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Foreign direct investment and infrastructural development in Nigeria: Comparative analysis of inflows from China, United States and the United Kingdom

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Abstract

This study compared FDI inflows on infrastructural development in Nigeria from three major trading and investing partners - the United States (USA), the United Kingdom (UK), and China. The study used time series data from 2005 to 2024, sourcing data from the Central Bank of Nigeria Statistical Bulletin, World Bank's Development Indicators, and the African Development Bank database. The study employed preliminary tests of Augmented Dickey-Fuller and Phillips-Perron unit root, while the main estimation technique was the Autoregressive Distributed Lag Model. The dependent variable is access to electricity, proxied for infrastructural development, while the independent variables include Chinese foreign direct investment, UK's foreign direct investment, USA's foreign direct investment, government effectiveness, financial development, gross domestic product growth rate, and exchange rate. The series considered exhibits a mixed order of integration, while the bounds test demonstrates the existence of a long-run relationship among the variables. The empirical findings indicate substantial variation in how FDI affects infrastructure, contingent upon the source country and the quality of institutions. Chinese FDI has a significantly negative effect on electricity access, worsened by governance inefficiencies, while UK FDI consistently shows a positive impact, enhanced by effective governance. US FDI has a persistently negative influence, indicating weak institutional frameworks. The study highlights the pivotal role of institutional quality in shaping the effectiveness of FDI in promoting infrastructure development in Nigeria. Also, among other conclusions, enhancing governance structures is crucial for improving the effectiveness of FDI; this can be achieved by strengthening transparency and regulatory frameworks.

Keywords: Access to electricity, Access to sanitation, ARDL model, Fixed broadband subscription, Foreign direct investment.
JEL Classification: H54; F21; E02; O43.

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Contents

Contribution of this paper to the literature
This study contributes to the existing literature by providing a comparative, source-country analysis of FDI and infrastructural development, incorporating institutional quality. The paper's primary contribution is finding that FDI effects vary by origin and governance strength. This study documents institutional quality as the decisive channel shaping FDI's infrastructure outcomes.

1. Introduction

The liberalization and amplification of Foreign Direct Investment (FDI) have become essential features in the global economic landscape, signifying the extension of physical capital beyond national borders (Cole, Elliott, & Zhang, 2017). FDI, characterized by the establishment of a lasting interest with at least a 10% ownership stake in foreign enterprises, has been integral to international development, contributing to the growth trajectories of host economies (Francis, 2010). Recognized for its ability to enhance domestic investment and stimulate economic expansion, FDI's role is particularly valued by nations that compete for these capital inflows due to the benefits they bring to local industries through technology transfers and managerial expertise, among other assets (Awadhi, James, & Byaro, 2022; Balasubramanyam & Wei, 2005).

Infrastructure development is essential for economic growth, as it facilitates business operations and economic activities (John & Kuso, 2019; Ng, Law, Jakarni, & Kulanthayan, 2019; Owusu-Manu, Jehuri, Edwards, Boateng, & Asumadu, 2019; Sahoo & Dash, 2009). Nigeria, however, faces significant infrastructure deficits, hindering economic progress (Olaseni & Alade, 2012). Inadequate infrastructure increases transaction costs and deters investment, negatively impacting growth (Easter, 2019; Nyo, 2016). Studies show that infrastructure investment significantly boosts GDP (Aschauer, 1989; Calderón & Servén, 2004). Nigeria has made strides in transportation and power infrastructure projects to enhance economic efficiency (Arowolo & Perez, 2020; Peter, Eremionkhale, & Makwe, 2015). Furthermore, FDI and Public-Private Partnerships (PPPs) are critical for bridging Nigeria's infrastructure gap (Babatunde & Perera, 2017; Dairu & Muhammad, 2015). However, challenges like regulatory issues and political instability must be addressed to maximize these benefits (Opawole & Jagboro, 2017). Improving the investment climate and enhancing PPP processes will help Nigeria attract more FDI and drive economic development (Kalu, Nwokoye, & Nwaigwe, 2010).

The impacts of FDI are multifaceted, involving both capital inflows and the strategic entry of multinational enterprises (MNEs) into developing countries. These MNEs contribute intangible assets, such as advanced technology and marketing channels, which are often scarce in the host economy (Bayar & Sasmaz, 2019). The World Bank (2023) underscores FDI as encompassing a variety of capital streams, and research indicates that these investments can bolster international competitiveness and enhance national economic performance (Han et al., 2022). FDI can foster favorable outcomes by increasing employment, generating tax revenue, and augmenting infrastructure capabilities, all of which collectively support national development (Hanim, 2021). Nevertheless, as Han et al. (2022) note, FDI's economic ramifications are complex due to the varying characteristics of investment flows.

In recent years, the increase in Chinese FDI in Nigeria's infrastructure sector has accentuated the critical role of quality institutions in optimizing investment benefits and minimizing risks (Chen, 2021). This trend highlights the necessity for strong institutions to manage foreign capital effectively, address environmental implications, and safeguard local industries (Adegboye, Osabohien, Olokoyo, Matthew, & Adediran, 2020). As global economic conditions evolve, the strategic collaboration between China and Nigeria presents both opportunities and challenges, especially in infrastructure development sectors such as energy, telecommunications, and transportation. Consequently, this research explores how robust institutional frameworks in Nigeria can enhance FDI's positive impacts on infrastructure, supporting sustainable growth and fostering an environment that balances economic aspirations with national interests.

