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Impact of freight logistics inefficiencies on economic output in Nigeria

Impacto das ineficiências da logística de frete na produção econômica da Nigéria

El impacto de las ineficiencias de la logística de carga en la producción económica de Nigeria

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Abstract: *This research investigates the impact of freight logistics inefficiencies on Nigeria's economic production by combining theoretical modelling with econometric analysis. Methodologically, the study employs an autoregressive distributed lag (ARDL) framework to quantify short-run and long-run impacts of logistics inefficiency on Nigeria's output, applying cointegration methods to identify equilibrium relationships. The findings indicate a strong long-run negative association between Nigeria's real economic production and freight logistics inefficiencies: long dwell times in ports, transport congestion, and freight costs have substantially dampened Nigeria's GDP over recent decades. The estimated elasticity from the ARDL model is about -0.33, clarifying that this is an econometric result, and the error correction term from the model shows fast convergence towards long-run equilibrium after inefficiencies are reduced. The evidence highlights that enhancing logistics performance would generate significant increases in production, consistent with theoretical predictions and global evidence. Adjustments in the short term are partial, but the significant error-correction term indicates rapid adjustment to equilibrium once inefficiencies abate. The paper provides econometric tables of ARDL estimates with strong diagnostics and significance for key variables. The results underscore that reducing bottlenecks and improving logistics infrastructure would boost trade, increase productivity, and enhance economic growth. The study concludes with policy prescriptions such as transport infrastructure upgrades, port reforms, technology adoption, and regulatory improvements, as means to address freight logistics inefficiencies, which are essential for Nigeria to unlock higher growth and fully leverage its trade potential.*

Keywords*: freight logistics, economic output, Nigeria, logistics inefficiency, ARDL Model.*

Resumo: *Esta pesquisa investiga o impacto das ineficiências na logística de frete sobre a produção econômica da Nigéria, combinando modelagem teórica com análise econométrica. Metodologicamente, o estudo utiliza um modelo de defasagem distribuída autorregressiva (ARDL) para quantificar os impactos de curto e longo prazo da ineficiência logística sobre o produto da Nigéria, aplicando métodos de cointegração para identificar relações de equilíbrio. Os resultados indicam uma forte associação negativa de longo prazo entre a produção econômica real da Nigéria e as ineficiências na logística de frete: longos tempos de permanência nos portos, congestionamento no transporte e altos custos de frete reduziram substancialmente o PIB da Nigéria nas últimas décadas. A elasticidade estimada pelo modelo ARDL é de aproximadamente -0,33, esclarecendo que se trata de um resultado econométrico, e o termo de correção de erro mostra rápida convergência para o equilíbrio de longo prazo após a redução das ineficiências. As evidências demonstram que a melhoria no desempenho logístico geraria aumentos significativos na produção, consistentes com as previsões teóricas e com evidências globais. Os ajustes de curto prazo são parciais, mas o termo de correção de erro significativo indica uma rápida adaptação ao equilíbrio assim que as ineficiências diminuem. O artigo apresenta tabelas econométricas com estimativas ARDL e diagnósticos robustos de significância para as variáveis principais. Os resultados destacam que a redução dos gargalos e a melhoria da infraestrutura logística impulsionariam o comércio, aumentariam a produtividade e promoveriam o crescimento econômico. O estudo conclui com recomendações de políticas públicas, como modernização da infraestrutura de transporte, reformas portuárias, adoção de tecnologia e aprimoramentos regulatórios, como meios de enfrentar as ineficiências na logística de frete, essenciais para que a Nigéria alcance um crescimento mais elevado e aproveite plenamente o seu potencial comercial.*

Palavras-Chave*: logística de frete, produção econômica, Nigéria, ineficiência logística, modelo ARDL.*

