Article

Brain Drain and Economic Development in Nigeria: Causal and Cointegration Analyses

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Abstract
This study examined the dynamic relationships between brain drain and economic development in Nigeria from 1990 to 2024, using the Autoregressive Distributed Lag (ARDL) model with the Granger causality framework, the study first tested the direction of influence among skilled emigration, financial inflows, human capital formation, and Nigeria's development trajectory. The causality results guided the choice of dependent and independent variables, after which the ARDL model captured both short-run adjustments and long-run equilibrium dynamics, offering clear insights into how these factors shape Nigeria's development path. Granger causality tests were first conducted to establish the direction of influence among the variables, which guided the specification of economic development as the dependent variable. The ARDL bounds test then confirmed long-run cointegration among the series. Findings showed that literacy rate exerted a consistently positive and significant effect on economic development in both the short and long run, underscoring the central role of human capital. Brain drain had a significantly negative long-run impact on economic development, indicating structural harm to the economic development, although the short-run effects were mixed. Remittances exhibited weak and delayed short-run impacts. In the long run, they were statistically insignificant, indicating limited developmental value without structured investment frameworks. The study calls for policy actions that encourage the retention and development of skilled labour, direct remittances into productive sectors, and enhance educational quality and access. Strengthening macroeconomic fundamentals is also essential to support sustained growth. These interventions are key to reducing the adverse effects of brain drain and maximising the developmental benefits of financial and human capital inflows.

Keywords:
Brain drain, remittances, economic development, human capital, ARDL model

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Introduction

The phenomenon of brain drain—the emigration of highly skilled and educated individuals from developing to developed countries—has emerged as a profound structural challenge facing many low- and middle-income nations, particularly in sub-Saharan Africa. Nigeria, Africa's most populous country and one of its largest economies, continues to witness an alarming exodus of professionals despite substantial investments in human capital through public education, scholarships, and professional training. According to the World Bank (2023), more than 40 per cent of Nigerian-trained medical doctors practise abroad. Similarly, the Nigerian Association of Resident Doctors (NARD) reported that over 2,000 health professionals emigrated in 2022 alone. Data from the United Nations Department of Economic and Social Affairs (UN DESA) show that the Nigerian diaspora grew from about 990,000 in 2010 to over 1.7 million by 2020, with a significant proportion consisting of university-educated and professionally skilled workers. This sustained outflow of talent raises urgent concerns for national development, labour productivity, institutional efficiency, and long-term economic resilience.

Although brain drain is often viewed as a rational individual response to socio-economic constraints—such as poor infrastructure, unemployment, insecurity, low remuneration, and political instability—its broader development implications are far more complex. Traditional approaches typically interpret brain drain as a one-directional loss, emphasising the erosion of technical expertise, declining service delivery, reduced innovation capacity, and institutional fragility (Tadesse, 2024). However, recent scholarship challenges this linear perspective, advancing a more dynamic and bi-directional interpretation. Underdevelopment, it is increasingly argued, does not merely result from brain drain; rather, it also acts as a powerful driver of it. The interplay between persistent socio-economic stagnation and skilled migration creates cumulative feedback loops that deepen the very conditions from which migration emerges, thereby entrenching structural inequalities over time (Mwangi, 2023a; Asante, 2024a).

To examine this complex dynamic, the present study adopts the Cumulative Causation Theory of Migration as its guiding framework. Originally formulated by Gunnar Myrdal (1957), the theory posits that migration and development are mutually reinforcing processes shaped by self-perpetuating cycles of cumulative causality. Within the Nigerian context, this framework provides a compelling lens through which to analyse how skilled migration both reflects and intensifies developmental bottlenecks (Letta *et al*., 2024). While brain drain depletes the stock of human capital, undermines public sector efficiency, and places fiscal strain on essential services such as

education and healthcare, persistent underdevelopment—manifested in chronic underemployment, inflationary pressures, weak public institutions, and limited professional advancement opportunities—remains a powerful push factor for the emigration of the country's most skilled individuals (Eberechukwu & Boris, 2023a; Mensah & Adeola, 2024). At the same time, the theory recognises the potential for positive feedback, such as the inflow of remittances—estimated at over US$24.05 billion in 2023 by the Central Bank of Nigeria—diaspora-led investment, transnational knowledge transfer, and the establishment of global professional linkages that may generate developmental dividends under conducive institutional conditions.

Despite these potential opportunities, Nigeria continues to experience the relentless outflow of its most skilled citizens, often described as a silent but systemic haemorrhage of human capital. Although migrant remittances contributed over US$24.5 billion to Nigeria's economy in 2023 (Central Bank of Nigeria, 2024), these inflows offer only partial compensation for the long-term erosion of technical capacity and institutional resilience across critical sectors. The healthcare system, for instance, continues to lose hundreds of trained professionals annually, with estimates indicating that over 45 per cent of Nigerian-trained medical doctors were practising abroad as of 2024 (World Bank, 2024), while academic and IT sectors face mounting shortages of expertise.

What remains especially troubling is the unresolved empirical ambiguity surrounding the direction of causality between brain drain and economic development. It is unclear whether deteriorating socio-economic conditions primarily drive skilled emigration, or whether the cumulative loss of talent itself acts as a catalyst for economic stagnation. This lack of analytical clarity hampers policy effectiveness, with responses often defaulting to reactive containment rather than addressing the root institutional, fiscal, and political drivers of emigration. By framing brain drain merely as an outcome of underdevelopment, existing scholarship frequently overlooks the feedback dynamics that transform it into a reinforcing agent of decline. This theoretical and methodological limitation has constrained the evidence base for sustainable human capital policies and obscured opportunities to harness diaspora potential through structured remittance investment, skill repatriation, and global collaboration.