2. Literature

Foreign Direct Investment (FDI) has become a crucial economic driver in the global economy, particularly for developing nations, where it serves as a key source of income and investment (Nwaogu & Ryan, 2015; Perea & Stephenson, 2017; Sabir, Rafique, & Abbas, 2019). Since the 1960s, FDI theories have evolved from microeconomic to macroeconomic perspectives, highlighting the competitive, internalization, and location advantages of multinational corporations (Buckley & Casson, 1985; Hymer, 1960). FDI is a cross-border investment where the investor establishes a long-term interest, often influencing the enterprise (OECD, 2019), and plays a significant role in global economic integration (Rygh & Benito, 2018). While FDI can enhance infrastructure, its impacts vary. For example, Yamin and Sinkovics (2009) found that FDI can strain infrastructure financing in least developed countries, whereas Huang, Qian, and Sui (2018) showed that Chinese FDI significantly improves infrastructure in Belt and Road nations. Similarly, studies in ASEAN countries highlight FDI's positive effects on infrastructure, particularly from China (Huang et al., 2018). In India, FDI inflows increase after infrastructure surpasses a critical threshold (Chakrabarti, Subramanian, & Meka, 2017). In Ghana, FDI positively influences electricity consumption, suggesting that liberalized FDI policies can enhance infrastructure (Ibrahim, Appiah, & Zamore, 2018). Overall, FDI inflows into the infrastructure sector significantly enhance the host nation's infrastructure development.

From a theoretical perspective, traditional theories of foreign direct investment (FDI) provide a variety of perspectives on why firms choose to invest abroad rather than export or license their products, with notable theories explaining different motivations. The product cycle theory (Vernon, 1966) suggests that firms invest overseas when a product reaches maturity and requires local production to maintain market dominance. Internalization Theory, developed by Buckley and Casson (1985), highlights market imperfections as motivators for firms to internalize production activities through FDI, leveraging firm-specific advantages. Finally, Dunning (1981) integrates Ownership, Location, and Internalization (OLI) advantages, proposing that FDI occurs when a firm has competitive ownership advantages, locational benefits in the host country, and finds it profitable to internalize production rather than outsourcing (Dunning & Lundan, 2008). Collectively, these theories underscore that FDI results from a firm's

strategic decisions to maximize benefits from foreign market conditions, competitive advantages, and control over production (Denisia, 2010; Nayak & Choudhury, 2014).

The evolution of Foreign Direct Investment (FDI) literature highlights a shift from microeconomic theories emphasizing competitive advantage in developed nations to a broader macroeconomic perspective that underscores FDI's role in developing economies. Pioneering FDI theories, such as those by Hymer (1960), Buckley and Casson (1985), and Kojima (1978), focused on the monopolistic, internalization, and locational advantages that attract FDI. More recent research emphasizes the importance of FDI in promoting infrastructure and growth in developing countries, with significant attention to investment location choices (Bakar et al., 2022; Bartels, Napolitano, & Tissi, 2014; Belkhodja, Mohiuddin, & Karuranga, 2017; Kang & Jiang, 2012; Ma, Xu, Zeng, & Wang, 2020; Okafor, 2015; Wang, 2019; Xiao & Tian, 2023). Specifically, studies show that Chinese FDI has positively impacted infrastructure in nations like Nigeria, where institutional quality mediates this relationship (Wang, 2019). Three primary research streams analyze this link: first, studies argue that infrastructure can enhance FDI's impact on per capita income (Nourzad, Greenwold, & Yang, 2014). Second, research suggests infrastructure attracts FDI, as seen in analyses by Globerman and Shapiro (2002), Ang (2008), and Chakrabarti et al. (2017). Finally, studies explore how FDI itself influences host country infrastructure, with mixed results. Yamin and Sinkovics (2009) found limited benefits in the least-developed countries, while (Huang et al., 2018) documented significant improvements in infrastructure within Belt and Road Initiative countries.

Empirical evidence supports a bidirectional relationship between FDI and infrastructure. Rehman, Khan, Khan, Pervaiz, and Liaqat (2020) found that sector-specific FDI and infrastructure development reinforce each other in Pakistan, while Mehmood, Atique, Bing, Khan, and Henna (2021) demonstrated a similar dynamic in China. These findings suggest similar dynamics may exist in Nigeria, where Chinese FDI could enhance infrastructure and attract further investment. In Ghana, Owusu-Manu et al. (2019) used cross-sectional data and found that while FDI boosts infrastructure development, its long-term effects on GDP growth may be less positive, highlighting a potential lag in economic benefits. In Nigeria, where FDI from China is substantial, these insights are especially relevant, given the market shocks from fluctuating global oil prices and political instability. Institutional quality also plays a critical role in FDI absorption. Blomström and Kokko (1998) and Acemoglu and Johnson (2005) argue that institutions reduce transaction costs and encourage innovation, thereby optimizing FDI's benefits. The OLI paradigm (Dunning, 1980) indicates that ownership, location, and internalization advantages drive MNEs to pursue FDI. Studies like those by Jude and Levieuge (2015) underscore that institutional strength influences FDI's effectiveness, advocating for institutional reforms to maximize FDI's positive impact on infrastructure and growth.

