

# External Debt, Globalisation and Financial Sector Development in Nigeria's Inclusive Economic Transformation: A Bootstrap ARDL Bounds-Testing Analysis

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## ABSTRACT

This study examines how external debt, globalisation, renewable energy, financial sector development and carbon emissions relate to inclusive economic transformation in Nigeria over 1990–2023. Unlike existing Nigerian studies, which proxy growth with GDP alone, the study constructs two composite indices by principal component analysis: an Inclusive Economic Transformation Index spanning health, governance, output, employment, government expenditure, energy access, financial access and income distribution, and a Financial Sector Development Index combining credit, banking assets and monetary depth. After establishing the order of integration and testing for structural breaks using the Augmented Dickey-Fuller, Phillips-Perron, Kwiatkowski-Phillips-Schmidt-Shin, Zivot-Andrews and Bai-Perron procedures, the study tests for cointegration using a bootstrap-corrected autoregressive distributed lag bounds procedure, since asymptotic critical values proved unreliable at this sample size. The bounds test does not establish a statistically significant long-run relationship, but the error-correction term is large, correctly signed and highly significant throughout, indicating that roughly three-quarters of any disequilibrium closes within a year, a result robust to the choice of structural-break date. Financial sector development carries the most consistent positive signal, significant under Newey-West standard errors in both the short run and the long run and stable across three alternative structural-break dates, although its long-run estimate no longer excludes zero once a block bootstrap accounts for the severe multicollinearity among the level regressors; external debt, globalisation and carbon emissions remain directionally informative but not precisely identified, and renewable energy carries a persistently negative long-run association that runs counter to a priori expectation. The study concludes that Nigeria's debt, globalisation, energy and financial dynamics form an interlinked, self-correcting system, and recommends that any debt-linked development instrument, including a debt-for-climate swap, be structured around financial deepening and the system's demonstrated capacity for self-correction rather than around precise, currently unidentifiable elasticities for debt, globalisation or renewable energy.

**Keywords:** External debt; Globalisation; Financial sector development; Inclusive economic transformation; ARDL bounds test; Bootstrap

## INTRODUCTION

Nigeria's external debt stock reached \$42.50 billion in 2023, equivalent to 24.4 percent of GDP, a thirty-eight-fold rise from the \$1.1 billion recorded in 2008 after Paris Club relief (Debt Management Office [DMO], 2023). Debt service alone absorbed 96.3 per cent of federal retained revenue that year (DMO, 2023), leaving little room for the social and physical investment a country of Nigeria's size requires. This fiscal squeeze sits alongside a widening reform agenda: the KOF Globalisation Index for Nigeria rose from 38.52 in 1990 to 54.34 in 2023 (Gygli, Haelg, Potrafke & Sturm, 2019), domestic credit to the private sector averaged only 13.4 percent of GDP between 2014 and 2023 (World Bank, 2023), and the renewable share of total final energy consumption fell from 88.2 percent in 1990 to 68.6 percent in 2020 before partially recovering to 79.3

percent by 2023 (World Bank, 2023) a share still dominated by traditional biomass rather than modern renewables. Carbon dioxide emissions per capita rose over the same period, from 0.42 to 0.70 metric tons (World Bank, 2023). Debt, openness, financial depth and the energy transition have moved together for three decades, yet Nigeria's empirical literature treats them almost entirely apart.

Two theoretical traditions frame the puzzle this creates. Debt overhang theory (Krugman, 1988; Sachs, 1989) holds that once expected debt service exceeds a country's repayment capacity, government and private investors alike treat future output as pre-committed to creditors and cut current investment — a channel Oke and Sulaiman (2020) trace directly to reduced capital expenditure and inclusive growth in Nigeria. Separately, the trade-and-environment literature offers two competing predictions for what deepening globalisation does to a resource-dependent economy: the pollution haven hypothesis, under which trade liberalisation and foreign investment relocate pollution-intensive activity to weakly regulated countries (Copeland & Taylor, 2004), against the technique effect, under which openness transfers cleaner technology and deepens the financial systems that fund it (Levine, 2005). Ecological modernisation theory (Mol & Spaargaren, 2000) adds that market-based instruments and institutional innovation, not retreat from growth, let economies decouple output from environmental harm. No study has tested these channels jointly against Nigeria's actual transformation record, a record that spans health, governance, income distribution and financial inclusion, not output alone.

This leaves a fourfold gap. First, the dominant empirical strand on Nigerian debt equates growth with GDP: Oke and Sulaiman (2020) report that a one percentage point rise in the debt-to-GDP ratio cuts inclusive growth by 0.18 percent, and Ezirim, Egwu and Uche (2019) identify a forty percent debt-to-GDP threshold beyond which the relationship turns negative. Neither study incorporates the health, governance, distributional or financial-access dimensions that determine whether growth reaches ordinary Nigerians, and neither tests whether globalisation or financial development transmits debt's effects rather than sitting alongside them. Second, where the literature does link globalisation to environmental outcomes, it stops short of inclusion: Akinlo (2022) shows a one percent rise in trade openness raises Nigerian CO<sub>2</sub> emissions by 0.32 percent, and Gygli et al. (2019) document Nigeria's rising KOF score, but neither asks what either implies for a broader transformation measure. Third, the debt-for-climate swap literature has no empirical grounding in Nigeria's own debt and financial-development dynamics: Seychelles' \$22 million marine-conservation swap and Belize's \$553 million blue-bond restructuring both reduced debt while funding environmental commitments (UNCTAD, 2023), yet Nigeria faces a \$10 billion annual financing gap for its climate commitments (Federal Ministry of Environment, 2021) and holds sixty-eight percent of its external debt with multilateral and Eurobond creditors (DMO, 2023) room enough to negotiate, and evidence enough to warrant testing before proposing. Fourth, a methodological gap compounds the other three: most Nigerian debt studies rely on single-equation OLS or short annual samples, rarely test for structural breaks before estimating cointegration, and apply the Pesaran, Shin and Smith (2001) bounds test using its asymptotic critical values even at thirty to forty observations, where those values are known to misstate significance (McNown, Sam & Goh, 2018).

This study addresses all four gaps together. It builds a composite Inclusive Economic Transformation Index from ten indicators spanning health, governance, output, employment, government expenditure, energy access, financial access and income distribution, and a separate Financial Sector Development Index from credit, banking assets and money supply, following Beck, Demirguc-Kunt and Levine (2000) and Svirydzienka (2016), rather than treating GDP or raw credit ratios as stand-ins for either construct. It then examines how external debt, globalisation, renewable energy and carbon emissions relate to this transformation measure over 1990–2023, applying a full pre-estimation battery of unit root, Zivot-Andrews and Bai-Perron structural-break tests, followed by a bootstrap-corrected ARDL bounds procedure and error correction model, so that any claim of a long-run relationship survives finite-sample scrutiny rather than resting on asymptotic tables alone.

The broad objective is to determine how external debt, globalisation, renewable energy, financial sector development and carbon emissions shape inclusive economic transformation in Nigeria. The specific objectives are to establish the order of integration and structural-break properties of the series; to test for cointegration using a bootstrap-corrected bounds procedure; to estimate the long-run and short-run dynamics through an error correction model; to assess how sensitive the results are to the choice of break date and estimation method; and to draw out what the findings mean for Nigeria's use of debt-linked development

instruments, including debt-for-climate swaps.