Given the scale, persistence, and strategic implications of skilled emigration from Nigeria, it is imperative to interrogate the bi-directional causal relationship between brain drain and economic development. An empirically grounded, theoretically robust inquiry is needed to capture the cyclical interplay between these phenomena. Without such insight, Nigeria risks continuing to view brain drain as an irreversible national loss rather than as a complex and potentially convertible challenge—one that, if effectively managed, could be redirected toward national regeneration through deliberate

diaspora engagement, institutional reform, and long-term development planning.

Although migration and brain drain have attracted considerable scholarly attention, several gaps remain. Much of the literature relies on outdated datasets (e.g., Farhan, 2017; Narcisse & Cha'ngom, 2020) that predate critical developments such as the COVID-19 pandemic and subsequent economic disruptions. Numerous studies also concentrate on foreign contexts—including Ghana (Asante, 2024b), Kenya (Mwangi, 2023b), and Eastern Europe (Rybak & Novak, 2023)—whose socio-political conditions differ markedly from Nigeria's, limiting the applicability of their findings. Others employ narrow econometric approaches, relying heavily on Ordinary Least Squares (e.g., Akinola & Adekile, 2024; Farhan, 2017), which may be inadequate to capture complex feedback mechanisms or address endogeneity issues inherent in the relationship between brain drain and economic development. More advanced techniques, such as vector error correction models, remain underutilised despite their ability to capture long-run causal dynamics. Furthermore, most existing research emphasises direct outcomes, such as remittance inflows or GDP contributions, while relatively few examine the cyclical causality between brain drain and economic development in Nigeria.

It is against this backdrop that the present study sets out to address two central objectives: first, to investigate the impact of brain drain on Nigeria's economic growth; and second, to examine whether there exists a Granger causal relationship between brain drain and economic development. In pursuing these objectives, the study seeks to advance a more comprehensive and policy-relevant understanding of the bi-directional dynamics linking skilled migration and national development.

Literature Review

Theoretical Framework

The Cumulative Causation Theory of Migration

The Cumulative Causation Theory of Migration, advanced by Gunnar Myrdal (1957), conceptualises migration as a self-reinforcing process driven by structural inequalities. Skilled emigration—particularly brain drain—emerges as both a consequence and a catalyst of underdevelopment. In Nigeria, the departure of professionals in healthcare, education, and technology weakens institutional capacity, reduces productivity, and undermines public service delivery. These deficits, in turn, exacerbate unemployment, insecurity, and poor governance, further stimulating outward migration.

This cumulative process entrenches structural disparities, trapping sending countries in cycles of stagnation (Letta *et al*., 2024; Ihezie *et al*., 2025). However, the theory also acknowledges positive feedback effects, including remittances, diaspora investment, and transnational knowledge transfer. In Nigeria, the diaspora has begun to contribute significantly in fintech, education, and healthcare—revealing developmental opportunities contingent on institutional reform and coherent policy frameworks (Akaeze *et al*., 2025). Accordingly, the theory underpins the adoption of a bi-directional empirical model in this study to examine how brain drain both influences and is influenced by economic development. By highlighting reciprocal causality, it clarifies why conventional, reactive policies have failed to curb skilled migration and redefines migration not merely as a developmental threat, but as a potential driver of transformation—if effectively harnessed through sound governance, strategic planning, and institutional renewal.

Empirical Literature

Migration and brain drain are significant forces shaping socio-economic development in Nigeria, Sub-Saharan Africa, and parts of Europe, linking human mobility to economic and institutional change. Across Nigeria and the wider region, poverty, insecurity, and weak governance drive skilled professionals abroad, draining critical sectors such as health and education. Similar trends appear across the African continent, where economic stagnation and political turmoil fuel talent migration. This study reviews recent empirical research exploring these dynamics. Eberechukwu and Boris (2023b) investigated the impact of migration on Nigeria's socio-economic development between 2015 and 2021, applying Relative Deprivation Theory. They argued that poverty is a primary driver pushing Nigerians to seek opportunities in developed nations, a trend exacerbated by worsening security and political conditions at home. Their findings underscored significant losses of skilled professionals who might otherwise contribute to national transformation. Similarly, Oyegoke and Amali (2022) assessed the role of international labour migration and remittances in Nigeria's economic development from 1977 to 2021. Drawing on annual time-series data, they concluded that both migration and remittances had a significantly positive effect on Nigeria's economic growth during the study period.

Ojiugo et al. (2021) examined the relationship between brain drain and sustainable development in Nigeria. Using the push-pull theory of migration, they found that socio-economic hardships strongly propel migration, while opportunities abroad—the so-called "greener pastures"—act as powerful pull factors for Nigerian professionals. Relying on secondary data, they revealed that sustained emigration of health and education professionals undermines Nigeria's capacity for effective service delivery, particularly in healthcare. John et al. (2020) studied migration and diaspora remittances using macroeconomic indicators and Ordinary Least Squares (OLS) analysis. They

identified a significant relationship between total remittances and Nigeria's GDP, although migration itself showed an insignificant direct effect on GDP growth.

Ogbenika (2019) presented a qualitative review demonstrating how brain drain and migration impede Nigeria's development. The author argued that the large-scale emigration of skilled professionals undermines national progress, fuelled by corruption, rising unemployment, and economic hardship. The study concluded that sustainable development cannot be achieved without effectively addressing this trend. Akinola and Adekile (2024) similarly analysed the effects of brain drain and unemployment on Nigeria's economic growth using OLS techniques. They identified low remuneration as a major cause of brain drain, which, alongside unemployment, negatively affects economic performance. The authors emphasised that the departure of skilled professionals poses a severe risk to Nigeria's development, and highlighted the moderating role of unemployment in the relationship between brain drain and economic growth.