Sreenu and Rao (2023) and Owusu-Manu et al. (2019) illustrate the complex interplay between FDI and infrastructure, emphasizing sector-specific analyses and the role of institutional quality. In Nigeria, these insights are crucial, given the infrastructure development driven by Chinese investment. Hayat (2019), Brahim and Rachdi (2014), and Meyer and Habanabakize (2018) further affirm that strong institutional quality enhances FDI's impact on economic growth by fostering competitiveness and capital accumulation. Studies such as those by Masron and Nor (2013) indicate that robust institutions correlate with higher FDI levels and reduce investment risks. In the Nigerian context, studies by Ejuvbekpokpo (2012) and Ewubare and Ekwe (2018) demonstrate that institutional quality and trade openness attract FDI and sustain inflows. Ejuvbekpokpo (2012) suggests that trade policy and institutional reforms can bolster Nigeria's investment climate, while Ewubare and Ekwe (2018) find that economic and social institutions have a greater influence on FDI than political institutions, especially in sectors less affected by political volatility. These studies underscore the significance of institutional quality in FDI attraction and its implications for economic growth. Jude and Levieuge (2015) conclude that institutional strength moderates FDI's impact on growth, advocating that policymakers in developing nations focus on reducing corruption and enhancing governance to fully benefit from foreign investments.

3. Methodology

To start with, this study seeks to examine the comparative impact of FDI from China, the United Kingdom, and the United States on infrastructural development in Nigeria. The data sources for the study included the Central Bank of Nigeria, the World Bank, and the African Development Bank, sourced from various periodic publications covering 19 years (representing 76 data points) from 2005 to 2024. These variables were selected based on theoretical postulations and empirical grounds (Adeleye, Osabuohien, & Bowale, 2018; Amiri & Ventelou, 2012; Asiedu, 2002; Bose & Kohli, 2018; Kaur, Yadav, & Gautam, 2016; Megbowon, Odugbesan, & Adediran, 2019; Nkoro & Uko, 2016; Ogunjimi & Amune, 2017; Olufemi, Samuel, & Simeon, 2013; Raji & Ogunrinu, 2018; Sghari & Hammami, 2013; Uddin, Chowdhury, Zafar, Shafique, & Liu, 2018; Wei, 2000). The choice of these countries (China, U.K. and U.S.) arose from the magnitude of FDI inflows emanating from the Nigerian economy, trade transactions between these selected countries and Nigeria over time, as well as differences in the life span of the investment inflows (Bose & Kohli, 2018; Kaur et al., 2016). Also, this study builds on similar studies like (Raji & Ogunrinu, 2018), which considers the implications of Chinese investment in economic security. Infrastructure improvement should, therefore, enhance the investment climate for FDI by limiting the costs of investment for foreign investors, increasing their return on investment (Olufemi et al., 2013). This was prompted by studies like Wei (2000) and Asiedu (2002), who concluded that good infrastructural development attracts more investments to countries. However, the infrastructural and FDI model by Ogunjimi and Amune (2017) was adopted to estimate this relationship. The functional form of the model by Ogunjimi and Amune (2017) is expressed in Equation 1.

$$FDI = f(ELPD, FTS, TRCT) \quad (1)$$

Where:

FDI = Foreign Direct Investment, ELPD = Electricity Production (kWh), FTS = Fixed Telephone Subscriptions (per 100 people), TRCT = Tractors per 100 sq. km of arable land.

However, to achieve the study's objective, the model of Ogunjimi and Amune (2017) was modified by including the variables of FDI inflows for China, the U.K., and the U.S., along with other control variables.

Therefore, the functional form of the model for the current study is expressed in Equation 2.

$$AELECT = f(CFDI, UKFDI, USFDI, GOV, FID, GDPG, EXR) \quad (2)$$

Where:

AELECT = Infrastructural Development proxied by Access to Electricity (% of population), CFDIN = Chinese Foreign Direct Investment to Nigeria, UKFDIN = United Kingdom Foreign Direct Investment to Nigeria, USFDIN = United States Foreign Direct Investment to Nigeria, GOV = Government Effectiveness (Index), FID = Financial Development, GDPG = Gross Domestic Product Growth Rate, EXR = Exchange Rate (US$/Naira).

In addition to access to electricity as the dependent variable for infrastructural development, fixed broadband subscriptions (FBS) (per 100 people) and access to improved sanitation facilities (ASF) (percentage of the population with access) will be used to validate the results. This study employed the Autoregressive Distributed Lag (ARDL) model proposed by Pesaran, Shin, and Smith (2001) to examine the cointegration relationship between FDI from China, the United Kingdom, the United States, and infrastructural development in Nigeria. The adoption of the ARDL approach for this study is due to its inherent advantages. The ARDL is a dynamic model suitable for impact analysis, chosen because it can be used when the variables in the model are integrated of order zero (I(0)) and one (I(1)). Autoregressive Distributed Lag (ARDL) is also selected as the technique for the objectives of the current study; this choice is based on the formulation of the research question, which compares FDI inflows from the U.K., the U.S., and China, with the primary aim of determining which of these FDI inflows contributed more to Nigeria's infrastructure development, either in the long run or in the short run, as well as the speed of adjustment. The ARDL model specification of the above functional form is expressed below in 3.