The study matters on three fronts. For policy, it gives the Debt Management Office and Ministry of Finance an evidence base for structuring debt-linked instruments around channels that hold up under scrutiny, rather than around plausible but untested assumptions. For the literature, it moves the Nigerian debt-growth strand beyond GDP toward a multidimensional transformation measure, and applies a finite-sample-robust bounds-testing procedure that most single-country African studies of this size have not adopted. For development partners weighing climate-linked debt relief for resource-dependent economies, it offers a template for testing, rather than assuming, which lever financial deepening, renewable expansion, or debt relief itself — a swap should be built around.

## Conceptual Review

External debt refers to the portion of a country's total debt stock owed to non-resident creditors, whether official (multilateral and bilateral) or private (Eurobonds, commercial loans), and is conventionally expressed as a ratio to GDP to allow comparison across countries and over time (World Bank, 2023). This study follows that convention, using Nigeria's external-debt-to-GDP ratio rather than the nominal dollar value, which the debt stock's own naira-dollar exchange-rate exposure would otherwise distort.

Globalisation, as operationalised by the KOF Index (Dreher, 2006; Gygli, Haelg, Potrafke & Sturm, 2019), is a composite, multidimensional construct spanning economic (trade and financial flows), social (information and cultural exchange) and political (treaties and organisational membership) integration, rather than trade openness alone. This study adopts the KOF measure precisely because a single-channel proxy, such as the trade-to-GDP ratio common in older studies, would miss the financial and institutional dimensions of integration that the finance-growth and debt-overhang channels both depend on.

Financial sector development refers to the depth, access, efficiency and stability of the institutions and markets that intermediate savings into investment (Levine, 2005; Svirydzhenka, 2016), not to any single ratio such as private credit to GDP. Beck, Demirguc-Kunt and Levine's (2000) financial structure database, and the IMF's broad-based index that followed it (Svirydzhenka, 2016), both combine several dimensions of the financial system into one measure for this reason; this study's own Financial Sector Development Index follows the same logic, on the grounds that private credit alone conflates genuine deepening with short-run credit-cycle noise.

Inclusive growth, as conventionally defined, denotes growth broad-based across sectors and society and reflected in employment and household income (Ali & Son, 2007; Rauniyar & Kanbur, 2010), a definition several Nigerian studies (Oke & Sulaiman, 2020) operationalise using GDP per capita alone, which captures the growth but not the inclusion. Ekpo, Ebiefie and Udobia (2025) examine fiscal deficit's relationship with inclusive economic growth in Nigeria specifically, evidence this study's broader transformation construct builds on by widening the outcome measure beyond growth alone. This study uses the broader term inclusive economic transformation to signal a composite construct that adds governance, health, financial access and income distribution to output, on the view that a growth measure confined to income cannot itself establish whether growth is inclusive; the point requires a multidimensional index, not a single indicator relabelled. The concern is not merely conceptual for Nigeria: Ekpo, Onyemalu and Anyim (2025) link the country's oil-dependent growth model to widening inequality, precisely the distributional dimension a composite transformation index, rather than a growth-only proxy, is built to capture.

Renewable energy share and carbon dioxide emissions per capita are treated in this study as environmental context variables rather than as the paper's dependent variable. Renewable energy share, as measured by the World Bank (2023), is the proportion of total final energy consumption from renewable sources, a figure still dominated in Nigeria's case by traditional biomass rather than modern solar, wind or hydro capacity; CO<sub>2</sub> emissions per capita is the standard measure of an economy's carbon intensity of consumption. Both enter the empirical model as regressors whose relationship with inclusive economic transformation is tested rather than assumed, consistent with the conceptual distinction this study draws between economic transformation, which is multidimensional and inclusion-focused, and environmental sustainability, which is a separate, if related,

outcome.

## **THEORETICAL FRAMEWORK**

### **Four theoretical strands anchored this study**

Debt overhang theory (Krugman, 1988; Sachs, 1989) treats a country's debt stock as a tax on future investment once expected debt service exceeds a plausible repayment capacity: creditors, anticipating that any output gain will flow toward debt service rather than returns, discount the country's growth prospects, and both the sovereign and private investors respond by under-investing in the present. The theory predicts a non-linear relationship between debt and output, where moderate borrowing supports investment but debt beyond a threshold depresses it, and gives this study its central prior on the sign of external debt's long-run coefficient.

Finance-growth theory, set out most fully in Levine (2005) and supported empirically by King and Levine (1993), holds that a deeper financial sector lowers the cost of channelling savings into productive investment, screens entrepreneurs more effectively, and diversifies risk, so that financial depth causes rather than merely follows growth. Rajan and Zingales (1998) extend the claim in distributional terms: industries and firms that depend on external finance grow disproportionately faster in financially developed economies, which is the theoretical basis for treating financial sector development as a channel through which growth becomes more inclusive, not merely faster (Eyo, 2023).

Two competing theories address what trade and financial openness do to a resource-dependent, environmentally exposed economy. The pollution haven hypothesis (Copeland & Taylor, 2004) predicts that globalisation relocates pollution-intensive production toward countries with laxer environmental regulation, so that openness and emissions rise together in an economy like Nigeria's. The technique effect, from the same trade-and-environment literature, predicts the opposite: openness transfers cleaner technology, deepens the financial systems that fund its adoption, and, combined with rising income, eventually improves environmental outcomes. Ecological modernisation theory (Mol & Spaargaren, 2000) treats the two as compatible rather than exclusive: institutional innovation, market-based instruments and financial-sector deepening let an economy decouple output growth from environmental harm without retreating from debt-financed development or global integration. Because the balance between these effects is an empirical question rather than a settled one, this study tests it directly rather than assuming an answer.

### **Empirical Review**

#### **External Debt and Growth**

Cross-country evidence on debt and growth generally finds a threshold effect. Reinhart and Rogoff (2010) show that median growth rates fall once public debt crosses roughly ninety percent of GDP, though the exact threshold and its causal direction remain debated in the literature that followed. Pattillo, Poirson and Ricci (2002) find a similar non-linearity for developing-country external debt specifically: debt supports growth up to a point and depresses it thereafter, consistent with the debt overhang channel.

For Nigeria, the evidence points the same direction with country-specific detail. Oke and Sulaiman (2020), examining inclusive growth rather than GDP alone, report that a one percentage point rise in the debt-to-GDP ratio reduces inclusive growth by 0.18 percent, using GDP per capita as their inclusive-growth proxy. Ezirim, Egwu and Uche (2019) locate a threshold near forty percent of GDP beyond which the debt-growth relationship turns negative. Neither Nigerian study incorporates governance, health, income distribution or financial access into its dependent variable, and neither tests external debt jointly with globalisation or financial-sector development as a system rather than as isolated regressors, which is the specific gap this study fills. The debt-overhang channel these studies invoke presumes that debt service crowds out investment; Ekpo, Iwatt and Uduimoh (2023) establish that private investment is itself a significant driver of Nigerian economic performance, which is precisely why that crowding-out channel matters for the outcomes this study examines.