Beyond Nigeria, several studies extend this discourse. Asante (2024a) explored the bi-directional relationship between brain drain and economic development in Ghana. Applying Cumulative Causation Theory, he found that skilled emigration depletes national human capital yet offers potential benefits through remittances and knowledge transfers. Time-series data from 1990 to 2022 indicated that economic stagnation fuels emigration, while remittances provide only modest support to GDP growth. Nonetheless, the net effect remained negative, particularly in health and education, prompting calls for stronger diaspora engagement and retention policies. Also, Mwangi (2023b) conducted a parallel study in Kenya, revealing that the outflow of healthcare professionals strained domestic services, although remittances helped sustain household incomes and macroeconomic stability. Political instability and youth unemployment emerged as critical push factors. Mwangi recommended reforms to wage structures, improved professional recognition, and greater use of diaspora networks for knowledge transfer.

Tadesse (2024b) documented Ethiopia's paradoxical experience with brain drain. While emigration weakened the health system, it simultaneously increased remittances and diaspora-led investment. His vector autoregression analysis showed that emigration peaks during political crises, with remittances boosting household consumption but failing to generate long-term economic growth. The study underscored the need for policies that both harness diaspora contributions and improve domestic working conditions. Moreover, Nakanwagi (2025) analysed brain drain's impact in Uganda, describing a feedback loop where emigration worsens service deficits while remittances partially alleviate fiscal constraints. She recommended expanding career

pathways and fostering transnational research collaborations. Diop (2024) examined Senegal's brain drain, finding that while remittances sustain household consumption, the loss of technical expertise hampers progress in health, education, and ICT sectors. Diop called for balanced policies combining diaspora engagement with domestic reforms.

Mukamana (2023), also using Cumulative Causation Theory, found that remittance inflows help reduce poverty in Rwanda, though professional emigration weakens institutional capacity. She advocated for domestic reforms and targeted diaspora investment strategies. Mwakalobo (2025) examined Tanzania's experience, finding that while remittances support household consumption and small businesses, persistent human capital losses in healthcare and education create a cycle in which underdevelopment fuels further migration. He stressed improving local working conditions and governance. Chanda (2024) employed time-series econometrics, showing that economic underperformance triggers skilled migration, while remittances modestly support GDP. He concluded that despite the benefits of remittances, brain drain results in a net loss of technical capacity and innovation, requiring targeted policy interventions.

Benabdallah (2025) further confirmed that while remittances help stabilise macroeconomic indicators, persistent losses of skilled labour hinder progress in sectors like ICT and healthcare. His recommendations focused on improving local employment prospects and promoting diaspora return programmes.

Narcisse and Cha'ngom (2020) evaluated brain drain's net economic impact across Africa between 1990 and 2015 using a development accounting framework. They found the continent overall to be a net loser from brain drain, though losses have been declining over time. Regionally, Sub-Saharan Africa remained a net loser, while North Africa shifted from losses to gains. Importantly, factoring in migrants' welfare significantly alters the net impact, suggesting that between 69% and 85% of African countries could become net winners when migrant well-being is considered. Mohamed, Amer, and Fattah (2024) analysed brain drain across 140 developing countries from 2007 to 2022 using a two-way fixed effects model. They observed that brain drain positively affects economic growth in many contexts, particularly in low-income countries, thanks to remittances and talent migration. However, they cautioned that the externalities of brain drain can have negative consequences, underscoring the crucial role of remittances in balancing these effects.

Farhan (2017) assessed brain drain's impact on Pakistan's economy between 1980 and 2016, employing OLS estimation. The results showed a significant negative relationship between brain drain and economic growth, although he noted that other economic factors beyond migration also shape growth dynamics. Fedderke and Dong (2024) examined emigration and productivity growth in South Africa using a vector error correction model. They confirmed a bi-directional relationship: emigration impedes productivity growth, which, in turn, can reduce emigration rates. Their robustness tests

supported the use of simultaneous equation estimation to analyse this complex link.

In Europe, Rybak and Novak (2023) studied the bi-directional relationship between skilled migration and economic development in Eastern European countries since the early 2000s. Their panel vector autoregression analysis revealed that brain drain initially undermines domestic productivity and innovation but can produce medium-term "brain gain" effects through remittances, knowledge transfers, and return migration. EU membership appeared to mitigate negative impacts through policy harmonisation and labour mobility. Rémy (2023) focused on Haiti, particularly rural communities, showing how emigration deprives regions of educated human resources, intensifying underdevelopment. His community-based research revealed strong push factors in the local economy and called for tailored interventions to stem talent outflows. Mishra and Khan (2022) analysed South Asia between 1995 and 2021, finding that skilled migration reduces domestic productivity and tax revenue in the short term. However, remittances play a crucial role in macroeconomic stabilisation. They confirmed a bi-directional relationship whereby economic instability fuels brain drain, which, in turn, worsens macroeconomic vulnerabilities. Fernandez and Vargas (2022) examined Latin America, showing that brain drain diminishes domestic innovation capacity, though robust institutions and diaspora engagement can transform emigration into an asset via knowledge spillovers and entrepreneurship. Also, Al-Maadeed and Khaled (2021) studied the Middle East, demonstrating that brain drain reduces economic diversification and heightens vulnerability to volatile sectors such as oil. Conversely, proactive diaspora policies help mitigate losses through remittances and entrepreneurial activity.

Batyrov and Erkin (2023) examined Central Asia, showing how skilled migration erodes institutional effectiveness while weak institutions further drive emigration. Nonetheless, diaspora networks can contribute to governance improvements when based on trusted partnerships. Hidalgo and Schwartz (2024) analysed global trends excluding Africa, finding that brain drain hinders progress toward Sustainable Development Goals (SDGs) by diminishing health workforce capacity, educational attainment, and innovation. However, remittances and transnational networks offer potential long-term benefits, suggesting that migration can be a tool for development if properly managed.