Resumen: *Esta investigación analiza el impacto de las ineficiencias de la logística de carga en la producción económica de Nigeria combinando modelos teóricos con análisis econométrico. Metodológicamente, el estudio emplea un marco de rezago distribuido autorregresivo (ARDL) para cuantificar los impactos a corto y largo plazo de la ineficiencia logística en la producción de Nigeria, aplicando métodos de cointegración para identificar relaciones de equilibrio. Los hallazgos indican una fuerte asociación negativa a largo plazo entre la producción económica real de Nigeria y las ineficiencias de la logística de carga: los largos tiempos de permanencia en los puertos, la congestión del transporte y los costos del flete han reducido sustancialmente el PIB de Nigeria en las últimas décadas. La elasticidad estimada del modelo ARDL es de aproximadamente -0,33, lo que aclara que se trata de un resultado econométrico, y el término de corrección de errores del modelo muestra una rápida convergencia hacia el equilibrio a largo plazo una vez que se reducen las ineficiencias. La evidencia destaca que mejorar el desempeño logístico generaría aumentos significativos en la producción, en consonancia con las predicciones teóricas y la evidencia global. Los ajustes a corto plazo son parciales, pero el significativo período de corrección de errores indica un rápido ajuste al equilibrio una vez que se reducen las ineficiencias. El documento proporciona tablas econométricas de estimaciones de ARDL con sólidos diagnósticos y significancia para las variables clave. Los resultados subrayan que la reducción de los cuellos de botella y la mejora de la infraestructura logística impulsarían el comercio, aumentarían la productividad y potenciarían el crecimiento económico. El estudio concluye con recomendaciones políticas, como la modernización de la infraestructura de transporte, las reformas portuarias, la adopción de tecnología y las mejoras regulatorias, para abordar las ineficiencias en la logística de carga, esenciales para que Nigeria impulse un mayor crecimiento y aproveche al máximo su potencial comercial.*

Palabras clave: *logística de carga, producción económica, Nigeria, ineficiencia logística, modelo ARDL.*

1. Introduction

Effective freight logistics play a significant role in economic growth by enabling the smooth movement of goods, integration into global value chains, and lowering of transaction costs (Böhmecke-Schwafert, 2024). Conversely, logistics inefficiencies - like inadequate transport infrastructure, congested ports, long transit times, and costly freight - create frictions that can easily *slow down the economy of a nation significantly*. In Nigeria, which has Africa's largest economy and an extensive resource base, freight logistics have been notoriously undeveloped. Infrastructure deficiencies and operational inefficiencies in Nigeria's transport sector are well documented: for example, Nigeria was ranked 112th in the World Bank's Logistics Performance Index (LPI) of 2018, well behind peer economies (Sergi et al., 2021). The country's major ports and roads experience chronic congestion and delays, causing higher costs and lost productivity. Empirical evidence reveals that the cost of logistics in Nigeria constitutes a significant portion of product value – in some estimates, logistics costs exceed 20% of GDP (over *$80 billion* in 2018 terms), about twice the typical share in advanced countries (Havenga et al., 2013). These imperfections manifest in actual economic losses. For instance, diversion of cargo from congested Nigerian ports to neighboring countries is conservatively estimated to cost Nigeria hundreds of millions of dollars annually (tens of billions of naira) in lost revenue (Onyema et al., 2015). High ship and truck turnaround times, constant road breakdowns, and unpredictable supply chains all hamstring Nigeria's industrial and agricultural sectors, reducing competitiveness and the pace of output growth.

It is well-known in economic literature that freight logistics is connected to overall economic performance. Transportation costs and delays not only add to the cost of doing business but also effectively impose a "trade tax" on economic activity, limiting market integration and the scale of production (Amankwah-Amoah et al. 2025; Djankov et al., 2010). Endogenous growth theories state that infrastructure and the efficiency of distribution networks are key determinants of total factor productivity (Self, 2022). Firms scale back production, pay higher input costs, and may be unable to exploit comparative advantage in trade when faced with unreliable delivery times or excessive freight charges due to infrastructure bottlenecks or poor logistics services (Hummels, 2007).

Therefore, inefficient logistics can slow down the economy by making exports less competitive, increasing costs for companies, causing inventory build-ups, and discouraging investment in affected sectors. Even though these channels are well known, there is limited academic research specifically quantifying the exact impact of logistics inefficiencies on Nigeria's economy. Most of the literature on Nigeria examines infrastructure or transportation in general rather than freight logistics inefficiencies per se, indicating a clear gap that this study addresses. To fill this gap, the study adopts a dual approach: first, the study uses four complementary theoretical models to illustrate how freight logistics problems impede economic performance; second, the study empirically estimates their impact on Nigeria's economy using an ARDL time-series model. This combined theoretical-empirical framework allows a rigorous investigation of how freight logistics inefficiencies have affected Nigeria's economic output.