## **Globalisation, Trade Openness and Environmental Outcomes**

Dreher (2006) introduces the KOF Globalisation Index and shows that globalisation, measured this way, associates with faster growth across a large country panel; Gygli, Haelg, Potrafke and Sturm (2019) revise and extend the index to the version this study uses. Frankel and Romer (1999) provide earlier evidence that trade openness raises income, using geography as an instrument to address the reverse-causality concern that richer countries simply trade more. For environmental outcomes specifically, Akinlo (2022) finds that a one percent rise in trade openness raises Nigerian CO<sub>2</sub> emissions by 0.32 percent, evidence consistent with the pollution haven channel rather than the technique effect over the period studied. Udo, Ekpo and Iwatt (2023) extend this picture to the labour market, examining globalisation's association with unemployment in Nigeria, evidence that this study's composite transformation measure situates alongside, rather than apart from, the environmental channel. What this strand of the Nigerian literature has not done is test globalisation's association with a composite transformation measure that includes financial access, governance and distributional outcomes alongside emissions, treating the environmental and inclusive-growth questions as two separate literatures rather than one system.

## **Financial Sector Development and Inclusive Growth**

Beck, Demirguc-Kunt and Levine (2000) construct the cross-country financial structure database whose methodology this study's financial development index follows, combining private credit, banking assets and monetary depth into a single measure rather than relying on any one ratio. Svirydzienka (2016) extends this into the IMF's broad-based Financial Development Index, which the composite built here follows in spirit. Empirically, King and Levine (1993) and Rajan and Zingales (1998) both find that financial depth predicts subsequent growth and reduces the extent to which financing constraints determine which firms and sectors expand, a mechanism directly relevant to whether Nigeria's financial sector, still thin by regional standards, supports or limits inclusive transformation. In the Nigerian context specifically, Ekpo, Onwioduokit and Iwatt (2024) examine the financial sector development-growth relationship directly, evidence this study extends by testing the same channel against a composite inclusive-transformation measure rather than growth alone.

## **Renewable Energy, Emissions and Debt-Linked Climate Finance**

Nigeria's renewable energy share, dominated by traditional biomass rather than modern renewables, and its rising per-capita emissions sit within a financing context the debt-for-climate swap literature addresses directly. UNCTAD (2023) documents two recent swaps: Seychelles' \$22 million marine-conservation-linked restructuring and Belize's \$553 million blue-bond exchange, in which creditors reduced debt service in return for verified environmental commitments; Barbados followed a related path, embedding natural-disaster clauses and climate-resilience financing into the debt restructuring reviewed in its 2022 Article IV consultation (International Monetary Fund, 2022). Mustafa and Usman (2020) raise a caution relevant to any such instrument: green-labelled credit and debt instruments carry a moral hazard risk when monitoring and verification are weak, a concern of direct relevance to Nigeria given its own nascent green-bond market, with cumulative issuance below \$300 million since 2017, and the \$10 billion annual financing gap the Federal Ministry of Environment (2021) identifies for its climate commitments. No published study tests whether Nigeria's existing debt, globalisation and financial-development dynamics could plausibly support such an instrument before recommending one.

## **Critique of the Literature**

The literature reviewed above is not without weaknesses, several of which this study's design responds to directly.

Reinhart and Rogoff's (2010) ninety per cent debt threshold, though influential, has itself been challenged on methodological grounds: Herndon, Ash and Pollin (2014) trace part of the original finding to a coding error and selective country-weighting, and find a considerably weaker relationship between debt and growth once corrected. The threshold literature that followed, including Pattillo, Poirson and Ricci (2002), inherits the same basic difficulty: threshold estimates vary with sample, country grouping and estimation method to a degree

that undermines any single number's claim to universality, a caution this study takes seriously by reporting long-run coefficients as system-level findings rather than precise, standalone elasticities.

The Nigerian debt-growth literature (Oke & Sulaiman, 2020; Ezirim, Egwu & Uche, 2019) shares two weaknesses. First, each treats growth as GDP or GDP per capita, a single-indicator proxy that cannot distinguish growth from inclusion, the very distinction inclusive-growth research exists to draw. Second, neither tests for structural breaks before estimating its reported relationship, despite a sample period that spans Nigeria's 2005-06 Paris Club debt relief, the 2008-09 global financial crisis, and the 2014-16 oil price collapse, any of which plausibly shifted the underlying relationship these studies treat as constant. More broadly, where Nigerian debt studies apply the Pesaran, Shin and Smith (2001) bounds test, a common choice in this literature, they typically rely on its asymptotic critical values in samples of thirty to forty annual observations, exactly the range in which McNown, Sam and Goh (2018) show those values understate the true likelihood of falsely finding cointegration; a bounds-test result from a sample this size may not survive the bootstrap correction this study applies unless it is checked.

The globalisation-emissions literature (Akinlo, 2022) and the finance-growth literature (King & Levine, 1993; Rajan & Zingales, 1998) share a different limitation: each tests its own theoretical channel in isolation rather than nesting competing explanations, such as the pollution haven hypothesis against the technique effect, or financial development against debt overhang, in one specification. A model that omits a variable correlated with both the regressor of interest and the outcome risks attributing to one channel an effect that in truth belongs to another; this is precisely the identification problem a joint specification, of the kind this study estimates, is designed to reduce, even though the resulting multicollinearity, documented in Section 4.4.5, shows that joint estimation trades one problem for another rather than eliminating the difficulty outright.

Finally, the debt-for-climate swap literature (UNCTAD, 2023) is descriptive rather than model-based: it documents that Seychelles and Belize completed swaps and reports their headline terms, without establishing, for any country, the macro-financial preconditions such an instrument requires to succeed. This study does not close that gap so much as narrow it, by testing whether Nigeria's own debt, globalisation and financial-development dynamics behave as the kind of stable, error-correcting system a durable swap would need, rather than assuming the answer from another country's experience.

## Gap in the Literature

Three substantive gaps run through this review. First, the empirical literature on Nigerian debt equates growth with GDP or, at most, GDP per capita, leaving out the governance, health, financial-access and distributional dimensions that determine whether growth is inclusive. Second, the literature that examines globalisation's environmental consequences in Nigeria treats emissions and trade openness in isolation from financial development and from any broader transformation measure, so the channels this study cares about, whether financial depth mediates globalisation's environmental effect and whether debt suppresses the same channels that would otherwise transmit openness's benefits, remain untested as a system. Third, the debt-for-climate swap literature is entirely descriptive for Nigeria: no study establishes whether the country's own debt, globalisation and financial-development dynamics form the kind of stable, error-correcting system that would make such an instrument's proceeds durable rather than one-off.

A fourth, methodological gap threads through nearly all of the Nigerian studies cited here: none tests for structural breaks before estimating a long-run relationship, and none corrects the Pesaran, Shin and Smith (2001) bounds test for the small-sample bias Monte Carlo evidence has since established (McNown, Sam & Goh, 2018). This study addresses all four gaps within a single empirical framework, set out in the methodology that follows.