$$\Delta AELECT_t = \delta_o + \delta_1 GFCF_{t-1} + \delta_2 lnCFDI_{t-1} + \delta_3 lnUKFDI_{t-1} + \delta_4 lnUSFDI_{t-1} + \delta_5 lnGOV_{t-1} + \delta_6 lnFID_{t-1} + \delta_7 lnGDPG_{t-1} + \delta_8 lnEXR_{t-1} + \sum_{i=0}^{p} \varphi_1 \Delta AELECT_{t-1} + \sum_{i=0}^{q} \varphi_2 \Delta lnCFDI_{t-1} + \sum_{i=0}^{q} \varphi_3 \Delta lnUKFDI_{t-1} + \sum_{i=0}^{q} \varphi_4 \Delta lnUSFDI_{t-1} + \sum_{i=0}^{q} \varphi_5 \Delta lnGOV_{t-1} + \sum_{i=0}^{q} \varphi_6 \Delta lnFID_{t-1} + \sum_{i=0}^{q} \varphi_7 \Delta lnGDPG_{t-1} + \sum_{i=1}^{q} \varphi_8 \Delta lnEXR_{t-0} + \lambda ECM_{t-1} + \varepsilon_t \quad (3)$$

Where $\delta_1 - \delta_8$ are the long-run parameters; $\varphi_1 - \varphi_8$ are the short-run parameters; δ_0 and ε are the intercept term and the white noise stochastic term, respectively; λ is the parameter of the error correction mechanism (ECM); ln is the natural logarithm of the variables, and Δ is the difference operator. A shock to any of the regressors may not result in an immediate long-run effect on infrastructural development, proxied by access to electricity (Percentage of population), which creates disequilibrium in the system and requires that the short-run adjusts to its long-run equilibrium through the error correction mechanism (ECM_{t-1}). The ECM_{t-1} is a one-lag error correction term that accounts for the speed of adjustment to the long-run equilibrium.

4. Results

Table 1 presents descriptive statistics of the variables used in the study. Starting with the mean, a preliminary review of Table 1 shows that the average growth rates are 53.52%, 26.83%, 0.03%, -1.05%, 4.06%, 17.47%, and N/$212.22 for AELECT, ASF, FBS, GOV, GDPG, FID, and EXR, respectively. Additionally, the data indicate that CFDI, UKFDI, and USFDI had average values of $13.11 million, $1492.92 million, and $745.32 million over the study period. Regarding other relevant statistics, particularly the normalized variant of the standard deviation, the magnitude of variation across the series appears generally small for the African infrastructural development index, access to electricity (% of population), access to improved sanitation facilities (% of population), fixed broadband subscriptions (per 100 inhabitants), and their corresponding explanatory variables, with the exception of Chinese FDI, which exhibits volatility. This suggests that all dependent variables and nearly all explanatory variables remained relatively stable over time. In terms of skewness distribution, the series were approximately symmetric, as indicated by values close to zero for most series, except for CFDI and FID. Essentially, the variables AIDIN, AELECT, ASF, FBS, UKFDI, USFDI, GOV, GDPG, and EXR exhibited platykurtic distributions, with kurtosis values less than three, while CFDI and FID, with kurtosis values of approximately 16.69 and 3.48, can be regarded as mesokurtic. The high Jarque-Bera statistic values suggest that the variables do not follow a normal distribution, necessitating further testing with the unit root test as shown in subsequent Table 1.

Table 1. Descriptive statistics of selected variables.

Variables	AELECT	ASF	FBS	CFDI	UKFDI	USFDI	GOV	GDPG	FID	EXR
Mean	53.524	26.833	0.032	13.113	1492.925	745.322	-1.051	4.060	17.479	212.225
Median	54.224	26.636	0.036	10.452	1261.619	662.457	-1.051	4.623	18.592	157.694
Maximum	60.020	31.972	0.062	109.717	4384.974	1856.163	-0.862	8.434	23.017	367.750
Minimum	46.751	22.359	0.001	0.002	2.529	116.400	-1.241	-1.941	7.156	115.414
Std. Dev.	3.947	2.958	0.019	18.774	1091.53	398.536	0.084	2.961	4.414	85.528
N_Std. Dev.	0.074	0.112	0.587	1.432	0.731	0.535	-0.079	0.729	0.253	0.403
Skewness	-0.151	0.165	-0.171	3.423	0.447	0.309	-0.224	-0.296	-1.228	0.502
Kurtosis	1.988	1.814	1.794	16.692	2.253	2.375	2.744	1.778	3.489	1.535
Jarque-Bera	3.346	4.525	4.717	702.765	4.073	2.322	0.799	5.533	18.818	9.473
Prob.	0.188	0.104	0.095	0.000	0.130	0.313	0.671	0.063	0.000	0.009
Obs	72.000	72.000	72.000	72.000	72.000	72.000	72.000	72.000	72.000	72.000

Table 2 holds the unit root test conducted on all variables under consideration as a prerequisite for most time series analyses. This analysis is essential for determining the stationarity of the series, which in turn informs the appropriateness of the selected estimation techniques. To ensure robustness and consistency, the study employed more than one unit root and stationarity test, specifically the Augmented Dickey-Fuller (ADF) test and the Phillips-Perron test. These tests were conducted on the unit root hypothesis under two specifications: with a constant only, and with both a constant and a trend. It is important to note that for each of these specifications, the unit root tests were applied to the natural logarithm of the series. For instance, the log of Chinese FDI (CFDI), log of exchange rate (EXR), log of the United Kingdom FDI (UKFDI), and log of United States FDI (USFDI). However, the series of AELECT, ASF, FBS, GOV, GDPG, and the FID variables remained as earlier defined. Utilizing the Augmented Dickey-Fuller (ADF) unit root test, the findings presented in Table 2 (Panel A) indicate that, regardless of whether the unit root testing is conducted using a model with a constant only or one that includes both a constant and a

trend, the null hypothesis of a unit root generally holds true for the variables AELECT, ASF, FBS, UKFDI, GOV, GDPG, alongside CFDI, EXR, and FID. The only significant deviation from this pattern is the financial development index (FID). Furthermore, regardless of whether the ADF test incorporates a constant only or both a constant and a trend, the order of integration appears to be mixed.