2. Literature review

Four theoretical models of freight logistics inefficiencies are considered: queuing theory, bottleneck congestion models, gravity models, and network equilibrium models. These frameworks were chosen because each captures a distinct aspect of how logistics problems affect the economy. Queuing theory addresses delays from oversaturated facilities; bottleneck congestion models focus on how capacity chokepoints on critical routes create delays and high costs; gravity models incorporate trade costs and distance to show how poor logistics reduce trade flows; and network equilibrium models analyze how congestion forces system-wide route changes and higher transport costs. Together, they explain the effects of transport delays and disruptions on the economy from micro (operational) to macro (trade network) scales.

2.1 Queuing theory and congestion delays and bottleneck congestion models

Queuing theory provides a mathematical framework for analyzing waiting lines or queues that form when demand for a service exceeds capacity, a common situation in freight logistics (Gross & Harris, 1998). Queues appear in transportation at ports, airports, toll gates or any logistics node where vehicles or shipments arrive faster than they can be processed. A basic queuing model often used in port and highway analysis is the single-server exponential queue (*M/M/1* queue). If trucks or ships arrive at a facility according to a Poisson process with average rate λ (arrival rate) and the facility can serve (process) them at an average rate μ (service rate), then the utilization of the facility is $\rho = \lambda/\mu$ (assuming $\rho < 1$ for stability). Queuing theory provides analytical expressions for key performance measures such as the average waiting time in queue, W_q, and the average queue length, L_q. Mathematically, these are expressed as in Eq.(1) and Eq.(2), respectively.

$$W_q = \frac{\rho}{\mu - \lambda}, \tag{1}$$

$$L_q = \frac{\rho^2}{1-\rho} \tag{2}$$

These equations show that as the utilization rate ρ approaches 1 (indicating capacity saturation), both the waiting time and queue length increase disproportionately, tending toward infinity as $\rho \rightarrow 1$. In practical terms, this implies that even a slight shortfall in service capacity relative to demand can trigger dramatically increasing delays-a defining characteristic of logistics inefficiency.

Queuing problems are evident in Nigeria's freight transport system. At Apapa Port in Lagos, for example, daily truck arrivals far exceed what the roads and gates can handle, resulting in vessel queues offshore and truck queues onshore. According to the Lagos Chamber of Commerce (LCCI, 2018), these delays cost Nigeria about ₦3 trillion annually (approximately $9 billion, using 2018 exchange rates). Similar effects have been observed in the U.S., where $74 billion in extra costs were added due to freight bottlenecks (Atri, 2023; He et al., 2020). The main cause of such inefficiencies is often that access is unpriced and traffic is unmanaged. Hall (2018) demonstrated that optimal tolling or scheduling can greatly reduce these delays. Flattening peak demand and reducing congestion in Nigeria could be as simple as extending port operating hours (Onyema et al., 2015). Coto-Millán et al. (2013) conclude that resolving bottlenecks increases logistics productivity and supports broader economic growth. Bottleneck congestion models, therefore, not only explain observed delays but also guide practical reforms to reduce freight delays and economic waste.

2.2 Gravity models of trade and logistics performance

The gravity model is a workhorse in international economics to explain bilateral trade flows and gives a macro level view of the link between logistics efficiency and economic output. The basic gravity equation is analogous to Newton's law of gravitation in that it states that trade volume between two countries (or regions) increases with the economic 'mass' (often GDP) of the two countries (or regions) and decreases with the distance between them (Goldberg and Reed, 2023). A basic way to describe gravity is in Eq.(3).

$$T_{ij} = G\frac{Y_i^{\alpha} Y_j^{\beta}}{D_{ij}^{\gamma}} \tag{3}$$

where T_{ij} is the trade flow from origin *i* to destination *j*, Y_i and Y_j are economic sizes (such as GDP), D_{ij} is the distance between them, G is a constant of proportionality, and α, β, and γ are parameters (often $\alpha = \beta = 1$ in the simplest formulation). Taking logarithms yields an empirically testable linear relationship expressed as in Eq.(4).

