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EFFECT OF TRANSPORT INFRASTRUCTURE ON ECONOMIC COMPLEXITY IN NIGERIA

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Abstract

This study investigates the relationship between transport infrastructure and economic complexity in Nigeria between 1998 and 2023. Using the Autoregressive Distributed Lag (ARDL) model, the research examines both the short-run and long-run dynamics between the Economic Complexity Index (ECI) and key explanatory variables, including the Transport Composite Index (TCI), Gross Domestic Product (GDP), and Foreign Direct Investment (FDI). Preliminary analysis through trend evaluation and descriptive statistics revealed fluctuating patterns in ECI and moderate changes in TCI, alongside volatile GDP and FDI trends. Unit root tests confirmed that all variables are integrated of order one, justifying the ARDL bounds test approach. The bounds test revealed a significant long-run relationship among the variables. The short-run ARDL results showed that GDP and FDI have statistically significant positive impacts on economic complexity, while TCI had a negative lagged effect, indicating possible adjustment costs. In the long run, GDP maintained a significant and positive effect on ECI, while both TCI and FDI were statistically insignificant. Diagnostic tests confirmed the robustness of the model, with no evidence of serial correlation, heteroskedasticity, or non-normality. The findings suggest that while economic growth significantly enhances economic complexity in Nigeria, transport infrastructure improvements may not yield immediate or direct long-term effects unless strategically aligned with industrial and trade policy. The study recommends enhancing infrastructure efficiency, fostering sustainable growth, and improving the investment climate to achieve greater economic diversification and complexity.

Keywords: Economic Complexity, Transport Infrastructure, ARDL, GDP, FDI.

"JEL Classification Code: O18, R42, H54, O14, O47."

1. Introduction

Transportation infrastructure is a fundamental component of economic development, playing a critical role in connecting regions, facilitating trade, and enhancing the efficiency of industries. Imagine a country without the inter or intra state highway system, the economic, social, and political scene would be deeply impacted. A lack of transportation infrastructure would create barriers to trade, hinder business activities, stifle innovation, and contribute to inequality. Ultimately, such a scenario would binder economic complexity, as the economy would struggle to evolve into more diverse, sophisticated industries due to the inefficiency of movement and communication. For a country to thrive and develop a complex economy, the development of a strong and interconnected transportation infrastructure is essential.

Across the globe, countries with advanced transport networks tend to experience higher levels of economic performance, with well-developed infrastructure enabling the smooth movement of goods, services, and people. For industrialized nations, transportation systems have long been recognized as a catalyst for growth, driving productivity and fostering economic expansion. In the settings of developing countries, the quality and availability of transportation infrastructure are even more pivotal, as they directly influence the nation's ability to diversify its economy and engage in the global market (Bagchi & Pradhan, 2013; Kim et al., 2014).

In Nigeria, transport infrastructure is seen as both a challenge and an opportunity for economic growth. Despite the country's abundant natural resources and emerging private sector investments, the state of its transportation networks has remained inadequate, particularly in terms of road and rail infrastructure. While recent investments in ports and airports have improved Nigeria’s international connectivity, road networks and rail systems are still far from meeting the demands of a growing population and expanding economy (African Development Bank, 2010). This infrastructure gap has had significant consequences on the Nigerian economy, hindering trade, limiting regional integration, and restricting access to key markets and technologies.

The relationship between transportation infrastructure and economic complexity is important in understanding how improvements in the transport sector can drive broader economic development. Economic complexity refers to the diversity and sophistication of a country's productive activities, particularly its exports. It is a measure of how well a country can utilize its knowledge, skills, and industrial capabilities to produce a wide range of advanced goods and services. Countries with more complex economies are better positioned to adapt to global economic shifts, foster innovation, and achieve sustainable growth. Economic complexity goes beyond traditional measures of economic performance, such as Gross Domestic Product (GDP), by analyzing the specific industries and knowledge sectors driving growth (Aluko et al., 2022; Hidalgo & Hausmann, 2009).

However, Nigeria’s transport infrastructure is currently facing several challenges that limit its potential to contribute to economic complexity. Despite the country’s vast geography, large population, and rich resource base, Nigeria still struggles with poor connectivity between key regions, deteriorating road conditions, and an underdeveloped rail system. The inefficiency of the transportation network limits access to markets, restricts the movement of key inputs for industrial production, and hampers the diffusion of technology and knowledge across regions. As a result, Nigeria's ability to diversify its economy and increase its economic complexity is hindered.

To understand the potential impact of transportation infrastructure on Nigeria's economic complexity, it is important to explore how improvements or deficiencies in this sector can influence the overall structure of the economy. By improving transport networks especially in underdeveloped regions, the Nigeria government can increase access to international markets, reduce costs of production, and stimulate the growth of more complex industries. Furthermore, well-planned transportation investments could enhance regional integration, enabling different sectors to specialize and collaborate, thus fostering innovation and technological advancement.