Jawaria and Blackwell (2021) focused on Europe, highlighting that academic brain drain is increasingly problematic, particularly in light of Europe's ageing population. Synthesising qualitative literature from 2000 to 2020, they identified drivers such as better salaries abroad, insecure short-term contracts, unfair recruitment processes, favourable migration policies, and internationalisation strategies that inadvertently encourage permanent

emigration. Finally, Woosik (2021) explored how brain drain affects economic growth through total factor productivity. Using panel data, he found that middle-income and rapidly growing economies experience higher rates of brain drain, which, despite initial losses, can enhance productivity through knowledge sharing and technology transfer—a phenomenon termed "brain circulation." He recommended policies to leverage overseas talent alongside domestic retention efforts. In summary, although these studies offer valuable insights, their findings remain mixed and at times contradictory, reflecting differences in methodologies and theoretical perspectives. Much existing empirical evidence relies on outdated data or originates from contexts outside Nigeria, where political, economic, and environmental conditions differ significantly. Accordingly, there is a strong imperative for new, Nigeria-specific empirical research to clarify these relationships with greater precision and relevance.

Methodology

Model specification

Based on the theoretical review and empirical consideration, the following model was used in this work: The relationship between the variables of interest is presented in the following form:

Mathematically, the model is expressed as follows;

$$RGDP = f(BD, REM, HC, FDI, EXR, INF) \text{ ---------- (1)}$$

The explicit estimable econometric, equation (i) is written as:

$$\text{R}GDP_t = \beta_0 + \beta_1 BD_t + \beta_2 REM_t + \beta_3 HC_t + \beta_4 FDI_t + \beta_5 EXR_t + \beta_6 INF_t + \varepsilon_t \text{ ------ (2)}$$

Where:

$RGDP_t$= Economic development proxy (RGDP a at time *t*)
BD_t= Brain drain (e.g., % Skilled Migrants (Estimate)
REM_t= Remittances (US$ inflow from diaspora)
HC_t= Human capital index (e.g., literacy rate)
FDI_t= Foreign direct investment (as % of GDP)
EXR_t= Naira/USD annual average.
INF_t= Inflation rate
ϵ_t= Error term

Explicit ARDL Model Specification

The Autoregressive Distribution Lag (ARDL) model based on equation (ii) is given as:

$$RGDP_t = \alpha_0 + \sum_{i=i}^{p} \beta_i RGDP_{t-i} + \sum_{j=0}^{q_1} \gamma_j BD_{t-j} + \sum_{k=0}^{q_2} \delta_k REM_{t-k} + \sum_{l=0}^{q_3} \phi_l LTR_{t-k} + \sum_{m=0}^{q_4} \theta_m FDI_{t-m} + \sum_{n=0}^{q_5} \vartheta_n EXR_{t-n} + \sum_{o=0}^{q_6} \tau_o INF_{t-o} + \varepsilon_t \text{ ---------(3)}$$

Where; α_0 =Intercept term; while β_1, γ_i, δ_k, ϕ_l, θ_m, ϑ_n, τ_0, = coefficient of respective lagged variables. ε_t =error term; $p, q_1, \text{----------} q_6$ = optimal lag lengths determined using AIC or SBC.

Error Correction Representation of ARDL model (ECM)
Since the cointegration was established via the Bounds Test, the ECM version of the ARDL model=

$$\Delta RGDP_t = \alpha_0 + \sum_{i=1}^{p-1}\beta_i \Delta RGDP_{t-i} + \sum_{j=0}^{q_1-1}\gamma_j \Delta BD_{t-j} + \sum_{k=0}^{q_2-1}\delta_k \Delta REM_{t-k} + \sum_{l=0}^{q_3-1}\phi_l \Delta LTR_{t-l} + \sum_{m=0}^{q_4-1}\theta_m \Delta FDI_{t-m} + \sum_{n=0}^{q_5-1}\vartheta_n \Delta EXR_{t-n} + \sum_{r=0}^{q_6-1}\eta_r \Delta INF_{t-r} + \lambda ECT_{t-1} + \mu_t \quad \text{------(4)}$$

Where; Δ = first difference generation; ECT_{t-1} = lagged error correction term from the long-run model; λ =speed of adjustment coefficient (expected to be negative and statistically significant).
μ_t = white noise disturbance term.

A-Priori Expectations

Hence, the a-priori expectations for equation (ii) are: $\beta_1<0$, $\beta_2>0$, $\beta_3>0$, $\beta_4>0$, $\beta_5<0$.

Table 1: A-Priori Expectations

Variable	Coefficient	Expected Sign	Economic Rationale
Brain Drain	β_1	Negative (–)	Loss of skilled labour reduces productivity and growth.
Remittances	β_2	Positive (+)	Supports consumption, investment, and GDP growth.
Human Capital	β_3	Positive (+)	Enhances productivity and fosters economic development.
FDI	β_4	Positive (+)	Brings capital, technology, and employment.
Exchange Rate	β_5	Ambiguous (±)	Depending on how currency movements influence the economy
Inflation	B_6	Negative (–)	Causes macroeconomic instability and discourages investment.

Source: Researcher's Compilation (2025)

Data and Sources

The study draws on annual data from the World Bank, NBS, and the Central Bank of Nigeria. It focused on national-level data covering the period from 1990 to 2024. However, the analysis was capped at 2024 to ensure the inclusion of the most recent and comprehensive information available, thereby providing a relevant and up-to-date basis for examining the nexus between brain drain and Nigeria's economic growth.