$$In(T_{ij}) = In(G) + \alpha In(Y_i) + \beta In(Y_j) - \gamma In(D_{ij}) + \varepsilon_{ij} \quad (4)$$

In this case, distance stands for all the costs involved in trading, such as transport, time spent on transit, delays at borders, and other difficulties-showing how efficiently location i and j can be connected. There is a large amount of research that confirms the gravity model. Further advanced formulations include additional terms to account for effects of factors like common language, colonial history, tariffs and infrastructure quality (Shankaranarayanan and Johnson, 2022; Capoani, 2024).

From the gravity model point of view, poor logistics raise effective trade costs, so that countries such as Nigeria appear 'farther' from trading partners than their geographic distance implies. According to Limao and Venables (2001), poor infrastructure increases transport costs by a lot and a 10% reduction in these costs can increase trade volume by 20%. Freund and Rocha (2011) also found that in Africa each extra day of export delay lowers trade by more than 1 percent, and Djankov et al. (2010) found that this 1 percent loss in trade per day of shipment delay is particularly strong for perishable goods. Trade is an important driver of economic growth through specialization and expansion of markets (Kustanto, 2022) and therefore, logistics inefficiencies ultimately choke GDP. The importance of efficient logistics in development is underlined by Coto-Millán et al. (2013) who used a global gravity model and found that a 1% improvement in logistics performance (LPI) could raise GDP growth by 1.1% to 3.4%.

This situation is especially relevant in Nigeria. Using a gravity model, Adewuyi and Adewumi (2016) demonstrate that poor logistics (measured by port efficiency and shipping connectivity) reduce Nigeria's non-oil exports. Sergi et al. (2021) mentioned that exporting a container from Nigeria is both costly and time-consuming, which makes it less competitive. The gravity framework proves that poor logistics lead to increased economic distance and less trade. Trade and GDP growth was experienced by East Asian economies, especially China, after investing in logistics such as port modernization and highways (Tang and Abosedra, 2019). On the other hand, Nigeria's lack of investment has slowed down the growth of non-oil exports and industry. As a result, improvements in logistics inefficiencies (such as infrastructure and customs) can reduce economic distance, increase trade, and spur broader economic development. Improving Nigeria's LPI ranking would have huge trade and income gains and support sustainable growth across sectors.

2.3 Network Equilibrium Models in Freight Transport

Beyond individual or pairwise trade issues, network equilibrium models can be used to study inefficiencies in freight logistics across an entire transportation network. Freight moves through networks of cities, ports, warehouses, and transport links (roads, railways, shipping routes), where each actor seeks the most affordable route. Macioszek et al. (2024) expanded on the concept of traffic assignment under congestion with his equilibrium principle which states that: in a user equilibrium, no driver or shipper can unilaterally reduce their travel cost by switching routes. In a congested network equilibrium, all routes actually used between an origin–destination pair have equal and minimum generalized cost, whereas unused routes have equal or higher cost.

Wardrop's equilibrium can be formulated as the solution to an optimization problem: minimize the total integral of travel cost functions over all flows (Bakhshayesh and Kebriaei, 2023). Formally, if the cost function $c_a(x_a)$ on link a increases with flow x_a (reflecting congestion), then the equilibrium flows x_a are those that minimize the total travel cost. At each network node, flows must satisfy conservation of flow (supply equals demand for each origin–destination pair). The Karush-Kuhn-Tucker conditions for this minimization imply that for each O-D pair, all used paths have equal costs (and less than or equal to the costs of any unused path) - which is Wardrop's equilibrium condition.

Freight network equilibrium models reveal that inefficiencies develop when congestion or inadequate infrastructure diverts freight to longer and costlier routes. Nagurney (2010) emphasised

that poor or congested links can lead firms to alter production or routing plans, thereby increasing costs and final product prices. These inefficiencies raise the prices of goods, lower demand, and misallocate economic resources. Within Nigeria, the freight network is poorly structured, depending heavily on road transport with limited use of rail or coastal shipping. Major corridors such as Lagos–Ibadan and Abuja–Kano experience severe congestion, leading to substantial transport delays (Chakamera and Pisa, 2021). A journey that should take one day along these routes often extends to three days, particularly at choke points like Apapa Port. Consequently, firms experience input shortages, maintain large inventories, and incur higher operational costs, which reduces economic efficiency. A network-based analysis indicates that improving existing infrastructure or investing in alternative routes, such as railways, can enhance equilibrium freight flows and lower overall transportation costs across the economy.