Nigeria's regional connections are fair, with a number of transnational corridors. These include connections to neighbouring countries like Niger, Chad, Cameroon and Benin, as well as coastal roads joining routes to Dakar in Senegal or Abidjan in Côte d'Ivoire. The Trans-Sahara Highway connects Nigeria with Algeria via Niger. A cross-African route, the Lagos Mombasa Highway, links Nigeria, Cameroon, the Central African Republic, the DRC (Democratic Republic of Congo), Uganda and Kenya.

Given Nigeria's vast geography, population, and resource endowment, transport infrastructure road, rail, air, and waterways should serve as a backbone for economic activities. However, poor connectivity, dilapidated road networks, underdeveloped rail lines, and congested ports continue to hinder economic complexity by limiting access to inputs, markets, and technology diffusion. Understanding how improvements or deficiencies in transport infrastructure influence Nigeria's economic complexity is crucial for informed policymaking.

This study, therefore, aims to examine the effect of transport infrastructure on economic complexity in Nigeria, focusing on the role of road, rail, and port systems in shaping the country's ability to diversify its economy. By investigating the relationship between transportation infrastructure and economic complexity, this research seeks to provide insights that can inform policymaking, with the goal of promoting sustainable economic development in Nigeria. Understanding how transport infrastructure affects the country's industrial structure and economic sophistication will be essential in designing future infrastructure policies that can drive long-term economic growth and development.

While numerous studies have examined the relationship between transport infrastructure and economic growth in Nigeria, there is a paucity of empirical research that specifically explores how transport infrastructure influences economic complexity—that is, the diversity and sophistication of the country's productive capabilities. This gap is critical, as understanding the impact of infrastructure on economic complexity provides deeper insight into how transport systems can be leveraged not just for growth, but for structural transformation and long-term development.

2. Literature Review

2.1 Conceptual Review

Economic Complexity

Economic complexity, a relatively recent addition to economic literature, provides novel opportunities for a comprehensive exploration of countries' economic development processes. This concept aims to grasp the productive structures of economies through establishing the Economic Complexity Index (ECI), where the index serves as a metric capturing knowledge-based productive capability and the potential for economic diversification in countries (Allen Whitehead & Bhorat, 2021; Mealy et al., 2019; Mealy & Teytelboym, 2020).

Transport Infrastructure

According to Central Bank of Nigeria (CBN) documents, transport infrastructure, including roads, rail, water, and air transport, is a crucial element for economic growth and development. It's considered a fundamental pillar for the overall progress of a country, enabling the movement of people, goods, and information, which are essential for a manufacturing and export economy.

Transport Infrastructure and Economic Complexity

The interaction between transport infrastructure and economic complexity stems from the ability of infrastructure to lower production and transaction costs, enable efficient logistics, and open up markets. These improvements support the growth of industries and diversification of exports, which are crucial for enhancing economic complexity.

2.2 Theoretical Review

New Economic Geography Theory

Paul Krugman introduces the achievements of New Trade and New Growth Theory into the traditional location theory, and puts forward a new location theory which is called New Economic Geography. Based on this theory and his achievements in the New Trade Theory, Krugman won the Nobel Prize in 2008. Krugman defined the New Economic Geography as the location theory of production, just as the concept of the classical location theory, which is proposed to explain the mechanism of formation and evolution of the economic spatial structure. The New Economic Geography theory of Krugman, scattered in his several books, is summed up as follows: a main idea, four propositions, four tools and three models. Krugman\'s new Economic Geography is based on the main idea that there exists multiple equilibrium state in the development of economic spatial structure. In order to analyze more clearly the process of formation and evolution of economic spatial structure, Krugman puts forward four propositions: (1) Transportation Costs play a key role in international trade and inter-regional trade; (2) Spatial agglomeration of interrelated economic activity could achieve cost-saving and benefit-increasing; (3) The cost-saving and benefit-increasing from the economic spatial agglomeration could promote the further concentration of economic development; (4) Early-development advantage could lead to the long-term accumulation of economic activity. Furthermore, Krugman introduces D-S Monopolistic Competition Model (built by A. Dixit and J. Stiglitz), "Iceberg"-type Transportation Costs, Self-organization Simulation and Computer Technology into the new Economic Geography, and builds three models, i.e., the Core-Periphery Model, Urban System Model and the International Model. The New Economic Theory of Krugman is a new development of Economic Geography under new situation, which can deal with the difficult problem in economic location study which has not been solved by traditional Economic Geography. But for a long time, the New Economic Theory of Krugman was considered a new academic field which is differentiated from or opposed to the classical Economic Geography in geographical circle. Therefore, this theory has attracted relatively little attention from the researchers in Geography. From the angle of geographic view, the paper reinterprets the theoretical connotation, significance of the New Economic Geography of Krugman and elaborates its relation with traditional location theory, analyses its effects on the development of Economic Geography, and hopes to provide the reference and consultation for innovation of the research paradigm of the Economic Geography in China and drafting of the long-term research program in regional development fields.