Despite the prominence of the ADF test as a fundamental tool for unit root testing in the literature, its low power, particularly when a trend is included in the specification, represents a significant shortcoming (Arltová & Fedorová, 2016). To address this limitation, Philip Perron proposed an extension to the ADF test. The results of the Perron test (PP), presented in Table 2 (Panel B), are intended to complement and strengthen the findings of the ADF unit root test. Crucially, the PP test results entirely corroborate the variations observed in the earlier ADF findings, with the order of integration primarily fluctuating between I(0) and I(1), regardless of whether the model includes a constant or both a constant and trend. This reinforcement of our findings underscores our preference for using the ARDL technique for the objective of this study, as the most appropriate method to accommodate the mixed order of integration exhibited by the series under consideration. At this stage, the variables in the model are ready for the ARDL bounds cointegration tests, as presented in Table 2.

Table 2. Summary of stationarity results.

Panel A: ADF unit root test results					
	Level	**Prob.**	**1st Diff**	**Prob.**	**I(d)**
AELECT	-1.232	0.655	-3.176**	0.026	I(1)
ASF	-0.176	0.229	-3.776***	0.001	I(1)
FBS	-2.229	0.466	-8.258***	0.000	I(1)
CFDI	-8.998***	0.000	-8.361***	0.000	I(0)
UKFDI	-2.901*	0.050	-6.664***	0.000	I(1)
USFDI	-4.268***	0.001	-8.587***	0.000	I(0)
GOV	-2.674*	0.084	-2.913**	0.049	I(1)
GDPG	-1.465	0.545	-4.069***	0.002	I(1)
EXR	-0.234	0.928	-3.602***	0.005	I(0)
FID	-3.387**	0.015	-3.898***	0.003	I(0)
Panel B: Philip Perron unit root test results					
	Level	**Prob.**	**1st Diff**	**Prob.**	**I(d)**
AELECT	-1.998	0.287	-5.613***	0.000	I(1)
ASF	1.443	0.999	-18.845***	0.000	I(1)
FBS	-2.326	0.167	-8.289***	0.000	I(1)
CFDI	-9.043***	0.000	-56.193***	0.000	I(0)
UKFDI	-2.901*	0.050	-7.389***	0.000	I(1)
USFDI	-4.223***	0.001	-12.808***	0.000	I(0)
GOV	-3.250**	0.021	-5.571***	0.000	I(0)
GDPG	-1.263	0.642	-4.179***	0.001	I(1)
EXR	-0.121	0.942	-5.379***	0.000	I(1)
FID	-1.979	0.295	-3.981***	0.003	I(1)

Note: The exogenous lags are selected based on Schwarz info criteria while ****, **, * imply that the series is stationary at 1%, 5% and 10% respectively. DF-GLS represent Dickey-Fuller GLS. The null hypothesis for DF-GLS is that an observable time series is not stationary (i.e., has unit root).
Source: Extract from Eviews 12 Output.

Overall, the analysis revealed that the integration properties of the series fluctuated between I(0) and I(1), regardless of the unit root tests applied. This finding underscores the appropriateness of the ARDL technique, as it effectively accommodates the mixed order of integration observed in both infrastructural development and Chinese FDI variables, as well as other series under examination.

In Table 3, ARDL estimates were conducted for Chinese, United Kingdom, and United States FDI series from 2005 to 2023 using quarterly data. Initially, the models did not incorporate interaction with the institutional quality variable. Subsequently, estimates were recalculated to include this interaction, aiming to assess its impact on infrastructural development. Table 3 reported the results of the bound test, revealing that all F-statistics exceeded their respective critical values at the 5% significance level. This provided strong evidence of a long-run relationship between the dependent and explanatory variables.

Table 3. ARDL estimates.

Panel A: Bounds test cointegration Result				
Level of significance	**F-statistics**		**Lower bound I(0)**	**Upper bound I(1)**
10%	5.523		1.76	2.77
5%			1.98	3.04
1%			2.41	3.61
Panel B: Short-run estimates	**Coefficient**	**Std. Error**	**T-Stat.**	**Prob.**
Constant	25.391	11.554	2.198	0.035
$\Delta AELECT_{t-1}$	-0.391	0.105	-3.736	0.001
$\Delta CFDI_{t-1}$	-3.449	0.822	3.892	0.017
$\Delta CFDI * GOV_{t-1}$	2.966	0.811	3.637	0.000
$\Delta UKFDI_{t-1}$	13.478	2.974	4.531	0.000
$\Delta UKFDI * GOV_{t-1}$	11.909	2.646	4.501	0.000
$\Delta USFDI_{t-1}$	-16.349	3.282	-4.982	0.000
$\Delta USFDI * GOV_{t-1}$	-13.690	2.942	-4.652	0.000
ECM_{t-1}	-0.391	0.042	-9.333	0.000
Panel C: Long-run estimates				
CFDI	-0.166	0.033	-3.019	0.045

CFDI*GOV	8.817	0.584	3.579	0.003
UKFDI	7.582	5.385	1.408	0.168
UKFDI*GOV	34.455	11.099	3.104	0.004
USFDI	30.443	9.638	3.159	0.003
USFDI*GOV	-41.796	12.878	-3.245	0.003

Note: * represent sign of interaction of two variables.