Results and Discussion

Descriptive Statistics

Table 2: Descriptive Statistics

	RGDP	BD	REM	LTR	INF	FDI	EXR
Mean	4.237	37.363	10356.86	60.479	121.646	1.258	110.331
Median	4.196	38.800	14640.08	61.000	70.016	1.197	100.631
Maximum	15.329	44.800	23809.28	70.000	421.071	2.900	273.009
Minimum	-2.035	0.357	10.009	51.080	2.414	-0.039	49.776
Std. Dev.	3.846	8.112	9619.588	3.799	126.048	0.857	47.550
Skewness	0.516	-2.737	0.009	-0.221	1.140	0.201	1.789
Kurtosis	3.600	13.336	1.096	3.198	3.101	1.854	6.453
Jarque-Bera	2.079	199.483	5.287	0.341	7.602	2.150	36.066
Probability	0.353	0.000	0.071	0.843	0.022	0.341	0.000
Sum	148.295	1307.657	362490.1	2116.780	4257.594	44.033	3861.570
Sum Sq. Dev.	502.872	2237.542	3.15E+09	490.746	540199.1	24.967	76874.56
Obs	35	35	35	35	35	35	35

Source: Researcher's Compilation, (2025) from E-views-9

Table 2 presents the descriptive statistics for seven variables across 35 observations, highlighting their central tendencies, dispersion, and distributional characteristics. REM recorded the highest mean (10,356.86) and variability (Std. Dev. = 9,619.59), whereas FDI had the lowest mean (1.258) with relatively moderate dispersion (Std. Dev. = 0.857). The skewness analysis revealed that BD was highly negatively skewed (–2.74), indicating a long-left tail, while INF and EXR were positively skewed, suggesting long right tails in their distributions. The Jarque-Bera test confirmed significant departures from normality in BD (p = 0.000), INF (p = 0.022), and EXR (p = 0.000), while RGDP, LTR, and FDI were approximately normally distributed at the 5% significance level. The widest ranges were observed in INF and REM, whereas LTR remained relatively stable over the period. Overall, the data indicate considerable disparities, particularly in remittance inflows and inflation levels.

Correlation Analysis

Table 3: Correlation Analysis

	RGDP	BD	REM	LTR	INF	FDI	EXR
RGDP	1	-0.407	-0.133	0.045	-0.219	0.328	-0.209
BD	-0.407	1	0.687	0.309	0.601	-0.286	0.124
REM	-0.133	0.687	1	0.352	0.774	-0.274	0.053
LTR	0.045	0.309	0.352	1	0.476	-0.223	0.101
INF	-0.219	0.601	0.774	0.476	1	-0.535	0.132
FDI	0.328	-0.286	-0.274	-0.223	-0.532	1	-0.623
EXR	-0.209	0.124	0.053	0.101	0.132	-0.623	1

Source: Researcher's Compilation (2025) from E-views-9

The correlation matrix in Table 3 underscores significant macroeconomic relationships. Foreign Direct Investment (FDI) exhibited a strong negative correlation with the exchange rate (EXR) (-0.623) and a moderate negative correlation with inflation (INF) (-0.535), suggesting that exchange rate volatility and rising inflation may discourage foreign capital inflows. Remittances (REM) showed strong positive correlations with both inflation (0.774) and the budget deficit (BD) (0.687), implying that increased remittance inflows may be associated with inflationary pressures and fiscal imbalances. A moderate positive correlation between REM and literacy rate (LTR) (0.352) indicates that higher literacy levels may facilitate greater remittance flows. BD was negatively correlated with real GDP (RGDP) (-0.407), suggesting a potential adverse impact of fiscal deficits on economic performance. Overall, inflation, remittances, and exchange rate dynamics appear to play a central role in shaping the macroeconomic environment.

Results of Unit Root Test

Table 4: Results of Unit Root Test at level and 1st deference

Variable	Test Statistic	5% critical Value	Remark	S/N	Test Statistic	5% critical value	Remark	S/N
RGDP	-3.805	-2.951	I(0)	S	-9.657	-2.954	I(1)	S
BD	-3.589	-2.951	I(0)	NS	-9.626	-2.954	I(0)	S
REM	-0.899	-2.951	I(0)	NS	-5.657	-2.954	I(1)	S
LTR	-3.914	-2.954	I(0)	S	-6.052	-2.960	I(1)	S
INF	4.316	-2.957	I(0)	NS	-4.232	-2.954	I(0)	S
FDI	-2.244	-2.951	I(0)	NS	-7.113	-2.954	I(0)	S
EXR	-2.669	-2.951	I(0)	NS	-5.538	-2.954	I(0)	S

Source: Researcher's Compilation (2025) from E-views-9

Table 4 presents the unit root test results for seven variables at both levels and first differences. A variable is considered stationary (S) if its test statistic is less than the 5% critical value; otherwise, it is deemed non-stationary (NS). At level, only RGDP and LTR were found to be stationary, while variables such as REM, INF, FDI, and EXR were non-stationary, indicating mixed integration orders. However, after first differencing, most variables achieved stationarity, confirming that they are integrated of order one, I(1). Notably, BD, INF, FDI, and EXR attained stationarity either at level or after first differencing, further reinforcing the presence of a combination of I(0) and I(1) variables. Given this mix of integration levels, the Autoregressive Distributed Lag (ARDL) Bounds Testing approach is considered the most suitable estimation technique. ARDL is well-suited for datasets with a combination of I(0) and I(1) variables,

performs effectively with small sample sizes, and provides robust estimates of both short-run dynamics and long-run equilibrium relationships.

Analysis of Empirical Results and Interpretation

Table 5: The Empirical Result of ARDL Bound Test

F-statistic	4.179	
% critical levels	Critical value for Bound test	
Significance	1(0) Bound	1(1) Bound
10%	2.12	3.23
5%	2.45	3.61
2.5%	2.75	3.99
1%	3.15	4.44

Source: Researcher's Compilation, (2025) from E-views-9

The ARDL bounds test result, as presented in Table 4.5, reported an F-statistic of 4.179, which exceeded the 5% and 2.5% upper bound critical values of 3.61 and 3.99, respectively. However, it falls slightly below the 1% upper bound of 4.44. Based on this, the null hypothesis of no cointegration is rejected at the 5% and 2.5% significance levels, confirming the existence of a long-run equilibrium relationship among the variables. This result implies that despite potential short-term fluctuations, the variables tend to move together in the long term. The rejection of the null hypothesis validates the suitability of the ARDL model for estimating both short-run dynamics and long-run relationships among the selected variables.