2.3 Empirical Review

Kancs and Siliverstovs (2024) focused on the European Union's Cohesion Policy, particularly road infrastructure investments. Using a structural gravity model, the research found that improvements in road transport infrastructure significantly enhance trade connectivity and regional GDP. This highlights the role of infrastructure in fostering economic integration within regions.

Emeka, Ogbuabor, and Nwosu (2024) analysed 34 African countries over the period 2010–2021. The findings indicated that public infrastructure development and industrialization positively influence economic complexity. Notably, industrialization was found to enhance the impact of infrastructure on economic complexity. Other factors such as trade openness, foreign direct investment, international tourism, and institutional quality were also identified as significant contributors.

Zhang and Zhang (2023) examined the UK's transport infrastructure from 1970 to 2017 using the Vector Error Correction Model. The study revealed that while transport infrastructure has a long-term positive effect on economic growth, its short-term impact can be negative. This underscores the importance of strategic planning in infrastructure development.

Wang et al. (2023) examined the effects of transport infrastructure investments on economic growth and environmental pollution in China, India, Japan, and Russia. The findings indicated that while transport infrastructure contributes to economic growth, it also poses challenges related to environmental pollution. This underscores the need for sustainable infrastructure development strategies.

Adebosin et al. (2022) using the Vector Error Correction Model indicated that road transport infrastructure investment positively influences economic growth, with a 1% increase in investment leading to a 0.22% increase in GDP.

Olowookere et al. (2021) argue that despite heavy investments, poor maintenance and corruption reduce infrastructure effectiveness, limiting its impact on economic complexity.

Adebosin et al. (2020) found that road transport infrastructure had a significant positive effect on sectoral growth, while other sectors like agriculture and industry showed negligible impacts.

Summary of Reviewed Literatures and Gaps Identified

Most studies focus on the broad impact of infrastructure on economic growth, with limited emphasis on economic complexity as an outcome variable in Nigeria. There is also a scarcity of empirical work combining transport infrastructure indices with complexity metrics such as the Economic Complexity Index (ECI). Furthermore, sector-specific analyses (e.g., road vs. rail vs. ports) are rarely undertaken in the Nigerian context. Limited Focus on economic complexity as an outcome while transport infrastructure is well-studied in the context of growth and trade, few studies directly measure its impact on economic complexity—particularly in developing countries. There is a need for broader empirical work comparing countries over time to isolate infrastructure's effect on the evolution of complexity, beyond export volume.

The literature highlights a strong theoretical and empirical basis for the role of transport infrastructure in shaping economic complexity. However, in Nigeria, this relationship remains underexplored in both academic and policy circles. This study aims to bridge this gap by providing empirical evidence on how transport infrastructure development influences Nigeria's economic complexity.

3. Methodology

3.1 Theoretical Framework

This study adopts the Endogenous Growth Theory, which highlights internal factors like infrastructure, human capital, and innovation as drivers of long-term growth. Within this framework, transport infrastructure such as roads, rail, air, and ports, enhances efficiency, lowers costs, improves connectivity, and supports trade and productivity, thereby fostering economic transformation. By enabling structural change, knowledge diffusion, and diversification into more sophisticated industries, transport infrastructure strengthens a nation's economic complexity. Thus, the study argues that investments in transport systems are central to innovation-driven and sustainable development.

3.2 Model Specification

The relationship between transport infrastructure and economic complexity is modeled using a linear functional form. The general model is specified as:

$ECI = f(TCI, GDP, FDI)$…………(1)

Where;
ECI = Economic Complexity
TCI = Transport Composite Index
GDP = Gross Dosmestic Product
FDI = Foreign Direct Investment Inflows

A priori expectation

$\beta_1 > 0$; $\beta_2 > 0$; $\beta_3 > 0$

3.3 Measurement of Variable and Data Sources

Table 1: Summary of variable measurement and data source

Variable	Measurement/Proxy	Source
Economic Complexity Index (ECI)	Annual Economic Complexity Index score	Observatory of Economic Complexity (OEC)
Transport Composite Index (TCI)	Composite index constructed from indicators of road, rail, air, and port infrastructure in Nigeria.	African Development Bank Group
Gross Domestic Product (GDP)	Real GDP in constant US dollars	World Bank Development Indicators (WDI)
Foreign Direct Investment (FDI)	Net FDI inflows as a percentage of GDP	World Bank Development Indicators (WDI)

Source: Researcher's Compilation (2025)

3.4 Estimation Technique

This refers to the various statistical and econometric methods used to estimate the parameters or coefficients of a model. For this research, Autoregressive Distributed Lag is employed.