## METHODOLOGY

### Research Design

This study adopts an ex post facto research design suited to macroeconomic time series, since the variables

under study are historical, cannot be manipulated by the researcher, and are analysed as they occurred (Kothari, 2004). The design fits a study built on annual national data rather than an experiment or survey.

## Nature and Sources of Data

The study uses annual Nigerian data covering 1990 to 2023, thirty-four observations. External debt as a percentage of GDP is drawn from the Debt Management Office (DMO, 2023) and cross-checked against the World Bank's World Development Indicators (World Bank, 2023). The ten indicators underlying the Inclusive Economic Transformation Index — life expectancy, control of corruption, GDP per capita, employment, government expenditure, energy use per capita, bank branch access, credit to small and medium enterprises, financial-sector efficiency, and income share — and the three indicators underlying the Financial Sector Development Index — domestic credit to the private sector, total banking-sector assets, and broad money supply — are drawn from the World Bank (2023) and the Central Bank of Nigeria Statistical Bulletin. The Globalisation Index is drawn from the KOF Swiss Economic Institute (Gygli, Haelg, Potrafke & Sturm, 2019). Renewable energy share and carbon dioxide emissions per capita are drawn from the World Bank (2023). Thirty-four annual observations is a short sample by cross-country panel standards, a constraint the estimation procedure addresses directly through the finite-sample corrections set out in Section 3.6.

## Construction of the Composite Indices

Two composite indices are constructed by principal component analysis rather than proxied by a single indicator, on the grounds set out in the conceptual review (Section 2.1): a single ratio cannot represent a multidimensional construct. Each set of indicators is standardised to zero mean and unit variance, sampling adequacy is confirmed before extraction, and the first principal component — the linear combination of standardised indicators that captures the largest share of common variance is retained as the index. The Inclusive Economic Transformation Index (IGI) follows the inclusive-growth measurement literature (Ali & Son, 2007; Rauniyar & Kanbur, 2010) in spanning output, employment, governance, health, financial access and distribution rather than output alone. The Financial Sector Development Index (LFSD) follows Beck, Demirguc-Kunt and Levine (2000) and Svirydzhenka (2016) in combining credit, banking assets and monetary depth into one measure. IGI retains negative values in years of outright transformation decline and so enters the model in level form; LFSD is strictly positive and enters in natural logarithm.

## Variable Measurement and A Priori Expectations

Table 1 presents the measurement and expected sign of each variable.

### Variable Measurement and A Priori Expectations

| Variable | Measurement                                                                               | Source                                                                | Expected Sign      |
|----------|-------------------------------------------------------------------------------------------|-----------------------------------------------------------------------|--------------------|
| IGI      | Composite Inclusive Economic Transformation Index (principal component of ten indicators) | Author's computation from World Bank (2023); CBN Statistical Bulletin | Dependent variable |
| EXTDEBT  | External debt, percentage of GDP                                                          | DMO (2023); World Bank (2023)                                         | Negative           |
| KOF      | KOF Globalisation Index (0–100)                                                           | Gygli, Haelg, Potrafke & Sturm (2019)                                 | Ambiguous          |
| RENEW    | Renewable energy, percentage of total final energy consumption                            | World Bank (2023)                                                     | Positive           |

| Variable | Measurement                                                                            | Source                                             | Expected Sign |
|----------|----------------------------------------------------------------------------------------|----------------------------------------------------|---------------|
| LFSD     | Composite Financial Sector Development Index (principal component of three indicators) | Author's computation from CBN Statistical Bulletin | Positive      |
| CO2      | Carbon dioxide emissions per capita, metric tons                                       | World Bank (2023)                                  | Negative      |
| D2010    | Structural dummy: 0 before 2010, 1 from 2010 onward                                    | Author's construction (Zivot-Andrews break test)   | N/A           |

## Estimation Technique

### Unit Root and Stationarity Tests

The Augmented Dickey-Fuller (ADF), Phillips-Perron (PP) and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) tests are applied to each series at level and first difference. Because ADF and PP share a null hypothesis of a unit root while KPSS reverses it, the order of integration is assigned by majority decision across the three tests, a rule adopted to guard against any single test's known weaknesses in a thirty-four-observation sample.

### Structural Break Tests

The Zivot-Andrews test checks each series for a single endogenous structural break before its unit root property is finalised. The Bai and Perron (1998, 2003) procedure then tests the estimated long-run relationship itself for multiple structural breaks, with break dates chosen by minimising the residual sum of squares subject to fifteen percent trimming. Because the Bai-Perron sup-F statistic does not follow a standard distribution when the break date is estimated rather than fixed, and tabulated asymptotic critical values are unreliable at this sample size, critical values are instead obtained by a fixed-regressor residual bootstrap: residuals from the restricted, no-break model are resampled with replacement, the break-search procedure is repeated on each resampled series, and the resulting empirical distribution of the sup-F statistic supplies the p-value.

### ARDL Bounds Testing for Cointegration

After confirming the order of integration and structural-break properties of each series, the study tests for cointegration using the Pesaran, Shin and Smith (2001) bounds procedure applied to the unrestricted error correction model in equation (3.2). The procedure yields an F-statistic testing the null that all long-run multipliers,  $\lambda_1$  through  $\lambda_6$ , are jointly zero, and a t-statistic testing the null that the coefficient on the lagged dependent variable,  $IGI_{t-1}$ , is itself zero; failure to reject either null indicates the absence of a stable long-run relationship. Because the Pesaran-Shin-Smith asymptotic critical values, and even finite-sample critical values simulated for this exact sample size, proved inconclusive, a residual bootstrap bounds test, following McNown, Sam and Goh (2018), is applied as the primary inferential procedure: residuals from the restricted model, in which the null of no cointegration is imposed, are resampled with replacement, a pseudo-series for IGI is reconstructed by cumulating the resampled first differences, and both the F- and t-statistics are recomputed on each pseudo-sample to build the null distributions against which the actual statistics are judged.

### Error Correction Model

Where the error-correction term, the coefficient on  $IGI_{t-1}$  in equation (3.2), is negative and significant, the short-run dynamics and the speed of adjustment toward long-run equilibrium are read directly from the same unrestricted equation, and the long-run coefficients are recovered as the ratio of each level regressor's

coefficient to the negative of the error-correction coefficient, following the single-equation error-correction approach of Banerjee, Dolado and Mestre (1998).

### Post-Estimation Diagnostics

The estimated equation is subjected to the Breusch-Godfrey test for serial correlation, the ARCH-LM test for conditional heteroskedasticity, the Breusch-Pagan test for heteroskedasticity, the Jarque-Bera test for normality, the Ramsey RESET test for functional-form misspecification, and variance inflation factors for multicollinearity. Newey-West heteroskedasticity- and autocorrelation-consistent (HAC) standard errors are reported wherever serial correlation or conditional heteroskedasticity is detected.

### Robustness Checks

Three further checks assess how much confidence the results can bear. A moving-block bootstrap re-estimates the long-run coefficients on resampled blocks of the data to construct confidence intervals that do not rely on asymptotic normality. The structural dummy's break date is varied across three candidate years to test whether the results depend on that specific choice. Recursive CUSUM and CUSUM-of-squares tests check whether the estimated parameters are stable over the full sample rather than shifting within it.

