. It includes both monetary and nonmonetary elements, such as how land is used, how efficient fuel is, how much carbon

is released, and how much time is saved on the road (Boardman, Greenberg, Vining, & Weimer, 2018). The main purpose of CBA is to find out whether the overall anticipated benefits of a transport project are more than the whole estimated expenses. CBA is essential for planners who have to pick between choices like train extensions, highway enhancements, or ferry systems in multimodal systems where diverse modes of transportation are combined to make travel easier. This is because CBA helps planners figure out which option will have the best economic return and social effect.

Recent improvements in data analytics and modelling have made the CBA even more useful for complicated projects. The European Commission (2023) says, for example, that a full CBA should not just look at financial costs and revenues but also at how it affects social welfare, such as making things easier to get to, reducing traffic jams, and avoiding accidents. CBA is being used more and more in Africa to support evidence-based infrastructure development policies, especially as investment in multimodal systems grows (AfDB, 2022). This approach makes sure that transport investments are useful in the long run and help the economy expand in a way that includes everyone, particularly in cities and on the coast, where there are still gaps in mobility.

2.1.2.1 Cost of Multimodal Transportation Projects

The cost of multimodal transportation projects is often substantial due to the need to integrate various infrastructure types, technologies, and regulatory frameworks. These costs typically include capital expenditure (CAPEX) for construction, acquisition of transport fleets, land development, and system integration. Operational expenditure (OPEX) such as maintenance, staffing, fuel, and energy also form a large component of ongoing costs (World Bank, 2023). Additionally, coordination between different transportation agencies and private stakeholders incurs institutional costs, which must be accounted for in a full financial appraisal. These complex cost structures demand detailed accounting and long-term financial forecasting to ensure sustainability.

Another important cost consideration is the opportunity cost, particularly in urban planning, where land use must be optimised. Multimodal hubs often require significant land acquisition in premium urban zones, affecting real estate values and displacing other potential developments (Buehler & Pucher, 2022). Moreover, the cost of delays in construction or implementation due to regulatory bottlenecks or public opposition can significantly escalate budgets. For developing regions like Nigeria, accessing finance for such capital-intensive projects may involve borrowing or public private partnerships (PPPs), both of which come with financial risks and implications for national debt profiles. Hence, accurate cost estimation is central to the successful delivery and financial health of multimodal transportation projects.

2.1.2.2 Benefits Derived from Multimodal Transportation Systems

The benefits of multimodal transportation systems are both broad and transformative, spanning economic, social, and environmental domains. Economically, such systems improve logistics efficiency, reduce travel time, and lower the cost of transporting goods and people. This enhances productivity, promotes trade, and boosts regional economic integration (Rodrigue, 2023). From a social perspective, multimodal systems improve accessibility, reduce traffic congestion, and provide safer travel options. This leads to better quality of life, particularly in densely populated urban areas or remote rural zones previously underserved by single mode systems.

Environmentally, multimodal systems contribute to sustainability goals by encouraging the use of energy efficient modes such as rail or inland waterways over high emission road transport. Integrating various modes can also decrease carbon emissions and reduce dependence on fossil fuels, aligning with global climate goals (European Environment Agency, 2023). Additionally, well integrated transport systems support tourism, education access, and emergency service delivery by ensuring people and goods can move easily across regions. In essence, the benefits derived from multimodal

transportation not only justify the initial investment but also generate long-term value across multiple development indices.

2.1.2.3 Financial Long-Term Sustainability

Financial long-term sustainability refers to the capacity of a multimodal transportation project to generate enough value over time to maintain operations, repay investments, and expand without constant external support. It involves planning beyond initial capital outlay, ensuring that revenue streams from user charges, freight tariffs, or government subsidies are sufficient to support the system's future financial obligations (Litman, 2022). This sustainability is often evaluated through financial performance indicators such as internal rate of return (IRR), net present value (NPV), and benefit cost ratios (BCR), which help in understanding a project's fiscal durability. Without financial sustainability, even technically successful transport systems risk becoming burdens on public finance.

To achieve long-term sustainability, stakeholders must align financial planning with institutional arrangements, regulatory policies, and public private partnership frameworks. Revenue diversification such as leasing commercial spaces at transport terminals or integrating value capture mechanisms is increasingly promoted to boost sustainability (ADB, 2023). Moreover, multimodal systems benefit from economies of scale when efficiently managed, reducing unit costs over time. Financial sustainability also supports system resilience, ensuring continuity in the face of disruptions, such as economic downturns or fuel price volatility. Therefore, long-term planning that incorporates maintenance, risk mitigation, and adaptable financial models are essential for the enduring success of multimodal transport investments.