Autoregressive Distributed Lag (ARDL) Bounds Test

The ARDL bounds test developed by Pesaran and Shin (1997) and Pesaran et al. (2001) is particularly effective for analyzing time series data where cointegration relationships may exist between variables. One of the advantages of ARDL over traditional cointegration techniques is its ability to accommodate variables that are either stationary at level or first difference. In this study, the ARDL approach is employed to investigate the short-run and long-run effects of transport infrastructure (proxied by a Transport Composite Index), Gross Domestic Product (GDP), and Foreign Direct Investment (FDI) on Nigeria's Economic Complexity Index (ECI).

The general ARDL model for this study is specified as follows:

$$\Delta ECI_t = \alpha_0 + \sum_{i=1}^{P} \beta_1 \Delta ECI_{t-i} + \sum_{i=0}^{q1} \beta_2 \Delta TCI_{t-i} + \sum_{i=0}^{q2} \beta_3 \Delta GDP_{t-i} + \sum_{i=0}^{q3} \beta_4 \Delta FDI_{t-i} + \varphi_1 ECI_{t-i} + \varphi_2 TCI_{t-i} + \varphi_3 GDP_{t-i} + \varphi_4 FDI_{t-i} + \mu_t$$

Where:
Δ = First difference operator
α = Intercept
$\beta_1,\beta_2,\beta_3,\beta_4$ = Short-run coefficients
$\phi_1,\phi_2,\phi_3,\phi_4$ = Long-run coefficients
μ_t= White noise error term
p,q_1,q_2,q_3 = Optimal lag lengths determined by criteria such as AIC

Bounds Test Hypothesis

To determine whether a long-run relationship exists among the variables, the ARDL bounds test evaluates the following hypotheses:
Null Hypothesis (H_0): $\phi_1 = \phi_2 = \phi_3 = \phi_4 = 0$ (No cointegration)
Alternative Hypothesis (H_1): $\phi_1 \neq \phi_2 \neq \phi_3 \neq \phi_4 \neq 0$ (Cointegration exists)
If the calculated F-statistic exceeds the upper critical value, the null hypothesis is rejected, indicating the existence of a long-run relationship.

Error Correction Representation of ARDL

If cointegration is confirmed, the ARDL model is re-parameterized into an Error Correction Model (ECM) to estimate short-run dynamics while maintaining the long-run equilibrium. The ECM form is specified as:

$$\Delta ECI_t = \alpha_0 + \sum_{i=1}^{P} \beta_1 \Delta ECI_{t-i} + \sum_{i=0}^{q1} \beta_2 \Delta TCI_{t-i} + \sum_{i=0}^{q2} \beta_3 \Delta GDP_{t-i} + \sum_{i=0}^{q3} \beta_4 \Delta FDI_{t-i} + \varphi_1 ECI_{t-i} + \varphi_2 TCI_{t-i} + \varphi_3 GDP_{t-i} + \varphi_4 FDI_{t-i} + ECM_{t-1} + \mu_t$$