Table 3 presents the ARDL estimates, focusing on Chinese Foreign Direct Investment (CFDI) in Nigeria, excluding interactions with institutional quality variables such as the government effectiveness index. Significant negative effects were observed on infrastructural development, specifically access to electricity (% of population). This outcome aligns with Ajakaiye and Oyeranti (2022) findings, suggesting that Chinese FDI in Nigeria has predominantly concentrated on the oil and gas sector, with limited positive spill-over effects on broader infrastructure, notably the electricity sector, exacerbated by inadequate government oversight and regulatory mechanisms. Moreover, Usman, Landry, and Kragelund (2021) underscored issues such as opaque bidding processes, corruption, and insufficient monitoring, which have plagued various Chinese infrastructure projects in Nigeria, resulting in cost overruns, delays, and substandard outcomes. These findings resonate with the results obtained from the analysis incorporating the interaction term of CFDI with the government effectiveness index (CFDI*GOV), consistent with previous empirical studies (Adegbite & Olayiwola, 2022; Onyekwena, Adamu, & Adekunle, 2021). Based on the signs, it indicates that government effectiveness has yet to reach the threshold where its impact can be felt, particularly in ensuring that Chinese FDI positively influences Nigeria's infrastructural development.

The series of United Kingdom Foreign Direct Investment (FDI) without interaction with the government effectiveness index (UKFDI) showed a positive association with infrastructural development in both the short run and long run, with statistical significance at the 5% level. According to the literature, FDI from the UK into Nigeria has traditionally focused on resource extraction; however, the broader sectoral distribution of investments has positively impacted infrastructure (Adegbite & Oyewo, 2021; Adeola & Ikhuoria, 2022). This finding is consistent with the outcome of UKFDI when interacting with the government effectiveness index (UKFDI*GOV), which also revealed a positive effect and statistical significance at the 5% level. The UK's aid programs and technical assistance have aimed at strengthening institutional capacity and regulatory frameworks in Nigeria's electricity sector (Adegbite, Oyewo, & Erin, 2022; Adekunle & Okoye, 2023). The findings further indicated that the short-run and long-run estimates for UKFDI and UKFDI*GOV were elastic, suggesting that any marginal change in government policies could significantly impact infrastructural development. This implies that the institutional mechanisms implemented by the government are capable of enforcing governance and attracting Foreign Direct Investment from the United Kingdom.

The current study estimated the impact of United States foreign direct investment (FDI) on infrastructural development in Nigeria, using access to electricity as a proxy, and revealed a negative and significant effect at the 5 percent level in both the short run and long run. However, the interaction of US FDI with the government effectiveness index (USFDI*GOV) showed a negative relationship, which was statistically significant in both the short run and long run. This finding suggests that the current governance structure has a negligible impact on the investment climate, particularly for investments originating from the United States. Furthermore, the results indicate that Nigeria continues to struggle with weak institutions rife with loopholes, and that despite changes in political regimes, the existing governance framework does not align with a favorable foreign investment climate. Essentially, the short-run and long-run results for USFDI*GOV demonstrated elastic estimates.

The coefficients of the Gross Domestic Product growth rate (GDPG) displayed a negative and statistically insignificant effect on infrastructural development in both the short and long term. Financial development, while exerting a positive but insignificant relationship with infrastructural development in both the short and long term. Furthermore, the negative coefficient for the exchange rate (EXR) suggests that increases in the exchange rate, typically in US dollars, tend to decrease infrastructural development in both the short and long term. Also, the consumer price index, which measures inflation, reveals a positive but insignificant impact on infrastructural development in Nigeria.

Table 4. Post estimation test.

Post-estimation results				
Adj. R^2	***F-statistics***	***Linearity test***	***Autocorrelation test***	***Heteroscedasticity test***
		Ramsey RESET	**LM test**	**ARCH**
0.777	0.523	2.942 (0.095)	0.217 (0.374)	0.799 (0.374)

Note: That probability values for the post-estimation test are in parentheses. * represent sign of interaction of two variables.

Table 4 presents the post-estimation results. The adjusted R-squared value indicates that the study's model explains approximately 77% of the total variation in infrastructural development, measured by access to electricity (% of population). The F-statistics for the joint significance of the independent variables are statistically significant, affirming the overall goodness of fit for the model. Additionally, the Ramsey RESET tests confirm the stability of the models, as the F-value and associated probability value for the ARDL model are insignificant, supporting the null hypothesis of linearity and correct model specification. However, the null hypothesis of autocorrelation is rejected for the social sustainability model. Consistent with earlier findings, the null hypothesis of heteroscedasticity is also rejected. This rejection indicates that the empirical estimates obtained from the models are predominantly efficient and robust for policy inference, even when Foreign Direct Investment is directed towards infrastructural development.

4.1. Robustness Check

Given the various measures of infrastructural development utilized in empirical literature, this study acknowledges these dynamics by incorporating alternative metrics such as access to improved sanitation facilities (percentage of the population) and fixed broadband subscriptions (per 100 people). The series for both access to improved sanitation facilities (ASF) and fixed broadband subscriptions (FBS) achieved stationarity at the first difference, with the other control variables exhibiting mixed orders of integration [I(0) and I(1)]. This prompted the selection of the ARDL bounds testing approach, alongside short-run and long-run estimates for the analysis. The model for ASF is presented in Tables 5.