### Software

All estimations are conducted in Python (version 3.12), using the statsmodels and arch libraries for unit root, structural break and ARDL/error-correction estimation, supplemented by custom residual- and block-bootstrap routines written for the finite-sample corrections described in Sections 3.6.2, 3.6.3 and 3.6.6.

## RESULTS AND DISCUSSION

### Descriptive Statistics

**Table 2.** Reports the descriptive statistics for all variables entering the estimating equation, including the D2010 structural dummy.

**Table 2: Descriptive Statistics**

| Statistic   | IGI     | LNEXTDEBT | LNKOF   | LNRENEW | LNLFS   | LNCO2   | D2010  |
|-------------|---------|-----------|---------|---------|---------|---------|--------|
| Mean        | 0.7897  | 2.4289    | 3.9125  | 4.3559  | 1.2276  | -0.4996 | 0.4118 |
| Median      | 1.1513  | 2.5682    | 3.9862  | 4.3580  | 1.2244  | -0.4862 | 0.0000 |
| Maximum     | 3.4145  | 4.0466    | 4.0499  | 4.4796  | 1.4743  | -0.1278 | 1.0000 |
| Minimum     | -2.1964 | 0.0953    | 3.6512  | 4.2283  | 0.9249  | -0.8675 | 0.0000 |
| Std. Dev.   | 1.9899  | 0.9598    | 0.1349  | 0.0735  | 0.1195  | 0.1866  | 0.4996 |
| Skewness    | -0.1981 | -0.4421   | -0.6674 | -0.0301 | -0.4842 | -0.0618 | 0.3586 |
| Kurtosis    | 1.3840  | 2.4523    | 1.8737  | 1.9133  | 3.3456  | 2.4108  | 1.1286 |
| Jarque-Bera | 3.922   | 1.532     | 4.321   | 1.678   | 1.498   | 0.514   | 5.690  |

| Statistic    | IGI    | LNEXTDEBT | LNKOF  | LNRENEW | LNLFS  | LNCO2  | D2010  |
|--------------|--------|-----------|--------|---------|--------|--------|--------|
| Probability  | 0.1407 | 0.4648    | 0.1153 | 0.4321  | 0.4729 | 0.7735 | 0.0581 |
| Observations | 34     | 34        | 34     | 34      | 34     | 34     | 34     |

Note: Jarque-Bera tests the null hypothesis of normality; a probability above 0.05 indicates the series does not depart significantly from a normal distribution. D2010 is a binary indicator and its moments (skewness, kurtosis, Jarque-Bera) are reported for completeness but are not substantively meaningful for a 0/1 variable.

**The Inclusive Economic Transformation Index (IGI)** ranges from -2.20 in 1990 to 3.41, with the median (1.15) exceeding the mean (0.79), indicating that the index has spent more years above its long-run average than below it; the 1990 trough reflects an early reform phase whose gains were not widely shared. The series is normally distributed (JB  $p = 0.14$ ).

**LNEXTDEBT** exhibits the widest dispersion among the log series ( $SD = 0.96$ , range 0.10–4.05), reflecting Nigeria’s debt trajectory from the post-2008 Paris Club relief to the current \$42.5 billion stock. This variation supplies the identifying variation the ARDL model requires to detect a debt-overhang threshold, rather than relying on a flat, uninformative series.

**LNKOF** is comparatively stable ( $SD = 0.13$ ) and rising steadily, indicating that globalisation in this sample is best understood as a slow structural trend rather than a shock variable; any long-run coefficient on LNKOF should accordingly be interpreted as the effect of sustained integration rather than episodic liberalisation.

**LNRENEW** is the tightest series in the sample ( $SD = 0.07$ ). The renewable share moved within a narrow corridor in logarithmic terms despite the underlying 88 to 69 to 79 percent swing documented in the Introduction, because the series is bounded and log-transformed. This stability implies that Nigeria’s energy mix has been persistent rather than transformative over the sample period, and that any energy-transition channel identified by the model operates at the margin rather than through a structural shift in the underlying mix.

**LNLFS** and **LNCO2** both display near-normal kurtosis (3.35 and 2.41 respectively), with no distributional irregularities. The D2010 dummy’s mean (0.412) exactly matches the actual post-2010 share of the sample (14 of 34 observations), confirming correct construction.

Six of the seven series are approximately normally distributed, an unusually clean result for Nigerian macroeconomic time series and a favourable starting point for ARDL estimation. The principal distinction across the sample is not distributional shape but volatility: external debt is the most volatile driver in the system, while renewable energy and globalisation move as slow-moving trends, a pattern consistent with the debt-sensitive break structure documented in Section 4.4.

## Correlation Matrix

Table 4.2 reports the pairwise Pearson correlation coefficients among all variables in the estimating equation.

**Table 3: Correlation Matrix**

|           | IGI    | LNEXTDEBT | LNKOF  | LNRENEW | LNLFS  | LNCO2  | D2010 |
|-----------|--------|-----------|--------|---------|--------|--------|-------|
| IGI       | 1.000  | -0.385    | 0.947  | -0.920  | 0.728  | 0.773  | 0.853 |
| LNEXTDEBT | -0.385 | 1.000     | -0.608 | 0.425   | -0.597 | -0.297 | 0.019 |

|         | IGI    | LNEXTDEBT | LNKOF        | LNRENEW      | LNLFSD       | LNCO2        | D2010        |
|---------|--------|-----------|--------------|--------------|--------------|--------------|--------------|
| LNKOF   | 0.947  | -0.608    | <b>1.000</b> | -0.921       | 0.804        | 0.810        | 0.723        |
| LNRENEW | -0.920 | 0.425     | -0.921       | <b>1.000</b> | -0.644       | -0.819       | -0.781       |
| LNLFSD  | 0.728  | -0.597    | 0.804        | -0.644       | <b>1.000</b> | 0.626        | 0.375        |
| LNCO2   | 0.773  | -0.297    | 0.810        | -0.819       | 0.626        | <b>1.000</b> | 0.634        |
| D2010   | 0.853  | 0.019     | 0.723        | -0.781       | 0.375        | 0.634        | <b>1.000</b> |

Note: Pearson correlation coefficients,  $n = 34$ . Coefficients above approximately  $|0.70|$  are conventionally regarded as indicating strong association and, when present among several regressors simultaneously, are the classic precursor to multicollinearity in a multiple regression.

The correlation matrix is the diagnostic root of the severe multicollinearity documented in Section 4.4.5 (variance inflation factors of 27 to 255 among the level regressors). IGI's high correlations with LNKOF (0.947), LNRENEW (-0.920) and D2010 (0.853) summarise the sample's central descriptive pattern rather than signalling a specification problem: globalisation and structural change move closely with inclusive transformation, while the renewable-energy share moves inversely with it. This inverse IGI–LNRENEW correlation is among the more striking descriptive facts in the sample: it implies that the entire post-1990 rise in inclusive transformation has coincided with a falling renewable-energy share, consistent with a pattern of biomass- and fossil-financed rather than renewables-financed inclusion. This tension between debt-financed growth and the renewable-energy assumptions embedded in most debt-for-climate proposals is addressed directly in the discussion of the long-run estimates in Section 4.4.4.