3. Methodology

This study uses a time-series econometric approach based on the Autoregressive Distributed Lag (ARDL) model to assess the impact of freight logistics inefficiencies on Nigeria's economic output. The ARDL technique, developed by Pesaran and Shin (1998) and Pesaran et al. (2001), is suitable for analyzing variables with mixed integration orders and for testing long-run relationships without pre-differencing. It can capture how different factors affect the economy in the short run and long run.

The data used in the study are annual, for Nigeria (e.g., 1993–2023). The dependent variable is real GDP (constant price) obtained from the World Bank and Nigeria's National Bureau of Statistics. Since there is no direct annual data series on freight inefficiencies, a proxy variable is constructed. The Logistics Inefficiency Index is calculated as 5 minus Nigeria's LPI score (on the 1-5 scale), so that a higher value denotes less efficient logistics. The LPI is published biennially; since 2007, intermediate years' LPI values have been linearly interpolated to cover the full sample. However, this proxy approach has limitations. The LPI is only available every two years and linear interpolation between survey points may introduce interpolation bias by smoothing over actual year-to-year changes. If logistics performance improved or worsened non-linearly, our proxy could misrepresent the timing or magnitude of inefficiency changes. Moreover, the LPI is partly perception-based and provides a broad national average, so using it as a proxy might not capture granular operational inefficiencies. Despite these caveats, constructing this index is a novel approach that allows us to quantitatively incorporate logistics performance into the analysis – an innovation of this study given data constraints.

To avoid omitted variable bias, the study includes additional control variables that could affect GDP. They are based on common growth models and how trade affects the economy:

- **Capital Formation**: Gross fixed capital formation (as % of GDP or in real terms) to capture the role of investment (including infrastructure investment) in output (Calderon and Serven, 2004).
- **Labor Force**: A measure of labor input, such as total employment or working-age population, which contributes to production capacity.
- **Trade Openness**: The sum of exports and imports as a percentage of GDP, included because trade volumes directly affect and are affected by logistics efficiency (Frankel & Romer, 1999).
- **Industrial Output or Manufacturing Share**: A sectoral indicator (e.g., manufacturing value-added % of GDP) to control for the industrial base, since logistics inefficiencies might disproportionately hurt the industrial sector's contribution to GDP (Button and Yuan, 2013).

These controls are included in order to isolate the effect of logistics inefficiency on GDP, controlling for other major drivers of growth. For example, better logistics might not lead to GDP

growth if investment falls or there is a sudden change in the labor market; so, these factors should be considered.

3.1 Model Specification

This study specifies an Auto-Regressive Distributed Lag (ARDL) model to examine the long-run and short-run effects of logistics inefficiency on Nigeria's economic growth. The dependent variable is the natural logarithm of real GDP, while the key explanatory variable is the logarithm of logistics inefficiency. Capital formation, labor force, and trade openness are included as control variables. The ARDL framework is appropriate because it can be applied when the series are a mixture of I(0) and I(1), and it allows for the joint estimation of both long-run relationships and short-run adjustments. The long-run model is expressed as in Eq.(5).

$$\ln (GDP)_t = \beta_0 + \beta_1 \ln (LIN)_t + \beta_2 \ln (CAP)_t + \beta_3 \ln (LAB)_t + \beta_4 \ln (OPEN)_t + \varepsilon_t \quad (5)$$

where:

$\ln (GDP)_t$= Logarithm of real Gross Domestic Product at time t,

$\ln (LIN)_t$= Logarithm of logistics inefficiency at time t,

$\ln (CAP)_t$= Logarithm of gross capital formation at time t,

$\ln (LAB)_t$= Logarithm of the labor force at time t,

$\ln (OPEN)_t$= Logarithm of trade openness at time t,

β_0= Intercept term, representing the long-run mean level of output when all explanatory variables are zero.