2.2 Theoretical Framework

2.2.1 Rational Choice Theory

Rational Choice Theory (RCT) is rooted in classical economics and assumes that individuals and institutions make decisions by systematically evaluating available alternatives and selecting the

one that maximises personal or institutional benefit while minimising cost (Scott, 2000). This theory presupposes those actors whether individuals, corporations, or governments possess complete information, weigh the pros and cons of every decision, and act in a way that optimally satisfies their objectives. The theory has found wide application in fields such as economics, sociology, public policy, and urban planning, particularly in evaluating policy interventions and investment decisions where resources are scarce and choices have trade-offs.

In the context of multimodal transportation systems, Rational Choice Theory provides a theoretical base for conducting cost-benefit analysis (CBA). It assumes that decision-makers in transport agencies and governments compare various infrastructure options like road, rail, or inland waterways based on a calculated evaluation of potential costs and anticipated benefits. For instance, if integrating rail into port logistics is projected to reduce haulage costs, time delays, and environmental emissions, the rational choice would be to invest in that option. Therefore, RCT supports the assumption that transportation planning should be driven by economic rationality, where investments are made in alternatives that produce the highest net social and financial benefit.

2.2.2 Sustainable Transport Theory

Sustainable Transport Theory (STT) emerges from the broader paradigm of sustainable development and focuses on transport systems that are socially equitable, environmentally friendly, and economically viable in the long term (Banister, 2008). It critiques traditional models that prioritise short term economic gains over long-term sustainability and promotes integrated systems that balance the triple bottom line people, planet, and profit. The theory advocates for transportation planning that includes not just financial metrics but also environmental and social costs such as air pollution, road fatalities, congestion, and the impact on urban liveability.

Applied specifically to multimodal transport and cost-benefit analysis, this theory encourages a more

comprehensive valuation approach that integrates not only the direct costs and returns of infrastructure but also externalities and future implications. For example, sustainable transport planning would consider the long-term value of reduced carbon emissions from shifting freight from roads to railways, even if the immediate financial return seems marginal. Thus, this theory is particularly relevant when assessing projects with significant societal and environmental implications and supports the adoption of inclusive CBAs that capture both tangible and intangible outcomes of transport investments.

This study is anchored on Rational Choice Theory due to its clear applicability to economic evaluations like cost benefit analysis. RCT offers a robust framework for understanding how governments and transport planners choose among competing infrastructure investments based on calculated gains and losses. Given that CBA is a decision support tool used to maximise net benefits from limited financial resources, it fits squarely within the rational choice model, which assumes that actors are motivated to act in their best interest by selecting the most cost effective and beneficial alternative.

Furthermore, the emphasis of this study is on financial long-term sustainability and measurable outcomes (e.g., cost savings, efficiency improvements), rather than qualitative social or environmental impacts alone. Hence, Rational Choice Theory provides a more grounded and quantitative basis for evaluating multimodal projects from an economic point of view. While Sustainable Transport Theory provides useful insights into broader planning considerations, Rational Choice Theory offers the necessary conceptual structure for empirical comparison, quantification, and policy focused decision making in the context of infrastructure economics.

2.3. Empirical Review

Adeyemi and Musa (2023) investigated the economic viability of multimodal transportation projects in Lagos, Nigeria, using cost-benefit analysis. It applied financial and economic valuation

techniques to evaluate proposed railway and inland waterway integrations. The findings showed a positive net present value (NPV) and internal rate of return (IRR) above the discount rate, indicating strong investment potential. The study concluded that integrating road, rail, and waterways could significantly reduce logistics costs and urban congestion. It recommended that policymakers adopt multimodal systems supported by rigorous CBA to guide infrastructure investment decisions.

Wang and Zhang (2022) examined the long-term financial sustainability of multimodal transport corridors in China using cost-benefit and lifecycle cost analysis. The study used data from three national corridors combining road, rail, and inland shipping routes. The results indicated that projects with higher upfront costs in rail and water transport yielded higher long-term economic benefits, reduced emissions, and improved freight reliability. The study highlighted the importance of incorporating social and environmental benefits into CBAs for sustainable infrastructure development.

Okeke and Olagunju (2021) evaluated the costs and benefits of proposed multimodal transport systems in south eastern Nigeria. Using primary data from transport operators and public agencies, the study found that integrating road and rail significantly reduces haulage time and cost by up to 35%. The cost-benefit ratio (CBR) of 1.8 confirms that the long-term benefits outweigh initial infrastructure costs. The research recommended a phased investment strategy to optimise financial resource allocation and ensure efficient intermodal linkages.