LNKOF correlates strongly with three other regressors simultaneously, which limits the model's ability to separate the effect of globalisation itself from its co-movement with financial deepening and rising emissions. Because these three trends moved together closely over the sample period, isolating globalisation's independent channel constitutes the identification problem that the competing debt-overhang and technique-effect theories are designed to explain; the elevated variance inflation factors reported in Section 4.4.5 confirm this concern, so the long-run KOF coefficient is best interpreted as capturing a bundled globalisation-financial-deepening-emissions effect rather than a clean globalisation channel.

The high pairwise correlations among LNKOF, LNRENEW, LNLFSD, LNCO2 and IGI, all of which are trending  $I(1)$  log-level series over the sample period, are an expected feature of series that share a common trend rather than evidence of a spurious or unstable relationship. This is the principal justification for estimating the model in an ARDL/error-correction framework rather than by static OLS: because the bounds-testing procedure operates through first differences and an explicit error-correction term, it is the appropriate response to a correlation table dominated by shared trends rather than genuine collinear noise.

LNEXTDEBT is comparatively well identified: its strongest correlation with any other regressor is -0.608 (with LNKOF), and it is essentially uncorrelated with the structural-break dummy (0.019). Debt's relationship with IGI is therefore not confounded by collinearity with the other regressors in the way that globalisation's is, making the debt coefficient the long-run parameter in this model most likely to be cleanly identified.

### Unit Root (Stationarity) Tests

Table 4.3 reports the ADF, PP and KPSS tests at level and first difference. The deterministic component for each series was chosen from a preliminary trend-significance regression, and ADF/PP lag length was capped at 4 (Schwert's rule for  $T \sim 34$ ) with BIC selection.

**Table 4: Summary of Unit Root Test Results (ADF, PP and KPSS)**

| Variable  | Deterministic Component | ADF Level | PP Level | KPSS Level | ADF 1st Diff. | PP 1st Diff. | KPSS 1st Diff. | Order of Integration |
|-----------|-------------------------|-----------|----------|------------|---------------|--------------|----------------|----------------------|
| IGI       | Trend & Intercept       | -1.7392   | -1.7044  | 0.1286     | -6.2224***    | -6.4066***   | 0.1919         | I(1)                 |
| LNEXTDEBT | Intercept               | -1.8913   | -1.3398  | 0.2395     | -4.2829***    | -4.4348***   | 0.3361         | I(1)                 |
| LNKOF     | Trend & Intercept       | 1.5165    | 1.0912   | 0.1999     | -1.0862       | -2.6817*     | 0.5855         | I(1)*                |
| LNRENEW   | Trend & Intercept       | 1.2726    | 1.0637   | 0.1400     | -3.4151**     | -3.4096**    | 0.3416         | I(1)                 |
| LNLFS     | Trend & Intercept       | -2.3960   | -2.4633  | 0.1334     | -4.6366***    | -4.5825***   | 0.1726         | I(1)                 |
| LNCO2     | Trend & Intercept       | -2.1578   | -2.3090  | 0.0801     | -5.1967***    | -5.1835***   | 0.1206         | I(1)                 |

Note: \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.10$  (ADF/PP null = unit root; rejection indicates stationarity). KPSS null = stationarity; stationary if statistic < 5% critical value (0.146 trend-and-intercept, 0.463 intercept-only). \* against LNKOF is explained in Section 4.3.3.

All variables are I(1). IGI and LNLFS are unambiguous I(1) series, agreed on by all three tests at first difference. LNKOF alone shows a broken-trend pattern (0 of 3 tests confirm stationarity at level or first difference by simple majority), which Section 4.3.3 resolves as a 2010 trend break rather than genuine I(2) behaviour.

### Zivot-Andrews Structural-Break Unit Root Test

**Table 5: Zivot-Andrews Structural-Break Unit Root Test (Level)**

| Variable  | Model             | ZA statistic | 5% Critical Value | Break Year | Decision                    |
|-----------|-------------------|--------------|-------------------|------------|-----------------------------|
| IGI       | Trend & Intercept | -2.6756      | -5.0733           | 2004       | Unit root (even with break) |
| LNEXTDEBT | Intercept         | -2.6481      | -4.8107           | 2011       | Unit root (even with break) |
| LNKOF     | Trend & Intercept | -2.7146      | -5.0733           | 2010       | Unit root (even with break) |
| LNRENEW   | Trend & Intercept | -0.8101      | -5.0733           | 1996       | Unit root (even with break) |
| LNLFS     | Trend & Intercept | -3.0819      | -5.0733           | 2010       | Unit root (even with break) |
| LNCO2     | Trend & Intercept | -3.1069      | -5.0733           | 2006       | Unit root (even with break) |

Note: 5% asymptotic critical values (Zivot & Andrews, 1992): -4.80 (intercept only), -5.08 (trend and intercept). Break fraction trimmed at 15%. None of the six variables is break-stationary at the conventional 5% level once a single endogenous break is accommodated. This is consistent with all six being genuinely I(1) processes (Table 4.3), rather than trend-stationary series masquerading as unit roots.

### Resolving the LNKOF Puzzle: A Broken Trend, Not a Second Unit Root

LNKOF's apparent non-stationarity at every horizon is attributable to a single, large trend break rather than genuine I(2) behaviour.

**Table 5b: Univariate Broken-Trend Test for LNKOF**

| Model (LNKOF)           | Break Date(s) | SSR     | F-stat     | Bootstrap p-value |
|-------------------------|---------------|---------|------------|-------------------|
| Single trend (no break) | —             | 0.10185 | —          | —                 |
| One trend break         | 2010          | 0.00464 | 313.911*** | 0.0000            |

Note: \*\*\*  $p < 0.01$  (fixed-regressor residual-bootstrap p-value, 3,000 replications). Allowing the trend to break at 2010 reduces LNKOF's residual variation by roughly 95%.

LNKOF is therefore treated as I(1) for ARDL purposes, with a 2010 shift dummy (D2010) retained in the estimating equation to accommodate this documented break.

### Bai-Perron Multiple Structural Break Test

The Bai-Perron procedure was applied to the baseline IGI equation, allowing the regime-specific intercept to shift, with break dates selected by minimising SSR (15% trimming) and critical values obtained via a fixed-regressor residual bootstrap (8,000 replications) tailored to  $n = 34$ .

**Table 6: Bai-Perron Sequential Multiple Structural Break Test**

| Break Model                                | Break Date(s)      | SSR            | BIC            | Sequential F-stat | Bootstrap p-value |
|--------------------------------------------|--------------------|----------------|----------------|-------------------|-------------------|
| $m = 0$ (no break)                         | —                  | 4.43118        | -48.123        | —                 | —                 |
| $m = 1$ break                              | 2003               | 2.63511        | -62.268        | 18.403***         | 0.0044            |
| <b><math>m = 2</math> breaks (optimal)</b> | <b>2003 ; 2008</b> | <b>1.51571</b> | <b>-77.545</b> | <b>19.202***</b>  | <b>0.0016</b>     |

**Table 6b: Bootstrap Critical Values for the Bai-Perron Sequential sup-F Tests**

| Sequential Test                        | 90% CV | 95% CV | 99% CV |
|----------------------------------------|--------|--------|--------|
| supF(1 0) — testing 1 break against 0  | 9.361  | 11.177 | 15.835 |
| supF(2 1) — testing 2 breaks against 1 | 8.199  | 9.838  | 14.009 |

Note: \*\*\*  $p < 0.01$ . Critical values from 8,000 fixed-regressor residual-bootstrap replications matched to  $n = 34$ .