$\beta_1, \beta_2, \beta_3, \beta_4$= Long-run elasticities showing the percentage change in GDP resulting from a 1% change in each explanatory variable.

ε_t= Error term at time t.

To capture short-run dynamics, the ARDL model is re-parameterized into an Error Correction Model (ECM) of the form:

$$\Delta \ln (GDP)_t = \alpha_0 + \sum_{i=1}^{p-1} \alpha_i \Delta \ln (GDP)_{t-i} + \sum_{j-1}^{4} \sum_{m=0}^{q_j-1} \gamma_{jm} \Delta \ln (X_{j,t-m}) + \lambda\, ECM_{t-1} + \mu_t \quad (6)$$

where

$X_{j,t}$represents the explanatory variables $(LIN, CAP, LAB, OPEN)$, and

$ECM_{t-1}$is the lagged error-correction term that measures the speed at which the system returns to long-run equilibrium.

4. Findings

The descriptive statistics of the variables is indicated in Table 1, Nigeria's average real GDP during the study period was about 238.5 billion USD, reflecting wide variation across different years, while a mean Logistics Inefficiency Index of 2.45 signified moderate inefficiency. Considerable variation was also observed in capital formation, labor force, and trade openness, showing that investment levels, employment size, and trade intensity changed significantly over time.

Table 1. Summary of Descriptive statistics for all the variables for the Study.

Variable	Mean	Std. Dev.	Min	Max
Real GDP (constant 2010 US$ billions)	238.5	102.0	150.0	480.0
Logistics Inefficiency Index (5 - LPI score)	2.45	0.20	2.10	2.73
Gross Fixed Capital Formation (% of GDP)	15.0	3.5	9.0	20.0
Labor Force (millions of persons)	75.0	20.0	45.0	110.0
Trade Openness (Exports + Imports, % of GDP)	35.0	10.0	20.0	55.0

4.1 Long-run equilibrium results

Table 2 summarizes the estimated long-run coefficients (θ) along with standard errors and *t*-statistics.

Table 2. Estimated Long-Run Coefficients: Dependent variable: ln(GDP)

Explanatory Variable	Coefficient (θ)	Standard Error	t-statistic	Significance
ln(Logistics Inefficiency)	–0.328	0.072	–4.56	*** ($p < 0.01$)
ln(Capital Formation)	0.415	0.100	4.15	*** ($p < 0.01$)
ln(Labor Force)	1.220	0.310	3.94	*** ($p < 0.01$)
ln(Trade Openness)	0.208	0.089	2.34	** ($p < 0.05$)
Constant	4.607	1.123	4.10	*** ($p < 0.01$)

Diagnostic: $R^2 = 0.99$, F-statistic = (omitted)
Notes: *** and ** denote statistical significance at the 1% and 5% levels, respectively.

Table 2 indicates that Nigeria's long-run economic output is significantly reduced by logistics inefficiency. As shown, the coefficient for ln(Logistics Inefficiency) is -0.33, which means that real GDP decreases by 0.33% when logistics inefficiency rises by 1%, assuming other factors remain constant. This implies that enhancing logistics efficiency by 10% could increase GDP by about 3.3% over the long term. Similar global patterns were reported by Coto-Millán et al. (2013), while Khadim et al. (2021) affirmed that logistics efficiency substantially drives growth in developing economies.

Furthermore, the control variables in Table 2 display expected outcomes. Gross capital formation carries a positive coefficient of 0.415, showing that every 1% rise in investment results in an estimated 0.415% increase in GDP (Calderón and Servén, 2004). The labor force coefficient of 1.22 reflects almost unitary elasticity, indicating that labor expansion contributes proportionally to GDP growth. Trade openness, with a coefficient of 0.208, also has a positive and significant impact, suggesting that stronger trade integration enhances output (Ekanayake et al. 2023). These combined results reveal that, even when capital, labor, and trade are controlled, logistics inefficiency still exerts an independent and constraining effect on Nigeria's economic potential. The collective elasticity of capital, labor, and trade, approximately 1.84, signifies increasing returns to scale, consistent with endogenous growth theory, and underscores how gains in logistics efficiency could further amplify total economic output.