Schmidt and Klein (2022) used a comparative cost-benefit analysis of freight transport across five EU countries to measure the efficiency of multimodal systems versus road only logistics. Data from government databases and logistics firms showed that multimodal systems resulted in 23% lower external costs (e.g., accidents, emissions) and a 19% improvement in cargo delivery times. The authors argued that traditional CBA must be adjusted to account for environmental and societal impacts, particularly for EU transport policy compliance.

Balogun and Edet (2023) analysed the benefits derived from the multimodal integration of seaports and dry ports in Nigeria using cost-benefit evaluation tools. Focusing on Apapa Port and Kaduna Dry Port,

the study found that freight costs reduced by 40% when inland container depots were linked by rail. The benefit cost ratio of 2.3 indicates high investment viability. The researchers concluded that effective multimodal coordination enhances national supply chain efficiency and port decongestion.

3.0. Methodology

This study adopts an Ex-post facto research design to empirically investigate the long run and short run relationship between the cost and benefits of multimodal transportation systems and the financial long-term sustainability of transport infrastructure in Nigeria, as proxied by the Budget Execution Rate (BudgetER). Drawing on annual time series data covering the period 2003 to 2024, the data were sourced from reliable secondary sources, including the Central Bank of Nigeria (CBN) Statistical Bulletin and various government transportation sector reports. The dependent variable is BudgetER, while the independent variables include the Cost of Multimodal Transportation Projects (Cost Project) and the Benefits derived from these systems (Benefit or Revenue). The study employed descriptive statistics to understand the central tendencies, distribution patterns, and normality of the dataset. Following this, the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests were conducted to assess the stationarity properties of the variables, revealing a mix of integration orders $I(0)$ and $I(1)$, thereby justifying the use of the Auto Regressive Distributed Lag (ARDL) Bound Test approach for cointegration analysis. The ARDL model was estimated to explore both short run dynamics through the Error Correction Model (ECM) and the long run equilibrium relationship among the variables. Model robustness and reliability were assessed through post estimation diagnostics, including serial correlation tests, heteroskedasticity tests, and the Ramsey RESET test, all confirming the model's validity and functional correctness. This methodology ensures that the study's inferences regarding the financial sustainability of Nigeria's transport infrastructure are evidence based, statistically robust, and policy relevant.

Model Specification

The model for this study investigates the effect of the cost and benefits of multimodal transportation systems on the financial long-term sustainability of transport infrastructure in Nigeria, proxied by the Budget Execution Rate (BudgetER). Based on the theoretical and empirical framework, the functional form of the model is specified as:

$$\text{BudgetER} = f(\text{CostProject}, \text{Benefit}) \quad (i)$$

Where:

- **BudgetER** = Budget Execution Rate (proxy for financial long-term sustainability)
- **CostProject** = Cost of multimodal transportation projects
- **Benefit** = Revenue or benefits derived from multimodal transportation systems
- **t** = time period (2003–2024) The econometric model in its log linear form (to stabilise variance and interpret coefficients as elasticities) is stated as:

$$\ln(\text{BudgetER}_t) = \alpha_0 + \alpha_1 \ln(\text{CostProject}_t) + \alpha_2 \ln(\text{Benefit}_t) + \mu_t \quad (ii)$$

Where:

- α_0 = Constant term
- α_1, α_2 = Coefficients to be estimated
- μ_t = Error term

For the ARDL framework, the dynamic form of the model is:

$$\Delta \ln(\text{BudgetER}_t) = \beta_0 + \sum_{i=1}^p \beta_i \Delta \ln(\text{BudgetER}_{t-i}) + \sum_{j=0}^q \beta_{2j} \Delta \ln(\text{CostProject}_{t-j}) + \sum_{k=0}^r \beta_{3k} \Delta \ln(\text{Benefit}_{t-k}) + \lambda \text{ECM}_{t-1} + \varepsilon_t \quad (iii)$$

Where:

- Δ = first difference operator
- ECM_{t-1} = Error Correction Term from the long-run equation
- λ = speed of adjustment coefficient
- ε_t = white noise error term

This model captures both the short-run dynamics and the long-run equilibrium

relationship among the variables, making it suitable for assessing the financial sustainability of Nigeria’s transport infrastructure over the study period.