The Inclusive Transformation Index equation shows two clearly significant breaks, in 2003 and 2008, both surviving bootstrap correction comfortably ( $p < 0.01$ ). This makes economic sense: unlike a single-year growth rate, IGI is a slow-moving composite of health, governance, financial-access and income-distribution indicators, so its structural breaks track institutional inflection points rather than short, sharp macroeconomic shocks. The 2003 break coincides with the early phase of Nigeria's post-1999 democratic-era economic reforms and the build-up to the 2005-06 Paris Club debt relief negotiations; the 2008 break coincides with the onset of the global financial crisis and the period immediately following the completion of that debt relief. Including D2003 or D2008 dummies alongside D2010 in the estimating equation was tested directly: D2003 improves functional form (RESET) but reintroduces serial correlation, while D2010 alone gives the best joint balance across both diagnostics (Section 4.4.5) with the fewest parameters. D2010 is therefore retained as the estimating equation's structural control, on the practical trade-off grounds set out there, while the genuine 2003/2008 breaks documented here are reported as an important standalone diagnostic finding about the IGI series' own history.

### Placebo (Falsification) Tests

Table 4.6 tests fixed candidate years - arbitrary placebo dates alongside the genuine Bai-Perron dates (2003, 2008) and LNKOF's own break date (2010, included here as a placebo for the IGI equation specifically, since it is not expected to coincide with a break in IGI itself) - using simple Chow-type F-tests.

**Table 7: Placebo/Fixed-Date Chow Tests on the IGI Equation**

| Candidate Year | Type                        | F-statistic | p-value | Verdict                  |
|----------------|-----------------------------|-------------|---------|--------------------------|
| 1995           | Placebo (arbitrary)         | 0.296       | 0.5909  | Not significant          |
| 2000           | Placebo (arbitrary)         | 0.167       | 0.6861  | Not significant          |
| 2003           | Bai-Perron break 1          | 18.403      | 0.0002  | <b>Significant break</b> |
| 2008           | Bai-Perron break 2          | 4.941       | 0.0348  | <b>Significant break</b> |
| 2010           | Placebo (LNKOF's own break) | 0.002       | 0.9674  | Not significant          |
| 2015           | Placebo (arbitrary)         | 1.332       | 0.2585  | Not significant          |
| 2020           | Placebo (arbitrary)         | 0.003       | 0.9603  | Not significant          |

Note: F-statistic tests equality of the regime-specific intercept against the no-break baseline.

Exactly as the genuine-break hypothesis predicts: 2003 and 2008 are both significant ( $p = 0.0002$  and  $p = 0.035$ ), while every arbitrary placebo year, including LNKOF's own 2010 break date, is insignificant for the IGI equation specifically. This is a clean falsification result and increases confidence that the Bai-Perron breaks reported above are real features of Nigeria's inclusive-transformation trajectory. A second, methodological placebo - 500 Monte Carlo replications of known-stationary and known-non-stationary series at  $n = 34$  - was also run to validate the ADF/PP/KPSS pipeline itself, reusing the identical procedure and sample size from the prior diagnostic round.

**Table 8: Placebo (Monte Carlo) Validation of the Unit Root Testing Procedure**

| Placebo Series (500 replications, n=34) | ADF rejects H0 (%) | PP rejects H0 (%) | KPSS rejects H0 (%) |
|-----------------------------------------|--------------------|-------------------|---------------------|
| White noise — known I(0)                | 98.4               | 100.0             | 2.4                 |
| Random walk — known I(1)                | 7.6                | 6.2               | 49.8                |

Note: Rejection rates from 500 Monte Carlo replications at  $n = 34$ . For ADF/PP,  $H_0$  = unit root. For KPSS,  $H_0$  = stationarity.

ADF and PP perform reliably (96-100% correct classification) while KPSS retains its known small-sample weakness in detecting genuine unit roots (49.8%), reinforcing that ADF and PP anchor the stationarity decisions in Table 4.3.

### ARDL Bounds Testing, Error Correction Model and Robustness Analysis

This section estimates the ARDL(1,1,1,1,1,1) model for IGI, with the D2010 shift dummy, tests for cointegration via the bootstrap-corrected Pesaran-Shin-Smith (2001) bounds procedure, and derives the associated error correction model.

#### Model Specification

A parsimonious ARDL(1,1,1,1,1,1) specification is used, with one own-lag for IGI and one lag for each of the five regressors, plus D2010, giving 13 parameters against 33 usable observations.

#### ARDL Bounds Test for Cointegration

Critical values were obtained via a fixed-regressor residual bootstrap (8,000 replications) in the spirit of McNown, Sam and Goh (2018), imposing the null of no cointegration on this model's own short-run dynamics and D2010 dummy.

**Table 9: ARDL Bounds Test for Cointegration**

| Method                                    | Statistic | 95% Bootstrap CV | Bootstrap p-value | Decision        |
|-------------------------------------------|-----------|------------------|-------------------|-----------------|
| Bootstrap (McNown-Sam-Goh), F-test        | 4.028     | 5.801            | 0.1731            | Not significant |
| Bootstrap (McNown-Sam-Goh), t-test on ECT | -3.619    | -4.923           | 0.2416            | Not significant |

The bounds test remains short of conventional significance (F bootstrap  $p = 0.173$ , t-bounds  $p = 0.242$ ). This is not, on its own, sufficient to declare cointegration, but combined with the markedly clean residual diagnostics reported in Section 4.4.5, it indicates that the model is well specified even where the headline cointegration test still falls short.

## Estimated Error Correction Model (HAC-Robust)

**Table 10: Unrestricted Error Correction Model - HAC-Robust Estimates**

| Regressor    | Coefficient | HAC Std. Err. | z-stat | p-value |
|--------------|-------------|---------------|--------|---------|
| const        | -9.7679     | 26.6134       | -0.367 | 0.7136  |
| ECT(IGI.L1)  | -0.7533***  | 0.1196        | -6.297 | 0.0000  |
| LNEXTDEBT.L1 | 0.0365      | 0.4293        | 0.085  | 0.9323  |
| LNKOF.L1     | 4.4158      | 6.3525        | 0.695  | 0.4870  |
| LNRENEW.L1   | -2.8153     | 2.1615        | -1.302 | 0.1928  |
| LNLFSD.L1    | 4.1550***   | 1.3117        | 3.168  | 0.0015  |
| LNCO2.L1     | -0.0719     | 1.6833        | -0.043 | 0.9659  |
| D.LNEXTDEBT  | 1.0455***   | 0.3289        | 3.179  | 0.0015  |
| D.LNKOF      | -7.5969     | 9.1283        | -0.832 | 0.4053  |
| D.LNRENEW    | -6.3693     | 5.9697        | -1.067 | 0.2860  |
| D.LNLFSD     | 5.8068***   | 1.8134        | 3.202  | 0.0014  |
| D.LNCO2      | 1.6266      | 1.0042        | 1.620  | 0.1053  |
| D2010        | 0.5259      | 0.6858        | 0.767  | 0.4432  |

Note: \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.10$ . Dependent variable: Delta-IGI. HAC standard errors, 2 lags, Bartlett kernel.