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Table 6: Regression Results: Brain Drain and Economic Development

Dependent Variable: RGDP				
Method: Autoregressive Distributed Lags (ARDL) (2, 3, 3, 3, 3, 3, 3)				
Variables	Coefficient	Std. Error	t-Statistic	Prob.
Short Run Estimate				
D(RGDP(-1))	-0.225	0.317	-0.708	0.511
D(REM)	0.000	0.000	1.086	0.327
D(REM(-1))	0.001	0.000	2.381	0.063
D(REM(-2))	-0.000	0.000	-0.739	0.493
D(LTR)	0.712	0.282	2.522	0.053
D(LTR(-1))	-0.372	0.215	-1.734	0.143
D(LTR(-2))	-0.319	0.153	-2.077	0.092
D(INF)	0.038	0.057	0.664	0.536
D(INF)	-0.185	0.1486	-1.247	0.268
D(INF)	0.3193	0.202	1.582	0.175
D(FDI)	0.111	1.709	0.065	0.950

D(FDI(-1))	-2.535	0.881	-2.877	0.035
D(FDI(-2))	-1.586	0.933	-1.701	0.149
D(EXR)	0.013	0.019	0.705	0.512
D(EXR(-1))	-0.022	0.013	-1.703	0.149
D(EXR(-2))	-0.038	0.013	-3.002	0.030
D(BD)	-0.364	0.059	-6.162	0.002
D(BD(-1))	-0.012	0.183	-0.064	0.951
D(BD(-2))	0.096	0.094	1.023	0.353
CointEq(-1)	-0.666	0.404	-1.647	0.160
Long Run Coefficients				
Variables	Coefficient	Std. Error	t-Statistic	Prob.
REM	0.000	0.000	1.266	0.261
LTR	1.303	0.364	3.578	0.016
INF	-0.062	0.078	-0.797	0.462
FDI	5.582	3.218	1.735	0.143
EXR	0.081	0.044	1.851	0.124
BD	-1.037	0.367	-2.823	0.037
C	-57.768	25.408	-2.274	0.072
$\mathbf{R^2}$: 0.977 DW* 2.86				

Source: Researcher's Compilation (2025) from E-views-9

Table 6 presents the empirical findings of the Autoregressive Distributed Lag (ARDL) model, which explores the dynamic relationship between brain drain—proxied by the percentage of skilled migrants—labour training, key macroeconomic fundamentals, and economic development in Nigeria. Real Gross Domestic Product (RGDP) was specified as the dependent variable. The ARDL methodology proves particularly apt for this analysis, as it captures both short-run fluctuations and long-run equilibrium dynamics, thereby providing a nuanced understanding of how these variables interact over time. In the short run, several noteworthy relationships emerged. The literacy rate (LTR) exhibited a statistically significant and positive contemporaneous effect on economic development, with a first-difference coefficient of 0.712 ($p = 0.053$), suggesting that improvements in human capital meaningfully contribute to short-term output growth. However, the lagged values of LTR were negative and only weakly significant, potentially indicating adjustment costs or diminishing marginal returns associated with successive increases in literacy over time.

The empirical findings revealed that brain drain (BD), proxied by the percentage of skilled migrants, exhibited a weak and mixed short-run influence on economic development, as the lagged effect of BD at one period [BD(–1)], although marginally significant (coefficient = 0.001, $p = 0.063$), suggested a

delayed and minimal positive association; however, both the contemporaneous and second-lag coefficients were statistically insignificant, thereby indicating that the immediate or extended short-run effects of skilled emigration did not substantially alter domestic economic output. From an a-priori theoretical standpoint, the expectation was that $\beta_1 < 0$, which implied that an increase in brain drain should depress economic development, as this position was premised on the assumption that the emigration of skilled labour diminished human capital accumulation—an essential engine of growth due to its critical roles in innovation, entrepreneurship, public service delivery, and productivity.

This finding aligned with the results of Ezenwa and Nwachukwu (2020), Bello and Akinbode (2020), Ogunleye and Owolabi (2021), Adebayo and Olayemi (2022), and Adepoju and Ayinde (2023), all of whom found weak or lagged short-run effects of brain drain on economic development in Nigeria; however, it contradicted the findings of Okonjo and Yusuf (2022), Chukwuma *et al*. (2023), and Obi and Onyekwere (2024), who reported strong and immediate negative effects. Moreover, in developing economies such as Nigeria, where skill-intensive sectors like healthcare, education, ICT, and research were already constrained, the continued loss of high-skilled professionals was expected to aggravate existing development challenges. Nevertheless, the marginal short-run significance and the absence of robust contemporaneous negative effects might have been attributed to certain offsetting mechanisms, including remittance inflows, which often enhanced household consumption, access to education, and investment capacity; diaspora knowledge transfers and potential return migration, which might have injected innovation and expertise into the domestic economy; and global networks, which could have facilitated trade, foreign direct investment (FDI), and broader institutional exposure. However, these benefits, though notable, were frequently insufficient to fully compensate for the structural loss of local expertise, institutional capacity, and national leadership, particularly when skilled emigration became systemic, persistent, and irreversible, thereby weakening the country's long-term development prospects.

Similarly, remittances (REM) exhibited mixed short-run dynamics. Although the first lag of remittances [REM(–1)] was marginally significant (coefficient = 0.001, $p = 0.063$), both the contemporaneous and second-lag coefficients were statistically insignificant. This outcome implies that remittance inflows do not generate immediate output gains. From an a-priori theoretical standpoint, the expectation that $\beta2>0\backslash beta\_2 > 0\beta2>0$ suggests a positive relationship between remittances and economic development. This is grounded in the notion that remittances enhance household income, ease liquidity constraints, and provide alternative financing for consumption smoothing, human capital investment, entrepreneurial activities, and local infrastructure—especially in developing economies like Nigeria. However, the marginal and delayed significance of REM in this study indicates that although remittances may eventually support development, their short-run effects are

limited. This subdued impact likely stems from the dominant use of remittances for non-productive purposes, including housing construction, ceremonial spending, and subsistence consumption.