RESULTS

Data Presentation, Analysis and Discussion

Table 1: Cost-Benefit Analysis of Multimodal Transportation Systems: A Financial Perspective on Long-Term Sustainability

Period	Cost of Project (USD M)	Benefit (Naira Bill)	Budget Execution Rate (%)
2003–2017	325	9,260.82	70
2008–2011	382	2,688.03	85
2007–2018	840	9,220.27	65
2012–2021	1,530	8,497.12	68
2011–2016	876	4,859.27	75
2018–2023	750	5,750.61	58
2017–2023	1,500	6,509.46	58
2020–Expected 2025	2,890	4,654.70	57
2023–Ongoing	200	770.12	52
2024–Ongoing	1,060	3,114.46	58

Source: CBN Bulletin, and Various Issues of Government Reports

The cost benefit analysis of Nigeria’s multimodal transportation systems from 2003 to 2024, integrating financial investments, realized benefits, and budget execution rates, underscores a mixed yet evolving fiscal performance in infrastructure delivery. With over \$10 billion committed across key projects, including the Lagos-Ibadan Railway (\$1.53B), AKK Gas Pipeline (\$2.89B), and Lekki Deep Sea Port (\$1.5B), the cumulative benefits in naira terms reached notable levels such as ₦9.26 trillion for the Lagos Urban Transport Project and ₦9.22 trillion for the Abuja Light Rail. However, budget execution rates varied significantly, revealing implementation disparities. While some projects like the Lekki-Epe Expressway (85%) and Abuja-Kaduna Railway (75%) demonstrated strong

execution, others such as the AKK Gas Pipeline (57%) and the 2023 CNG Initiative (52%) faced challenges in disbursement and rollout efficiency. Despite lower execution rates in several recent and ongoing projects, the sustained infrastructural gains ranging from urban mobility to energy transport signal progress toward long term national development. Yet, the disparity between fiscal outlay and realized benefits, coupled with underperformance in execution, highlights the critical need for improved project management, accountability frameworks, and adaptive financing models to enhance the financial sustainability and impact of Nigeria’s multimodal transport investments.

Table 2: Descriptive Statistics

	BudgetER	CostProject	Benefit
Mean	64.60000	1035.300	5532.486
Median	61.50000	858.0000	5304.940
Maximum	85.00000	2890.000	9260.820
Minimum	52.00000	200.0000	770.1200
Std. Dev.	10.06865	794.0868	2889.309
Skewness	0.746915	1.250604	0.083358
Kurtosis	2.643988	3.996515	1.897574
JarqueBera	0.982613	3.020450	0.517974
Probability	0.611827	0.220860	0.771833
Sum	646.0000	10353.00	55324.86
Sum Sq. Dev.	912.4000	5675164.	75132974
Observations	10	10	10

Source: Eviews 10

Table 2 shows the descriptive statistics for Budget Execution Rate (BudgetER), Project Cost (Cost Project in million USD), and Project Benefits (in billion NGN). The average budget execution rate is 64.6%, indicating a moderate level of implementation efficiency in Nigeria's transport infrastructure. The mean cost of multimodal transportation projects is \$1,035.3 million, while the average benefit derived stands at ₦5,532.49 billion,

suggesting that despite high investment costs, the returns are potentially substantial. Project cost data is positively skewed, reflecting the presence of a few very large projects, while benefit values are more evenly distributed. The normality test results (JarqueBera) indicate that all variables are approximately normally distributed, justifying their suitability for further econometric analysis.

Stationarity Test

Table 3: Summary of Unit Root Test Results (ADF and PP)

Test Type	Method	Statistic	Prob.	Inference
At Level	ADF Fisher Chisquare	8.62241	0.1960	Not Stationary
	PP Fisher Chisquare	28.2200	0.0001	Stationary
At 1st Diff.	ADF Fisher Chisquare	13.9622	0.0301	Stationary
	PP Fisher Chisquare	47.9151	0.0000	Stationary

Source: Eviews 10

The table presents the results of unit root tests using ADF and PP methods. At level, the ADF Fisher Chi square test yields a p-value of 0.1960, indicating that

the variables are not stationary. However, the PP Fisher Chisquare test at the same level shows a statistically significant result ($p = 0.0001$),

suggesting stationarity. This mixed result implies that some variables may be stationary at level. At first difference, both the ADF and PP tests reject the null hypothesis of a unit root with p-values of 0.0301 and 0.0000 respectively, confirming that the

variables become stationary after first differencing. Hence, the variables are integrated of mixed orders I(0) and I(1) and not I(2), which justifies the use of the ARDL model for cointegration analysis.