4. Results and Discussion

4.1 Trend of Economic Complexity Index and Transport Composite Index

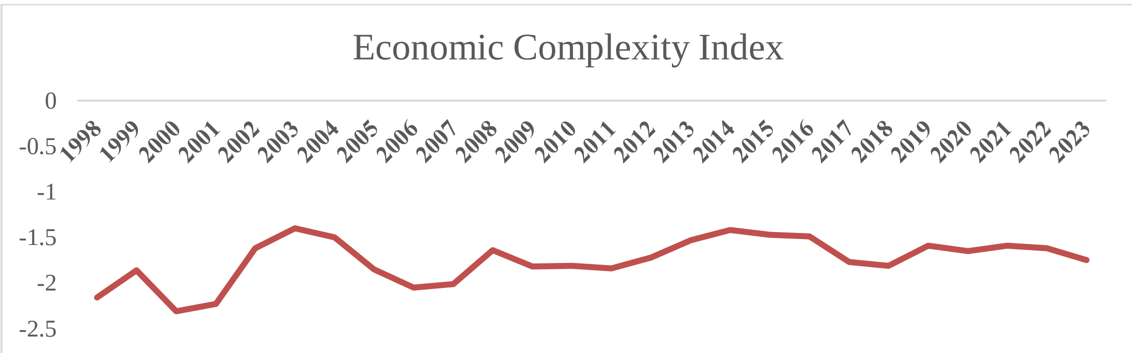

Fig. 1

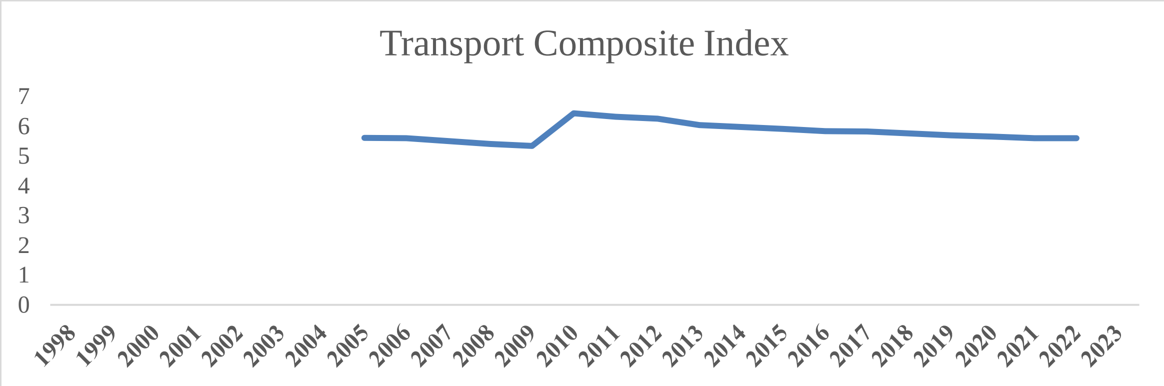

Fig. 2

Figure 1 representing the Economic Complexity Index (ECI), reveals a fluctuating but generally contained trend over the period. The graph shows that the ECI started at -2.16 in 1998, experienced a dip around 2000, and then saw a notable increase reaching -1.4 by 2003. This suggests a period of improvement in economic complexity. Following this, the ECI entered a period of decline and volatility, fluctuating between -1.5 and -2.0 until around 2012. From 2012 to 2014, there was another upward trend, with the ECI peaking -1.4. The years after 2015 show continued variability, with the index generally ranging between -1.5 and -1.8, ending at -1.75 in 2023. This volatility indicates that the factors contributing to economic complexity are subject to various influences, leading to periods of both advancement and stagnation.

Figure 2 depicts the trend of the Transport Composite Index (TCI) over the same period, starting from 2005. The graph indicates a relatively stable trend with a distinct peak. The TCI begins around 5.6 in 2005, experiences a slight dip around 2009, and then shows a sharp increase, reaching its highest point at approximately 6.4 in 2010. This rapid rise suggests a significant improvement or expansion in the transport composite during that time. Following this peak, the TCI enters a phase of gradual and consistent decline, settling around 5.6 by 2022 and 2023. This prolonged slight downturn after the initial growth period might suggest a maturity in the transport sector's development or a plateauing of the factors contributing to the composite index.

The trends illustrated in these figures suggest a potential, albeit not overtly direct, relationship between the Economic Complexity Index and the Transport Composite Index. While the ECI shows more frequent and pronounced fluctuations, the TCI exhibits a sharper initial increase followed by a more gradual decline. The peak in the TCI around 2010 broadly coincides with a period where the ECI was showing some upward movement or stabilization before its later fluctuations. This could imply that improvements in transport infrastructure or services (as reflected in the TCI) might initially support or be a consequence of increasing economic complexity. However, the subsequent divergence in their detailed trends, particularly the TCI's gradual decline while the ECI continues to fluctuate, suggests that their relationship is dynamic and influenced by other factors beyond a simple one-to-one correlation. These figures help to visually demonstrate the independent and possibly interdependent evolution of economic complexity and transport infrastructure/services over time.

4.2 Summary statistics

Table 2: Summary Statistics Results

VARIABLE	MEAN	MAXIMUM	MINIMUM	STD. DEV.
ECI	-1.7044	-1.42	-2.05	0.1791
TCI	5.8016	6.4398	5.3428	0.3092
GDP	4.30E+11	5.35E+11	2.74E+11	8.55E+10
FDI	1.3107	2.9002	-0.0391	0.9158

Source: Author's Computation, 2025.

Table 2 presents the summary statistics for the variables used in this study: Economic Complexity Index (ECI), Transport Composite Index (TCI), Gross Domestic Product (GDP), and Foreign Direct Investment (FDI). These statistics provide a preliminary understanding of the central tendencies and dispersion of the data, helping to inform further econometric analysis.

The Economic Complexity Index (ECI) has a mean value of -1.7044, with a maximum of -1.42 and a minimum of -2.05, indicating relatively low economic complexity for Nigeria over the sampled period. The standard deviation of 0.1791 suggests moderate variation in ECI over time. This reflects the country's relatively limited diversification and technological advancement in its export base, which is typical of resource-dependent economies.