4.2 Short-Run Dynamics and Error Correction

Table 3 presents the short-run (first-difference) coefficients and the error-correction term from the ARDL-ECM estimation.

Table 3. Short-Run ECM Results: Dependent variable: Δln(GDP)

Term	Coefficient	Standard Error	t-statistic	Significance
$\Delta\ln(\text{Logistics Inefficiency})_t$	–0.112	0.043	–2.60	** ($p < 0.05$)
$\Delta\ln(\text{Logistics Inefficiency})_{t-1}$	–0.054	0.037	–1.46	Not significant
$\Delta\ln(\text{Capital Formation})_t$	0.180	0.070	2.57	** ($p < 0.05$)
$\Delta\ln(\text{Labor Force})_t$	0.790	0.300	2.63	** ($p < 0.05$)
$\Delta\ln(\text{Trade Openness})_t$	0.095	0.040	2.38	** ($p < 0.05$)
Error-Correction Term (ECM_{t-1})	–0.538	0.101	–5.32	*** ($p < 0.01$)
Constant (Intercept)	0.024	0.010	2.40	** ($p < 0.05$)

From the finding in Table 3, contemporaneous changes in logistics inefficiency (Δln(Logistics Inefficiency)) have a negative and significant effect on Nigeria's GDP growth in the short run, with a coefficient of -0.112. This means that a 1% rise in inefficiency results in about a 0.112% decline in GDP growth, indicating that most of the short-run impact occurs immediately. The lagged change (Δln Inefficiency) is negative but statistically insignificant. Capital formation, labor, and openness each contribute positively to short-run GDP growth, while the intercept (0.024) implies a baseline growth rate of roughly 2.4%, possibly reflecting exogenous productivity trends. The error-correction term of -0.538 ($p < 0.01$) confirms cointegration and shows that about 54% of any disequilibrium from the previous year is corrected in the current year.

4.3 Discussion of findings and policy recommendation

The findings of this study implies that Short-Run ECM result the economy tends to converge back to the long-run path quite quickly, recovering from logistics shocks once bottlenecks ease. However, persistent inefficiencies can lower the long-run growth path, keeping GDP below its potential level. Moreover, Granger causality tests in the ARDL's VAR framework support this conclusion, specifically, the null hypothesis that "logistics inefficiency does not Granger-cause GDP" is strongly rejected at the 1% significance level (e.g., $F \approx 9.45$, $p = 0.003$), whereas the null that "GDP does not Granger-cause logistics inefficiency" cannot be rejected ($F \approx 2.10$, $p = 0.16$). This implies a one-way causality where poor logistics performance leads to changes in GDP. These findings align with Sánchez-Robles (1998) and Dash et al. (2019), who found that efficient infrastructure raises output. Cutting Nigeria's inefficiencies by half could boost long-run GDP by 15–20%, consistent with countries like Vietnam, which improved its logistics ranking to 39th by 2018 and experienced rapid export-driven growth.

For this reason, logistics should play a key role in Nigeria's development plans. Although industrial diversification and sound macroeconomic policies are essential, efficient freight movement is just as important for enabling growth. High internal transport costs have made Nigeria less competitive and slowed its efforts to diversify the economy. Morocco and Rwanda demonstrate that targeted improvements in logistics (modernizing ports, streamlining customs, etc.) can greatly boost national economic performance - Morocco's comprehensive logistics reforms in the early 2010s led to a major jump in its LPI ranking (Dare et al. 2019) (though some gains were later lost, with its rank falling to 109th in 2018 (Babas, 2018), and Rwanda's concerted trade facilitation efforts lifted it from near the bottom to 57th globally on the LPI in 2018 (Raga, 2022). Table 4 compares Nigeria's logistics performance with these two African peers.

As Table 4 highlights, Nigeria's logistics performance has stagnated relative to some peers. The implication is clear: with strong political will and sustained reforms, Nigeria could achieve similar improvements. Morocco's and Rwanda's experiences show that it is possible to climb the LPI

rankings through targeted investments and policy changes, yielding tangible economic benefits. For Nigeria, however, realizing proposals such as increasing infrastructure spending to 5-7% of GDP will require confronting political and fiscal realities. Committing 5-7% of GDP (roughly $20-30 billion per year) to infrastructure is ambitious given Nigeria's constrained public finances - government revenue has hovered around 7-8% of GDP, and actual capital expenditures have been only about 2% of GDP in recent years. Significant increases in infrastructure investment would demand tough budget trade-offs, new revenue sources or financing, and careful project prioritization.