This finding aligns with the empirical results of Okonkwo and Okafor (2020), Olabisi and Ajayi (2021), Ibrahim and Usman (2022), Oni and Abiola (2022), and Ishola and Akintoye (2023), who also reported that remittance inflows in Nigeria tend to exert weak or delayed effects on economic growth. These studies emphasise that without targeted policies or financial instruments to channel remittances into productive sectors, their developmental benefits remain muted in the short term. In contrast, this outcome diverges from the conclusions of Chukwu and Agu (2021), Amoo and Kehinde (2022), and Olawale and Dada (2023), who documented significant and immediate growth-enhancing effects of remittances, citing improved household liquidity, investment in micro-enterprises, and the presence of multiplier effects across local economies. Moreover, foreign direct investment (FDI) exhibited an unexpectedly negative and statistically significant effect in the short run, with FDI(–1) bearing a coefficient of –2.535 (p = 0.035). This may indicate that recent inflows displaced domestic investment or failed to integrate effectively into the local economy, thereby exerting contractionary pressures on output.

Similarly, the exchange rate (EXR) exerted adverse short-run effects, with EXR(–2) significantly negative (coefficient = –0.038, p = 0.030), reflecting the inflationary and uncertain consequences of currency depreciation, which likely undermined short-term economic activity. Further, brain drain (BD) displayed a consistent and robust contractionary influence, with its contemporaneous coefficient significantly negative (–0.364, p = 0.002), emphasising the adverse short-term consequences of skilled labour migration—especially where it results in talent shortages, reduced productivity, and weakened innovation capacity within the domestic economy. Conversely, inflation (INF) was statistically insignificant across all short-run lags, suggesting that variations in the price level did not exert any immediate or discernible impact on output during the observation period. Although the error correction term, CointEq (–1), bore the expected negative sign (–0.666), it was statistically insignificant (p = 0.160), indicating a weak and slow speed of adjustment to the long-run equilibrium following short-term deviations.

In the long run, more coherent structural relationships became evident. Literacy rate (LTR) continued to exert a positive and statistically significant effect on economic development (coefficient = 1.303, p = 0.016), reaffirming the centrality of sustained investments in human capital as a catalyst for long-term productivity and growth In the long run, brain drain (BD) maintained a negative and statistically significant impact on output (coefficient = –1.037, $p = 0.037$), underscoring the detrimental consequences of sustained human

capital flight—particularly through the erosion of the domestic skills base, diminished productivity, and weakened innovation potential. This result aligns with the *a priori* expectation ($\beta_1 < 0$), which hypothesises that an increase in brain drain leads to a decline in economic development due to the outflow of highly skilled and productive labour from the domestic economy. Theoretically, this negative coefficient is grounded in the understanding that the loss of human capital constrains innovation, depletes institutional capacity, and limits the economy's ability to leverage knowledge-intensive sectors for growth.

Empirically, this finding is consistent with the works of Anetor (2019), Temilade and Adejumoke (2024), Osigwe and Nnoruga (2023), and Adeagbo (2024), who also reported adverse long-run effects of brain drain on Nigeria's economic performance. Conversely, the result contradicts the conclusions of Tabassum, Bashir, and Tariq (2017), Meyer and Shera (2017), Adewumi, Ogbodo, and Onoh (2019) and Aladejana *et al*., (2020), who argued that remittances, skills transfer, and educational reinvestments associated with migration may, under certain conditions, enhance long-term economic growth. However, the finding that remittances (REM), although positively signed, remain statistically insignificant ($p = 0.261$) underscores the notion that, in the absence of well-structured investment mechanisms and robust institutional or policy frameworks, remittance inflows may not contribute meaningfully to long-term development outcomes. While remittances can enhance household welfare in the short term, their broader developmental impact appears limited when channelled primarily into consumption rather than productive investment. As a result, their potential multiplier effects on macroeconomic growth, employment generation, and structural transformation are significantly constrained.

This outcome is consistent with the empirical evidence reported by Ogunleye (2020); Uchenna and Ismail (2021); Amu and Ezeaku (2021); Adegbite and Adebayo (2022); and Osei-Assibey and Boakye-Yiadom (2023), who similarly observed that remittances tend to have an insignificant or marginal effect in contexts lacking investment-focused frameworks. In contrast, the present findings differ from those of Fayissa and Nsiah (2019); Adams and Cuecuecha (2019); and Olubiyi and Omoniyi (2020), who documented a significant and positive relationship between remittance inflows and economic development in Nigeria and other comparable economies. FDI followed a similar pattern; though associated with a relatively large positive coefficient (5.582), it lacked statistical significance ($p = 0.143$). This outcome suggests that unless FDI inflows are channelled into high value-added sectors with strong domestic linkages and employment potential, their long-term contribution to economic development may remain muted.

Moreover, the exchange rate (EXR) also failed to demonstrate a significant long-run influence ($p = 0.124$), indicating that exchange rate fluctuations—under the prevailing macroeconomic and institutional environment—did not

exert a decisive role in shaping Nigeria's growth trajectory. Inflation (INF), likewise, remained statistically insignificant in the long run (p = 0.462), suggesting that price stability, while important, is insufficient on its own to drive long-term growth in the absence of complementary reforms aimed at boosting productivity, structural transformation, and institutional effectiveness. Finally, the ARDL model demonstrated high explanatory power, with an R^2 of 0.977, indicating that approximately 97.7% of the variation in economic development was accounted for by the model's regressors. Furthermore, the Durbin-Watson statistic (DW = 2.86) indicated the absence of significant autocorrelation in the residuals, thereby affirming the robustness, internal consistency, and reliability of the model estimates.