For the Transport Composite Index (TCI), the mean value stands at 5.8016, with a range between 5.3428 and 6.4398, and a standard deviation of 0.3092. This moderate level of variation implies that although there have been changes in the transport infrastructure over the years, the pace of improvement has not been drastic. It also suggests consistency in the measurement of transport infrastructure development across the years.

In the case of Gross Domestic Product (GDP), the mean value is ₦4.30 $\times 10^{11}$, with a wide range from ₦2.74 $\times 10^{11}$ to ₦5.35 $\times 10^{11}$ and a large standard deviation of ₦8.55 $\times 10^{10}$. This reflects strong growth in Nigeria's economic output over the years, albeit with notable fluctuations, possibly due to external shocks, oil price volatility, and macroeconomic reforms. Lastly, FDI has an average of 1.3107, with a maximum of 2.9002 and a minimum of -0.0391, alongside a standard deviation of 0.9158. The negative minimum suggests there were years of net outflows or disinvestment, while the variation in FDI implies inconsistent investor confidence over the years.

Overall, the summary statistics suggest moderate fluctuations in transport and complexity levels, while GDP shows strong but volatile growth. FDI remains unstable, pointing to external influences and domestic structural issues affecting investment inflows.

4.3 Pre-Estimation Test

4.3.1 Unit Root Test

Table 3: Augmented Dickey Fuller Unit Root Test

VARIABLE		level			first difference		1(d)
	t-statistic	Critical Value @ 5%	p-value	t-statistic	Critical Value @ 5%	p-value	
ECI	-3.0376	-3.9919	0.0656	-4.8412	-3.0124	0.0010	I(1)
TCI	-1.9745	-3.0522	0.2940	-4.1285	-3.0656	0.0067	I(1)
GDP	-1.4562	-2.9919	0.5379	-3.2367	-2.9919	0.0301	I(1)
FDI	-0.9631	-3.0124	0.7466	-8.3761	-2.9919	0.0000	I(1)

Source: Author's Computation, 2025.

Tables 3 present the results of the Augmented Dickey-Fuller (ADF) unit root tests used to determine the stationarity of the variables: Economic Complexity Index (ECI), Transport Composite Index (TCI), Gross Domestic Product (GDP), and Foreign Direct Investment (FDI). Stationarity is crucial in time series analysis because non-stationary variables can lead to spurious regression results. All variables (ECI, TCI, GDP, and FDI) were found to be non-stationary at their levels, as indicated by their p-values exceeding 0.05 and t-statistics being higher than the 5% critical values. However, when differenced once, all four variables became stationary, showing significant p-values (less than 0.05) and t-statistics lower than the critical values. This indicates that all variables are integrated of order one, I(1).

Table 4: Optimal Lag Selection

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-418.716	NA	1.04E+18	52.83953	53.03268	52.84942
1	-371.48	64.94927*	2.29E+16	48.93505	49.90079	48.98451
2	-345.737	22.52513	1.12e+16*	47.71718*	49.4555	47.80619
3	-159.321	13.85657*	1.02E+15	16.4906*	18.8518*	23.1271*

Source: Author's Computation, 2025.

Table 4 show the optimal lag selection based on various criteria: Log Likelihood (LogL), Likelihood Ratio (LR), Final Prediction Error (FPE), Akaike Information Criterion (AIC), Schwarz Criterion (SC), and Hannan-Quinn Criterion (HQ). These criteria help in identifying the most suitable lag length for the ARDL model estimation. Upon comparison, lag 3 has the lowest values for the AIC (16.4906), SC (18.8518), and HQ (23.1271), indicating that it is the most appropriate lag length among all the tested options.

The likelihood ratio (LR) test statistic for lag 3 (13.85657) also supports its adequacy, and although the value is relatively lower than that of lag 1, it is consistent with the sharp decline in FPE at lag 3 (1.02E+15), which further supports model efficiency. Choosing an optimal lag is essential for capturing the dynamic structure of the model without overfitting or underfitting. Therefore, lag 3 is preferred, as it balances model complexity and goodness of fit, which enhances the robustness of the long-run and short-run estimations in the ARDL analysis.

4.3.3 ARDL Bounds Test

Table 5: ARDL Bounds Test

Null Hypothesis: No long-run relationships exist

Test Statistic	Value	k
F-statistic	38.15529	3
Critical Value Bounds		
Significance	I0 Bound	I1 Bound
10%	2.37	3.2
5%	2.79	3.67
2.5%	3.15	4.08
1%	3.65	4.66

Source: Author's Computation, 2025.