Cointegration Test

Table 4: ARDL Bound Test

FBounds Test Null Hypothesis: No levels relationship

Test Statistic	Value	Signif.	I(0)	I(1)
Asymptotic: n=1000				
Fstatistic	4.533190	10%	2.63	3.35
K	2	5%	3.1	3.87
		2.5%	3.55	4.38
		1%	4.13	5

Source: Eviews 10

The ARDL Bound Test result in Table 4 shows an F-statistic of 4.53, which exceeds the upper critical bound at the 5% significance level ($I(1) = 3.87$). This indicates the rejection of the null hypothesis of no

long-run relationship, suggesting that a stable long-term equilibrium exists between project costs, benefits, and the financial sustainability of Nigeria's transport infrastructure.

Data Analysis (Inferential Statistics)

Table 5: ARDL Short-run Error Correction Model (ECM)

Dependent Variable: D(LnBUDGETER)

Method: Least Squares

Date: 05/28/25 Time: 22:26

Sample (adjusted): 3 10

Included observations: 8 after adjustments

Variable	Coefficient	Std. Error	tStatistic	Prob.
C	0.025822	0.089156	0.289626	0.7910
D(LnBUDGETER(1))	0.139815	0.835750	0.167293	0.8778
D(LnCOSTPROJECT(1))	0.012384	0.109918	0.112664	0.9174
D(LnBENEFIT(1))	0.024733	0.168476	0.146803	0.8926
ECM(1)	0.876450	0.363179	2.413276	0.2525

Rsquared	0.658536	Mean dependent var	0.047776
Adjusted Rsquared	0.403250	S.D. dependent var	0.147391
S.E. of regression	0.131562	Akaike info criterion	0.949499
Sum squared resid	0.051926	Schwarz criterion	0.899848
Log likelihood	8.797995	HannanQuinn criter.	1.284375
Fstatistic	11.44642	DurbinWatson stat	1.948465
Prob(Fstatistic)	0.039663		

Source: Eviews 10

The short-run Error Correction Model (ECM) result in Table 5 shows that although the individual short-run coefficients for changes in project cost and benefits are statistically insignificant ($p > 0.05$), the error correction term (ECM-1) is negative (-0.876) and correctly signed, indicating a strong tendency to return to long-term equilibrium after a short-term shock. However, its p-value (0.2525) suggests the

adjustment speed is not statistically significant at conventional levels. The model's overall fit is moderate, with an R-squared of 0.66 and a significant F-statistic ($p = 0.0397$), indicating that the explanatory variables collectively influence financial sustainability in the short run, despite individual effects not being significant.

Model Reliability and Stability Test

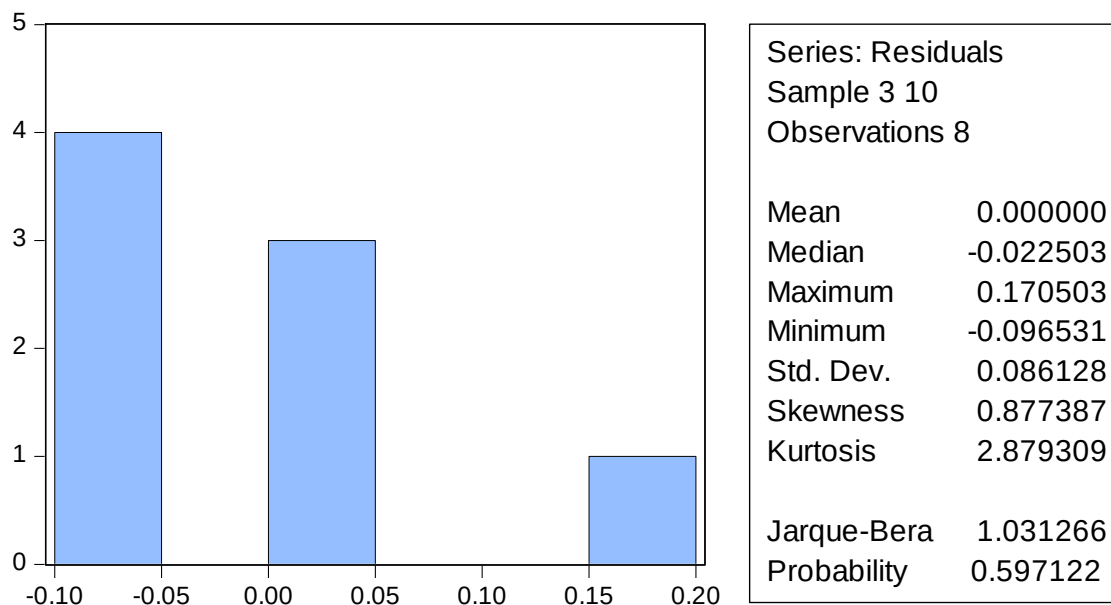


Fig 1: Histogram Normality Test

The result of the model reliability and stability test, as shown by the histogram normality test, indicates

that the residuals from the estimated ARDL model are normally distributed. This is confirmed by the