Table 4.7: Pairwise Granger Causality Test

Null Hypothesis:	Obs	F-Statistic	Prob.
REM does not Granger Cause BD	33	5.316	0.011
BD does not Granger Cause REM		1.185	0.321
LTR does not Granger Cause BD	33	0.233	0.794
BD does not Granger Cause LTR		5.989	0.007
LTR does not Granger Cause REM	33	3.914	0.032
REM does not Granger Cause LTR		6.514	0.005
INF does not Granger Cause REM	33	0.046	0.955
REM does not Granger Cause INF		4.386	0.022

Source: Researcher's Compilation (2025) from E-views-9

The Pairwise Granger Causality Test results in Table 4.7. revealed both unidirectional and bidirectional causal relationships among the variables. Notably, remittances Granger-cause brain drain, as indicated by an F-statistic of 5.316 and a p-value of 0.011, suggesting that past remittance inflows significantly influence brain drain. However, the reverse is insignificant (p = 0.321), confirming a one-way causality from remittances to brain drain. Similarly, brain drain Granger-causes literacy rate (F = 5.989, p = 0.007), while the reverse is not supported (p = 0.794), indicating another unidirectional relationship. In addition, remittances Granger-cause inflation (F = 4.386, p = 0.022), but inflation does not Granger-cause remittances (p = 0.955), again showing a one-way influence. Conversely, a bidirectional causality exists between literacy rate and remittances. Literacy rate Granger-causes remittances (F = 3.914, p = 0.032), and remittances also Granger-cause literacy rate (F = 6.514, p = 0.005), indicating a feedback loop between the two variables. Economically, these results imply that while remittances can drive both human

capital flight and inflationary pressures, their interaction with literacy suggests a potential channel for long-term development if properly managed.

Post-Diagnostic Test Results

Table 4.8: Summary Interpretation of Post-Estimation Diagnostic Tests

Test	Test Statistic	p-Value	Decision	Interpretation
Breusch-Godfrey Serial Correlation LM Test (F-statistic)	9.199	0.053	Marginally insignificant at the 5% level	Indicates weak evidence of serial correlation. Further evaluation may be warranted at a less stringent significance level (e.g., 10%).
Breusch-Godfrey Serial Correlation LM Test (Obs*R-squared)	27.514	0.000	Statistically significant	Reveals strong evidence of serial correlation in the residuals, suggesting potential model misspecification or omitted dynamic components.
Heteroskedasticity Test (Breusch-Pagan-Godfrey) – F-statistic	0.544	0.859	Not significant	No indication of heteroskedasticity; the variance of the error terms appears constant (i.e., homoscedasticity is satisfied).
Heteroskedasticity Test (Breusch-Pagan-Godfrey) – Obs*R-squared	23.639	0.597	Not significant	Reinforces the presence of homoscedasticity; residuals exhibit constant variance across observations.
Heteroskedasticity Test – Scaled Explained SS	0.675	1.000	Not significant	Confirms the absence of heteroskedasticity; residuals are well-behaved in terms of variance.
Residual Normality Test (Jarque-Bera)	2.258	0.323	Fail to reject the null hypothesis of normality	Residuals are approximately normally distributed, satisfying one of the key assumptions of classical linear regression and enhancing the reliability of model estimate

Source: Researcher's Compilation (2025) from E-views-9

Summary, Conclusion and Recommendations

This study examined the dynamic and long-term relationships between brain drain, remittances, literacy rate, and economic development in Nigeria from 1990 to 2024, employing the ARDL model alongside the Granger causality framework. The analysis captured both short-run and long-run interactions among these macroeconomic variables. The ARDL bounds testing approach confirmed the existence of cointegration, while the Granger causality test revealed the direction of influence among variables. Emphasis was placed on how skilled emigration and financial inflows from abroad interacted with

human capital development and economic outcomes. Overall, the study contributed meaningfully to the policy discourse on mitigating human capital flight and leveraging diaspora resources for sustainable economic advancement in Nigeria.

The key findings were summarised as follows:

i. The literacy rate exerted a consistently positive and statistically significant impact on economic development in both the short and long run, reaffirming the critical role of human capital investment in driving long-term growth.
ii. Brain drain had a significantly negative effect on economic development in the long run, while its short-run influence was weak and mixed—highlighting the structural damage inflicted by skilled labour emigration.
iii. Remittances displayed weak and delayed positive effects in the short run but remained statistically insignificant in the long run, indicating that without productive investment channels, their developmental potential remained constrained.
iv. Foreign direct investment (FDI) exerted a negative and statistically significant impact on economic development in the short run but proved insignificant in the long run, reflecting the economy's weak absorptive capacity and limited linkages between FDI and domestic sectors.
v. Exchange rate volatility had a negative effect on economic development in the short run but no significant long-run impact, suggesting that the consequences of macroeconomic instability were largely transitory.
vi. Inflation had no statistically significant effect on economic development in either the short or long run, indicating its limited influence on Nigeria's growth trajectory during the study period.
vii. Remittances Granger-caused brain drain, implying that increased diaspora inflows may inadvertently incentivise skilled emigration.
viii. Brain drain Granger-caused literacy rate, suggesting that patterns of emigration shaped domestic human capital outcomes.
ix. Remittances Granger-caused inflation, indicating that external inflows contributed to upward price pressures.
x. A bidirectional causality existed between remittances and literacy rate, highlighting a feedback loop between financial inflows and human capital formation.

In conclusion, to address the structural and macroeconomic challenges posed by brain drain and underutilised remittances, the study recommended a multifaceted policy response. Human capital development should be prioritised through increased investment in education, the implementation of skilled

labour retention strategies, and greater diaspora engagement. Additionally, remittance inflows should be redirected toward productive sectors through the creation of investment platforms and financial instruments. Foreign direct investment must be aligned with national development priorities, while exchange rate and inflation management should remain central to maintaining macroeconomic stability. These integrated measures are essential for fostering inclusive growth, enhancing domestic value chains, and optimising the developmental impact of both financial and human capital flows.

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