Table 5 reports the ARDL Bounds Test results for long-run relationships among the model variables. The calculated F-statistic (38.155) far exceeds the upper critical bounds at all significance levels 10% (3.20), 5% (3.67), 2.5% (4.08), and 1% (4.66). Thus, the null hypothesis of no long-run relationship is rejected, providing strong evidence of a stable long-run equilibrium. This implies that the independent variables exert lasting effects on the dependent variable, thereby justifying the estimation of long-run coefficients within the ARDL framework.

4.4 Error Correction Model (ECM) Short run Model

Table 6: Estimated Short Run

Cointegrating Form

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(TCI)	0.146255	0.110449	1.324194	0.2336
D(TCI(-1))	-0.37258	0.104649	-3.56032	0.0119
D(GDP)	4.43E-12	2.15E-12	2.064306	0.0846
D(GDP(-1))	6.21E-12	2.38E-12	2.610493	0.0401
D(FDI)	0.196583	0.074903	2.624501	0.0393
CointEq(-1)*	-0.95926	0.189289	-5.06767	0.0023

Source: Author's Computation, 2025.

Table 6 presents the short-run estimation results of the ARDL model, specifically capturing how changes in Transport Composite Index (TCI), Gross Domestic Product (GDP), and Foreign Direct Investment (FDI) affect the Economic Complexity Index (ECI) in the short term. The selected model, ARDL(1, 2, 2, 1), indicates the optimal lag structure based on the Akaike Information Criterion (AIC).

Starting with D(TCI), the coefficient (0.1463) is positive, suggesting that an increase in transport infrastructure is associated with an increase in economic complexity in the short run. However, with a p-value of 0.2336, this effect is not statistically significant, implying weak immediate impact. Interestingly, the lagged change in TCI (D(TCI(-1))) has a negative and statistically significant coefficient (-0.3726) with a p-value of 0.0119, indicating that past increases in TCI are associated with a significant reduction in current ECI. This may reflect short-term adjustment costs or inefficiencies from rapid infrastructure changes that take time to yield complex productivity gains.

For GDP, both current and lagged differences show positive coefficients (4.43E-12 and 6.21E-12, respectively), meaning economic output positively influences ECI in the short run. The lagged GDP effect is statistically significant (p = 0.0401), suggesting that past increases in GDP contribute meaningfully to improving economic complexity, possibly through gradual structural transformation and capital investment effects.

FDI also shows a positive and statistically significant coefficient (0.1966, p = 0.0393), indicating that foreign direct investment plays an important role in enhancing economic complexity in the short run. This may be due to technology transfer, knowledge diffusion, and increased production diversification associated with FDI inflows.

Finally, the error correction term (CointEq(-1)) is negative (-0.9593) and highly significant (p = 0.0023). This coefficient represents the speed of adjustment back to long-run equilibrium after a short-run shock. The magnitude suggests that approximately 96% of any disequilibrium is corrected within one period, implying a very strong and fast adjustment toward long-run equilibrium.

Overall, the short-run model suggests that GDP and FDI have significant positive effects on economic complexity, while TCI shows a delayed negative impact in the short run. The significant and strongly negative error correction term confirms that, despite short-run fluctuations, the model converges to a stable long-run relationship.

4.5 ARDL Long Run Output

Table 7: Summary of ARDL Long Run Coefficients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
TCI	0.202363	0.190508	1.062333	0.329
GDP	4.62E-12	1.81E-12	2.549297	0.0486
FDI	-0.005977	0.017028	-0.033763	0.9742
C	-3.792491	1.101123	-3.444203	0.0137

Source: Author’s Computation, 2025

Table 7 reveals that in the long run, the Transport Composite Index (TCI) has a positive but statistically insignificant effect on government expenditure. With a coefficient of 0.2024, this implies that a 1-unit increase in TCI is associated with a 0.20 unit increase in government spending. However, the p-value of 0.329 and t-statistic of 1.062 indicate that this relationship lacks statistical significance at the 5% level, suggesting that while transportation development may contribute to fiscal expansion, its long-run effect in this context is weak and not conclusive.

Moreover, the Gross Domestic Product (GDP) exerts a significant and positive influence on government expenditure. The coefficient value of 4.62E-12 suggests that increases in economic output correspond with increases in government spending. This relationship is statistically significant, with a p-value of 0.0486 and a t-statistic of 2.549, reinforcing the idea that economic growth enhances government’s capacity to spend, possibly due to increased tax revenues or public investment opportunities arising from higher national income.

In contrast, Foreign Direct Investment (FDI) demonstrates a negative but statistically insignificant relationship with government expenditure in the long run. The coefficient of -0.00598, with a p-value of 0.9742 and t-statistic of -0.0338, indicates that FDI does not have a meaningful long-term effect on government expenditure. Lastly, the constant term (C) is negative and statistically significant, with a coefficient of -3.7925, a t-statistic of -3.444, and a p-value of 0.0137, implying that other external factors not captured by the model may be exerting downward pressure on government expenditure when the explanatory variables are held constant..