Table 5 (Panels A1, A2, and A3) presents the results on the relationship between infrastructural development, measured by access to improved sanitation facilities (ASF), and foreign direct investment (FDI) from China, the United Kingdom, and the United States. Panel A1 indicates a strong long-term relationship among the variables, as evidenced by an F-statistic of 5.876892, which exceeds the critical values at both the lower and upper bounds. Further analysis reveals that FDI inflows from China and the United Kingdom have a positive and significant impact on infrastructural development, as measured by access to improved sanitation facilities in Nigeria, in both the short and long run. These findings are consistent with existing literature (Adegbite & Oyewo, 2021; Adeola & Ikhuoria, 2022). Conversely, FDI inflows from the United States, while positive, do not show a significant relationship with infrastructural development in Nigeria in either the short or long term. This limited impact of US FDI on access to improved sanitation facilities is supported by previous studies (Adegbite et al., 2022; Adeola, Okafor, & Adekunle, 2023; Usman et al., 2021). The Error Correction Model (ECM) coefficient of -0.569 suggests an average adjustment speed of approximately 56% towards equilibrium in the long run, should there be any short-run disequilibrium.

Table 5 (Panel B1, B2 & B3) presents the findings on the relationship between infrastructural development, represented by access to improved sanitation facilities (ASF), and foreign direct investment (FDI) from China, the United Kingdom, and the United States, with the moderating influence of the government effectiveness index (GOV) as an institutional quality indicator. Panel B1 reveals that the F-statistic of 5.770930 indicates a long-term relationship among infrastructural development, FDI inflows from China, the United Kingdom, and the USA, and the interaction with institutional quality. This conclusion is supported by the F-statistic exceeding the critical values at both the lower and upper bounds. Furthermore, FDI inflows from China, the UK, and the USA, when interacted with institutional quality, exhibit a negative effect on infrastructural development, as proxied by access to improved sanitation facilities in Nigeria, in both the short and long term.

Table 5. ARDL estimates infrastructural development, proxied by access to improved sanitation facilities.

Without quality institution interaction					***With quality institution interaction***				
Panel A1: Bounds test cointegration result					***Panel B1: Bounds test***				
Level of significance	**F-Stat.**		**Lower bound I(0)**	**Upper bound I(1)**	**Level of significance**	**F-Stat.**		**Lower bound I(0)**	**Upper bound I(1)**
10%	5.877		1.88	2.99	10%	5.771		1.88	2.99
5%			2.14	3.30	5%			2.14	3.30
1%			2.65	3.97	1%			2.65	3.97
Panel A2: Short run	***Coef.***	***Std. error***	***T-Stat.***	***Prob.***	***Panel B2: Short run***	***Coef.***	***Std. error***	***T-Stat.***	***Prob.***
ΔASF_{t-1}	-0.569	0.078	-7.317	0.000	ΔASF_{t-1}	-0.579	0.079	-7.268	0.000
$\Delta CFDI_{t-1}$	0.008	0.003	3.028	0.004	$\Delta CFDI * GOV_{t-1}$	-0.007	0.002	-2.911	0.005
$\Delta UKFDI_{t-1}$	9.598	3.780	2.537	0.015	$\Delta UKFDI * GOV_{t-1}$	-8.710	3.580	-2.436	0.019
$\Delta USFDI_{t-1}$	0.001	0.001	1.003	0.321	$\Delta USFDI * GOV_{t-1}$	-0.001	0.001	-1.103	0.276
CointEq(-1)	-0.569	0.068	-8.382	0.000	CointEq(-1)	-0.579	0.069	-8.307	0.000
Panel A3: Long run					***Panel B3: Long run***				
CFDI	0.015	0.005	3.107	0.003	CFDI*GOV	-0.013	0.004	-2.976	0.005
UKFDI	0.001	6.420	2.622	0.012	UKFDI*GOV	-0.001	5.950	-2.527	0.015
USFDI	0.002	0.001	1.037	0.305	USFDI*GOV	-0.002	0.001	-1.146	0.258

Note: * represent sign of interaction of two variables.

The series of Chinese FDI and UK FDI inflows are statistically significant, aligning with previous findings in the literature (Adegbite & Olayiwola, 2022; Onyekwena et al., 2021). Conversely, the inflows of FDI from the USA did not exhibit a significant relationship with infrastructural development, as measured by access to improved sanitation facilities in Nigeria, in either the short run or the long run. This outcome is consistent with the earlier findings presented in Table 6.6a, which indicate that US FDI inflows do not contribute to improving sanitation facilities in Nigeria (Adegbite et al., 2022; Adeola et al., 2023; Usman et al., 2021). The ECM coefficient value of -0.579567 suggests an average speed of adjustment strategy of approximately 57% to reach equilibrium in the long run if there is any disequilibrium in the short run.

Table 6. ARDL estimates for the model of infrastructural development proxied by fixed broadband subscriptions.