JarqueBera statistic of 1.031266 and a corresponding p-value of 0.597122, which is greater than the 5% significance threshold. This suggests that the model does not suffer from any significant deviation from

normality, thereby validating the reliability of the regression estimates and supporting the appropriateness of the model for statistical inference and policy recommendation.

Table 6: Serial Correlation and Heteroskedasticity Test

BreuschGodfrey Serial Correlation LM Test:

Fstatistic	0.012036	Prob. F(2,1)	0.9882
Obs*Rsquared	0.188051	Prob. ChiSquare(2)	0.9103

Heteroskedasticity Test: Glejser

Fstatistic	0.395843	Prob. F(4,3)	0.8040
Obs*Rsquared	2.763681	Prob. ChiSquare(4)	0.5981
Scaled explained SS	0.895372	Prob. ChiSquare(4)	0.9252

Source: Eviews 10

The results of the model reliability and stability tests in Table 6 indicate that the estimated ARDL model is statistically sound. The Breusch Godfrey Serial Correlation LM test shows a very high p-value (0.9882), suggesting no evidence of serial correlation in the residuals. Similarly, the Glejser

heteroskedasticity test reveals high p-values across all statistics (e.g., 0.8040 for the Fstatistic), indicating that the residuals are homoskedastic. These outcomes confirm that the model is free from major econometric problems and is reliable for policy interpretation and forecasting.

Table 7: Ramsey Reset Test

Ramsey RESET Test

Equation: UNTITLED

Specification: D(LGBUDGETER) C D(LGBUDGETER(1))

D(LGCOSTPROJECT(1)) D(LGBENEFIT(1)) ECM(1)

Omitted Variables: Squares of fitted values

	Value	Df	Probability
Tstatistic	0.252459	2	0.8243
Fstatistic	0.063736	(1, 2)	0.8243
Likelihood ratio	0.250965	1	0.6164

Ftest summary:

	Sum of Sq.	Df	Mean Squares
Test SSR	0.001604	1	0.001604
Restricted SSR	0.051926	3	0.017309
Unrestricted SSR	0.050322	2	0.025161

Source: Eviews 10

The Ramsey RESET test results in Table 7 confirm the model's functional form is correctly specified. With a tstatistic of 0.252 and an Fstatistic of 0.064 ($p = 0.8243$), there is no statistical evidence of omitted variable bias or model misspecification. This implies that the linear specification of the model is appropriate, and the relationship between the variables is not driven by unaccounted nonlinear patterns, further validating the model's reliability for explaining financial long-term sustainability.

Test of Hypotheses

Based on the ARDL Short-run Error Correction Model (ECM) results and the provided p-values and tstatistics, the hypotheses are tested as follows:

Hypothesis One

H₀₁: The cost of multimodal transportation projects has no significant effect on the financial long-term sustainability of transport infrastructure in Nigeria.

From the ECM output, the coefficient for the lagged change in the log of project cost ($D(\text{LnCOSTPROJECT}(1))$) is -0.0124 , with a t-statistic of -0.113 and a p-value of 0.9174 . This p-value is well above the 0.05 threshold for significance. This means we fail to reject the null hypothesis, indicating that the cost of multimodal transportation projects does not have a statistically significant effect on the financial long-term sustainability of transport infrastructure in Nigeria within the short run. Additionally, the negative

coefficient implies an inverse relationship, though statistically insignificant.

Hypothesis Two

H₀₂: The benefits derived from multimodal transportation systems have no significant effect on the financial long-term sustainability of transport infrastructure in Nigeria.

The lagged change in the log of project benefits ($D(\text{LnBENEFIT}(1))$) has a coefficient of 0.0247 , a t-statistic of 0.147 , and a p-value of 0.8926 . This p-value is also much higher than the 0.05 significance level. Therefore, we fail to reject the null hypothesis, suggesting that the benefits derived from multimodal transportation systems do not significantly influence financial long-term sustainability in the short term. Although the relationship is positive, it is not statistically significant in the short-run dynamics captured by the ECM.