4.5 Post Estimation Test

4.5.1 Breusch-Godfrey Serial Correlation LM Test

Table 8: Breusch-Godfrey Serial Correlation LM Test:

F-statistic	2.916183	Prob. F(2,22)	0.1655
Obs*R-squared	9.490885	Prob. Chi-Square(2)	0.0087

Source: Author's Computation, 2025

The Breusch-Godfrey LM test for autocorrelation (Table 8) yielded an F-statistic of 2.916 with a p-value of 0.1655. Since the p-value exceeds the 5% significance level, the null hypothesis of no serial correlation cannot be rejected. This indicates that the regression model is free from serial or autocorrelation issues.

4.5.2 Heteroskedasticity Test

Table 9: Heteroskedasticity Test: Breusch-Pagan-Godfrey

F-statistic	1.163261	Prob. F(10,24)	0.4425
Obs*R-squared	10.17099	Prob. Chi-Square(10)	0.3368
Scaled explained SS	1.823835	Prob. Chi-Square(10)	0.9940

Source: Author's Computation, 2025.

In Table 9 the heteroskedasticity test was conducted following the Breusch-Godfrey test procedure. Heteroskedasticity is a statistical property where the variance of a random variable or a stochastic process is not constant across different values of the variable or other variables in the model. The F-statistic for this test is 1.1633, with a p-value of 0.4425. Since this p-value is greater than 5% significance levels (0.05), we fail to reject the null hypothesis of homoskedasticity, meaning the variance of the error term is constant.
4.5.3 Jarque-Bera Normality Test

Additionally, the Observation R-squared statistic is 10.171, with a p-value of 0.3368. This statistic serves as the test statistic for the chi-square test of heteroskedasticity. Again, the p-value exceeds the significance level, leading us to fail to reject the null hypothesis of homoskedasticity. Therefore, the results of the Breusch-Pagan-Godfrey test indicate that there is no evidence of heteroskedasticity in the model.

Source: Author's Computation, 2024.

The histogram depicted in the figure above represents the distribution of the residuals from the regression model, aimed at assessing whether the normality assumption of the classical linear regression model has been violated. While the histogram alone may not provide a definitive conclusion, the Jarque-Bera normality statistic has been included to evaluate if the residuals follow a normal distribution. The significance of the Jarque-Bera statistic is indicated by its p-value of 0.3889, which is greater than 0.05. This suggests that the statistic is not significant at the 5% significance level. Therefore, the null hypothesis of the test, which asserts that the residual series is normally distributed, is validated. This indicates that the residual series of the regression model is normally distributed, and the normality assumption of the classical linear regression model holds.

5. Conclusion and Recommendations

Based on the results of the analysis, this study concludes that transport infrastructure, as proxied by the Transport Composite Index, does not exert a statistically significant influence on economic complexity in the long run in Nigeria. However, short-run dynamics reveal that past improvements in transport infrastructure might even temporarily dampen economic complexity, possibly due to adjustment costs or delayed benefits. On the other hand, GDP growth plays a pivotal and statistically significant role in enhancing Nigeria's economic complexity both in the short and long term. Foreign direct investment shows a short-term positive influence, but its long-term impact remains statistically insignificant.

These findings underscore the complexity and multifaceted nature of the relationship between infrastructure development and economic outcomes. While transport infrastructure is often assumed to enhance productivity and trade sophistication, this study finds that its impact on economic complexity may be indirect, delayed, or conditioned by other factors such as policy stability, institutional quality, or the absorptive capacity of the economy.

Based on the findings of this study, the following recommendations are made:

Strengthen Transport Infrastructure Planning and Implementation: Government and stakeholders should ensure that transport projects (road, rail, air, and seaports) are aligned with long-term economic transformation goals, especially those that promote value-added production and export diversification.

Promote Complementary Macroeconomic Policies: Since GDP and FDI significantly impact economic complexity, policies that improve macroeconomic stability, encourage investment, and facilitate industrial growth should be prioritized alongside infrastructure development.

Improve Project Efficiency and Reduce Transition Costs: The short-run negative lag effect of transport infrastructure suggests inefficiencies in the transition period. There is a need to strengthen project execution, monitoring, and timely completion to realize benefits faster and reduce delays that may discourage productive restructuring.

Encourage Public-Private Partnerships (PPP): Leveraging PPPs can mobilize funds and expertise for large-scale transport infrastructure projects while ensuring accountability, innovation, and efficiency in implementation.

Integrate Infrastructure into National Innovation Systems: Infrastructure investment should support technological diffusion, skill development, and logistics efficiency to promote complex, knowledge-intensive economic activities.

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