Without quality institution interaction					***With quality institution interaction***				
Panel C1: Bounds test cointegration result					***Panel D1: Bounds test***				
Level of significance	**F-Stat.**		**Lower bound I(0)**	**Upper bound I(1)**	**Level of significance**	**F-Stat.**		**Lower Bound I(0)**	**Upper Bound I(1)**
10% 5% 1%	8.782		1.88 2.14 2.65	2.99 3.30 3.97	10% 5% 1%	5.771		1.88 2.14 2.65	2.99 3.30 3.97
Panel C2: Short run	***Coef.***	***Std. Error***	***T-Stat.***	***Prob.***	***Panel D2: Short run***	***Coef.***	***Std. Error***	***T-Stat.***	***Prob.***
ΔFBS_{t-1}	-0.645	0.094	-6.846	0.000	ΔFBS_{t-1}	-0.662	0.098	-6.729	0.000
$\Delta CFDI_{t-1}$	-0.003	0.001	-3.224	0.004	$\Delta CFDI * GOV_{t-1}$	0.003	0.001	3.028	0.006
$\Delta UKFDI_{t-1}$	-1.130	3.750	-3.007	0.006	$\Delta UKFDI * GOV_{t-1}$	9.130	3.810	2.399	0.026
$\Delta USFDI_{t-1}$	-6.650	1.140	-5.829	0.000	$\Delta USFDI * GOV_{t-1}$	4.900	1.160	4.233	0.004
CointEq(-1)	-0.645	0.058	-11.124	0.000	CointEq(-1)	-0.662	0.064	-10.26	0.000
Panel C3: Long run					***Panel D3: Long run***				
CFDI	-0.005	0.001	-3.896	0.001	CFDI*GOV	0.005	0.001	3.258	0.004
UKFDI	-1.750	6.210	-2.813	0.010	UKFDI*GOV	1.380	5.930	2.325	0.030
USFDI	-0.001	1.880	-5.495	0.000	USFDI*GOV	7.400	1.680	4.406	0.002

Note: * represent sign of interaction of two variables.

Table 6 (Panel C1, C2, & C3) presents the results of the ARDL analysis examining the relationship between FDI inflows from China, the United Kingdom, and the USA, and infrastructural development, as indicated by fixed broadband subscriptions. The ARDL bounds test reveals that the F-statistic of 8.782167 exceeds the critical values at the 10%, 5%, and 1% significance levels, suggesting a long-term relationship among the variables under study. Furthermore, the coefficients for Chinese FDI (CFDI), UK FDI (UKFDI), and US FDI (USAFDI) indicate a significant negative impact on infrastructural development in Nigeria, both in the short and long run. These findings align with existing empirical studies (Adegbite et al., 2022; Adeola et al., 2023; Usman et al., 2021). Empirical evidence indicates that the majority of foreign direct investment (FDI) from China, the United Kingdom, and the United States has predominantly targeted sectors such as oil and gas, extractive industries, and manufacturing. There has been minimal investment in telecommunication infrastructure, which is crucial for the development of fixed broadband (Adeola & Ikhuoria, 2022). This shortfall can be largely attributed to policy inconsistencies, non-transparent licensing processes, and weak regulatory enforcement (Adegbite & Oyewo, 2021). The Error Correction Model (ECM) coefficient value of -0.645045 suggests that approximately 64% of the disequilibrium in the short run is adjusted in the long run.

Table 6 (Panels D1, D2, and D3) presents the results of the ARDL model analyzing the moderating effect of institutional quality on FDI inflows from China, the United Kingdom, and the USA, alongside infrastructural development proxied by fixed broadband subscriptions. The ARDL bounds test indicates the presence of a long-run relationship among the variables, as evidenced by the F-statistic of 7.374303, which exceeds the lower and upper critical bounds at the 10%, 5%, and 1% significance levels. The estimates for Chinese FDI (CFDI), UK FDI (UKFDI), and US FDI (USA) demonstrate a positive and significant impact on infrastructural development in Nigeria in both the short and long run, aligning with empirical findings in the literature (Adeola et al., 2023). These targeted investments have significantly contributed to the expansion of fixed broadband networks and increased access to high-speed internet services in Nigeria (Adegbite et al., 2022). The Error Correction Model (ECM) coefficient value of -0.645045 suggests an average adjustment speed of approximately 64%, indicating the system's ability to restore equilibrium in the long run following any short-run disequilibrium.

5. Conclusion

The findings reveal that FDI from China, the UK, and the US affects Nigeria's infrastructural development, particularly electricity access, in distinct ways. Chinese FDI has a significantly negative effect on electricity access, worsened by governance inefficiencies, while UK FDI consistently shows a positive impact, enhanced by effective governance. US FDI has a persistently negative influence, indicating weak institutional frameworks. Validation using sanitation facilities and broadband access highlights similar patterns: Chinese and UK FDIs positively affect sanitation access, but all three FDIs negatively influence broadband. However, with stronger institutional quality, all three FDIs significantly improve broadband development, underscoring the vital role of governance in maximizing FDI's infrastructure benefits.

To optimize the impact of foreign direct investment (FDI) on Nigeria's infrastructural development, several strategic actions are essential. First, strengthening governance structures by improving transparency and regulatory frameworks will not only reduce the negative effects seen from US FDI but also enhance the positive outcomes from

UK investments. Next, Nigeria should prioritize attracting targeted FDI in critical sectors like electricity, sanitation, and broadband, aligning policies to support sustainable growth. Building institutional capacity is also crucial—empowering regulators to manage infrastructure projects effectively and maximize FDI benefits. Encouraging public-private partnerships and fostering policy coherence across sectors will further amplify FDI's impact. Lastly, implementing robust monitoring and evaluation systems will ensure continuous insights into FDI performance, shaping future strategies for sustainable infrastructure growth. Together, these steps aim to create an investment-friendly environment that maximizes FDI's potential and drives long-term development in Nigeria.

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