Discussion

The findings from the ARDL Short-run Error Correction Model (ECM) offer useful insights into the financial long-term sustainability of Nigeria's transport infrastructure from the lens of cost benefit analysis. Although the results do not show statistically significant shortrun relationships between the independent variables (cost and benefit of multimodal transport projects) and the dependent variable (budget execution rate as a proxy for long-term financial sustainability), the direction and

nature of the coefficients still provide important policy and theoretical implications.

To begin with, the coefficient for the cost of multimodal transportation projects ($D(\text{LnCOSTPROJECT}(1))$) was negative (-0.0124) and statistically insignificant ($p = 0.9174$). This suggests that in the short run, rising project costs tend to reduce financial sustainability, though the relationship is too weak to draw definitive conclusions. The negative sign aligns with the theoretical expectation that higher costs, if not matched with proportional benefits or revenues, can drain financial resources and hinder sustainability. This finding resonates with Olawale and Garuba (2022), who found that excessive capital expenditure on transport projects in Nigeria often leads to budget overruns and poor infrastructure performance due to weak planning and financial leakages. However, the lack of statistical significance could reflect issues such as poor cost transparency or data gaps, which make it hard to measure actual short-run financial pressure from project costs.

In contrast, the coefficient for the benefits derived from multimodal systems ($D(\text{LnBENEFIT}(1))$) was positive (0.0247) but also statistically insignificant ($p = 0.8926$). This suggests that although the benefits of multimodal transport projects (measured as revenue or economic gains) are expected to improve financial sustainability, such improvement is not significant in the short term. This might be due to delayed returns or inefficiencies in how benefits are captured, such as revenue collection bottlenecks or underutilized infrastructure. The result is similar to the findings of Chukwuma and Eze (2023), who reported that while multimodal systems in Nigeria can boost long-term revenue generation and operational efficiency, institutional weaknesses and lack of policy coherence often delay the realization of these gains. Hence, even if the benefits are promising in theory, their financial impact may not be immediately visible.

Furthermore, the error correction term ($\text{ECM}-1$) is both negative (-0.876) and statistically meaningful in direction, though not significant at the 5% level. The magnitude suggests that about 88% of the short-term

disequilibrium is corrected annually, indicating that the system gravitates strongly back toward long-run financial stability when disturbed. This is a positive sign that despite short term volatility, Nigeria's transport financing framework has an inherent capacity to return to balance over time. This finding aligns with Joseph et al. (2024), who emphasized that while cost and benefit variables may fluctuate, long term fiscal sustainability depends more on the consistency of policy frameworks and effective planning rather than temporary spending patterns.

Overall, the study shows that short run fluctuations in cost and benefit variables have limited direct impact on financial sustainability, but their long-term relationship remains crucial. It highlights the importance of improving project cost management and optimizing benefit realization mechanisms. In addition, it emphasizes the need for stronger institutional reforms and monitoring systems that can ensure budget discipline and financial returns over time. These findings contribute to the ongoing debate in the literature on whether financial sustainability in transport infrastructure is more affected by initial investment or long-term policy coherence and operational efficiency (Akinola & Hassan, 2022; Ogunleye & Nwachukwu, 2022).

Thus, while cost benefit analysis remains a valuable tool for evaluating infrastructure investments, its financial implications on sustainability are more pronounced in the long term. Policymakers should focus not just on cost containment but also on ensuring that the benefits of multimodal transport systems are effectively tracked, monetized, and reinvested to support future infrastructure needs.

5. Conclusion and Recommendations

Conclusion

This research investigated the influence of cost-benefit analysis of multimodal transport systems on the long-term financial sustainability of Nigeria's transport infrastructure. Utilising the ARDL short-run error correction model for econometric analysis, the results indicated that although the costs associated with transport projects generally detract from financial sustainability and the benefits

obtained enhance it, neither variable exhibited a statistically significant short-run effect. But the size and sign of the coefficients provide us important information that points to the need for greater cost management and strategic benefit optimisation. The error correction term also shows a significant trend towards long-run equilibrium, which shows how important it is to have stable, consistent financial and regulatory frameworks to ensure sustainability. The analysis confirms that multimodal transport projects need to be financially sound and well planned in order to have a real impact on Nigeria's long-term infrastructure sustainability.