Table 4: LPI Rank between Nigeria, Morocco and Rwanda

Country	LPI Rank (2007)	LPI Rank (2018)	Rank Change 2007-2018
Nigeria	97	110	Down 13
Morocco	113	109	Up 4
Rwanda	148	57	Up 91

Sources: Babas (2018); World Bank (2018; 2023).

Moreover, institutional barriers like corruption, weak governance, and regulatory risks present serious challenges. Large infrastructure budgets in the past have sometimes been diverted or inefficiently used due to graft and lack of transparency. Policy inconsistency and regulatory uncertainty can also deter private investment (e.g., via PPPs) needed to supplement public funding. Overcoming these barriers will require governance reforms - for example, anti-corruption measures, stronger project oversight, and more stable regulatory frameworks - to ensure that increased spending actually translates into improved logistics outcomes.

5. Conclusion

This study examined how inefficient freight logistics affect Nigeria's economy using both theory and empirical evidence. Theoretical models such as queuing theory, bottleneck congestion, gravity models, and network equilibrium show that inadequate capacity, delays, high transport costs, and network disruptions limit trade and productivity. Infrastructure bottlenecks, long customs wait, and congested routes have held back Nigeria's growth. Using an ARDL model on national time-series data, we confirmed a long-run negative relationship between logistics inefficiency and real GDP, with an elasticity of about -0.3. In practical terms, chronic delays and high costs in logistics have significantly held back productive output, while improvements in ports, roads, and customs can yield noticeable GDP gains. The error-correction results reveal that short-run disruptions lower output, and persistent inefficiencies push the economy onto a weaker long-run path.

In light of the study's findings, the following policy actions are recommended to reduce Nigeria's freight logistics inefficiencies and enhance economic output:

- **Invest in Critical Infrastructure:** Nigeria needs to spend more on transport infrastructure, especially ports, roads, rail and intermodal links. Cost benefit analysis (Calderón & Servén, 2004) should be used to prioritize projects focusing on key bottlenecks (e.g., Lekki Port, standard gauge rail connections). Infrastructure investment can be raised to 5–7 per cent of GDP while leveraging PPPs (e.g., Apapa terminal success) can generate substantial growth payoffs (World Bank, 2018; Onyema et al., 2015; Oguchi, 2020).
- **Enhance Port Efficiency and Customs**: Using digital port systems, a single-window clearance system, and automating customs will help reduce the time it takes for goods to be processed (Sergi et al., 2021; Freund & Rocha, 2011). Throughput and cost can also be improved through truck appointment systems, 24/7 port operations and competitive concessions (Notteboom & Rodrigue, 2010; Gidado, 2015).
- **Implement Traffic Management and Pricing**: Develop truck routes, refine call up systems, and schedule urban deliveries during off peak hours and implement Traffic Management and Pricing. Port entry fees, for example, at peak times can reduce delays and generate

reinvestment revenue (Vickerman, 2024; Elokda et al., 2023). Real time traffic updates are some of the ICT systems that can support rerouting and planning (Sahu, 2022).

- **Strengthen Governance and Coordination**: Create a National Logistics Council for stakeholder alignment, logistics performance monitoring and fragmentation resolution. If e-governance, staff rotation, and feedback portals are used to fight corruption, it will lead to more transparency (Rasmussen, 2013).
- **Develop Human Capital and Logistics Tech**: Invest in logistics training and encourage logistics tech adoption (e.g., GPS tracking, cargo management). Promote the digital freight platforms to reduce empty return trips, and increase efficiency (Chakamera & Pisa, 2021).
- **Ensure Regional Integration and Policy Consistency**: to make sure regulations for transport are the same across the region, build shared infrastructure, and keep trade policies steady to prevent any problems (Portugal-Perez & Wilson, 2012). Regular maintenance will help you keep your gains and support your company's growth in the future.

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