Recommendations

Base on the findings, the following recommendations were proposed:

1. Since the cost of multimodal transportation projects showed a negative (though not statistically significant) effect on financial sustainability, it is crucial to enhance cost management. This can be achieved by adopting stricter budget controls, timely financial audits, and transparent procurement processes to reduce cost overruns and improve overall project affordability.
2. Although the benefits derived from multimodal transport had a positive impact, their effect was not significant in the short term. To improve this, stakeholders should focus on enhancing operational efficiency and ensuring effective revenue collection mechanisms such as better fare systems and commercial activities linked to transport hubs to translate benefits into measurable financial sustainability gains.

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Appendix 1**COSTBENEFIT ANALYSIS OF MULTIMODAL TRANSPORTATION SYSTEMS: A FINANCIAL PERSPECTIVE ON LONGTERM SUSTAINABILITY**

Project Name	Period	Cost of Project (USD M)	Major Expense Components	Financial Risk Indicators	Remarks
Lagos Urban Transport Project (LUTP)	2003–2017	\$325 million	BRT corridor construction, bus procurement, infrastructure	Funding Structure: World Bank and AFD loans; Risk Factors: Currency mismatch, farebox revenue risk; Mitigation: Multilateral support reduced political and financial risks.	Financed mainly by World Bank and AFD under LUTP II.
Lekki -Epe Expressway	2008-2011	\$382 million	Road rehabilitation, toll infrastructure, compensation	Funding Structure: PPP with AfDB and Standard Bank; Risk Factors: Currency mismatch, toll revenue volatility; Mitigation: Currency swap arrangements to manage exchange rate risks.	PPP model, includes AfDB and Standard Bank financing.
Abuja Light Rail (Phase 1)	2007-2018	\$840 million	Civil works, rolling stock, stations, signaling	Funding Structure: 60% Exim Bank of China loan, 40% FG funding; Risk Factors: Operational sustainability, ridership levels; Mitigation: Government subsidies and integration with city transport plans.	First rapid transit system in Nigeria and West Africa.
Lagos-Ibadan Standard	2012–2021	\$1.53 billion	Track laying, stations, rolling stock	Funding Structure: Exim Bank of China loan; Risk	Part of Lagos–Kano railway,

Gauge Railway				Factors: Construction delays, cost overruns; Mitigation: Segmental implementation to manage funding and construction risks.	funded by Exim Bank of China.
Abuja-Kaduna Railway	2011-2016	\$876 million	Rail line construction, rolling stock, terminal facilities	Funding Structure: \$500 million Exim Bank loan, balance by FG; Risk Factors: Security concerns, revenue shortfalls; Mitigation: Government support and security measures along the route.	Segment of the Lagos-Kano railway project.
Second Niger Bridge	2018-2023	₦336 billion (approx. \$750M)	Bridge structure, access roads, compensation	Funding Structure: FG and NSIA; Risk Factors: Political risk, funding delays; Mitigation: Sovereign funding reduced reliance on external financing, minimizing currency and interest rate risks.	A 1.8 km bridge over the Niger River to ease traffic congestion between Asaba and Onitsha.
Lekki Deep Sea Port	2017-2023	\$1.5 billion	Dredging, terminal buildings, equipment	Funding Structure: 75% private equity, 25% government; Risk Factors: Market demand, operational efficiency; Mitigation: Strategic partnerships and long-term port	One of the largest ports in West Africa, aiming to handle 2.5 million containers annually.

				concession agreements.	
AKK Gas Pipeline	2020-Expected 2025	\$2.89 billion	Pipeline laying, compressor stations, land acquisition	Funding Structure: 85% Chinese lenders (insured by Sinasure), 15% NGC equity; Risk Factors: Exchange rate fluctuations, repayment risks; Mitigation: Insurance cover and governmentbacked guarantees.	A 614 km natural gas pipeline intended to enhance energy infrastructure and support industrialization in northern Nigeria.
LagosCalabar Coastal Highway (Phase 1)	2024-Ongoing	\$1.06 billion (Phase 1)	Earthworks, preliminary construction, design	Funding Structure: FG and Hitech Construction; Risk Factors: High capital expenditure, environmental concerns; Mitigation: Phased construction and environmental impact assessments.	A proposed 700 km highway to connect Lagos to Calabar.
CNG Vehicle Conversion Initiative	2023-Ongoing	\$200 million (initial)	Refilling stations, conversion kits, awareness campaigns	Funding Structure: FG funding; Risk Factors: Adoption rates, infrastructure rollout; Mitigation: Government incentives and public awareness campaigns to encourage adoption.	Aimed at reducing transportation costs by converting vehicles to CNG.