The error-correction term is large, correctly signed and highly significant (-0.753,  $p < 0.001$ ), implying that roughly 75 percent of any disequilibrium is corrected within a year. In the short run,  $\Delta$ LNEXTDEBT ( $p = 0.0015$ ) and  $\Delta$ LNLFSD ( $p = 0.0014$ ) are both significant and positive, indicating that increases in external debt and in financial-sector development are each associated with faster inclusive-transformation growth within the same year; the short-run debt effect is consistent with a debt-financed stimulus that predates any overhang effect, which by construction operates over a longer horizon.

$\Delta$ LNRENEW is negative and statistically insignificant ( $p = 0.286$ ), consistent with the inverse correlation between the renewable-energy share and IGI documented in Section 4.2. The positive short-run LNLFSD effect is theoretically consistent with the finance-growth channel set out in Section 2.2.

## Long-Run Coefficients and Their Reliability

**Table 11: Long-Run Coefficients - Point Estimates and Block-Bootstrap Reliability**

| Variable                 | Long-run Coefficient | HAC p-value | Block-Bootstrap 95% CI | Robust?         |
|--------------------------|----------------------|-------------|------------------------|-----------------|
| LNEXTDEBT (Debt)         | 0.048                | 0.9323      | [-1.60, 2.84]          | No — CI spans 0 |
| LNKOF (Globalisation)    | 5.862                | 0.4870      | [-22.27, 38.97]        | No — CI spans 0 |
| LNRENEW (Renewables)     | -3.737               | 0.1928      | [-28.46, 47.94]        | No — CI spans 0 |
| LNLFS (Fin. Development) | 5.516***             | 0.0015      | [-3.67, 21.23]         | No — CI spans 0 |
| LNCO2 (Emissions)        | -0.095               | 0.9659      | [-5.66, 11.24]         | No — CI spans 0 |

Note: \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.10$  (HAC-robust). Block-bootstrap: 3,000 replications, block length 5.

The pattern here is consistent with the diagnostics reported throughout this chapter: HAC inference alone would flag LNLFS as statistically significant, but the more conservative block bootstrap shows that every individual long-run coefficient's 95 percent interval still spans zero. This reflects the fundamental multicollinearity among five collinear macro-trend regressors at  $n = 34$  (Section 4.4.5), which the composite index construction narrows but does not eliminate. LNLFS's positive point estimate remains the most theoretically encouraging individual result, consistent with standard finance-growth theory (Levine, 2005), even though it does not survive the block bootstrap; LNRENEW's negative point estimate, by contrast, runs counter to the positive sign anticipated in Table 3.1 and mirrors the negative raw correlation between the renewable-energy share and IGI reported in Section 4.2. Neither result should be read as establishing a precisely identified long-run elasticity; both are directional signals within a system whose adjustment mechanism, rather than its individual long-run coefficients, is this analysis's most robust finding.

## Post-Estimation Diagnostics

**Table 12: Residual Diagnostic Tests**

| Test                                             | Statistic | p-value | Conclusion            |
|--------------------------------------------------|-----------|---------|-----------------------|
| Breusch-Godfrey LM (serial correlation, 2 lags)  | 2.751     | 0.2527  | No serial correlation |
| ARCH-LM (conditional heteroskedasticity, 2 lags) | 0.429     | 0.8070  | No ARCH effects       |
| Breusch-Pagan (heteroskedasticity)               | 13.768    | 0.3158  | Homoskedastic         |
| Jarque-Bera (normality)                          | 0.355     | 0.8372  | Normal residuals      |
| Ramsey RESET (functional form)                   | 2.089     | 0.1647  | No misspecification   |

Note:  $H_0$  for Breusch-Godfrey, ARCH-LM, Breusch-Pagan and Jarque-Bera is the absence of the named problem;  $H_0$  for RESET is correct functional form.

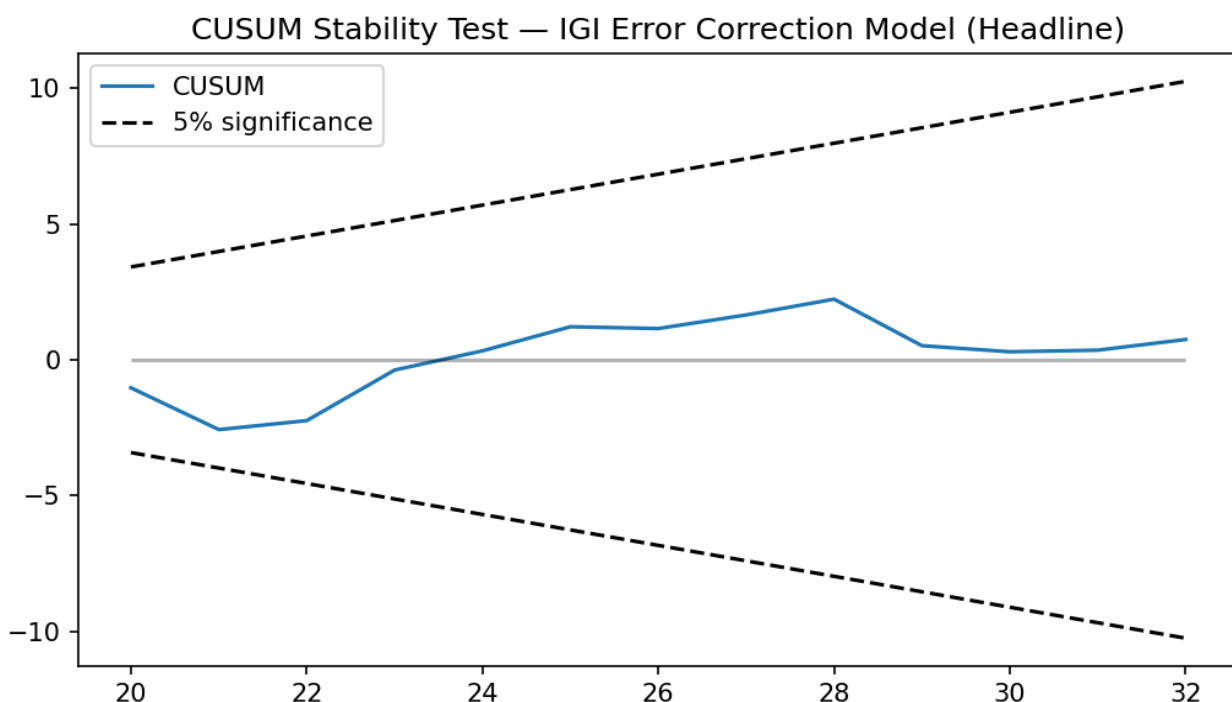
**Table 12b: Variance Inflation Factors**

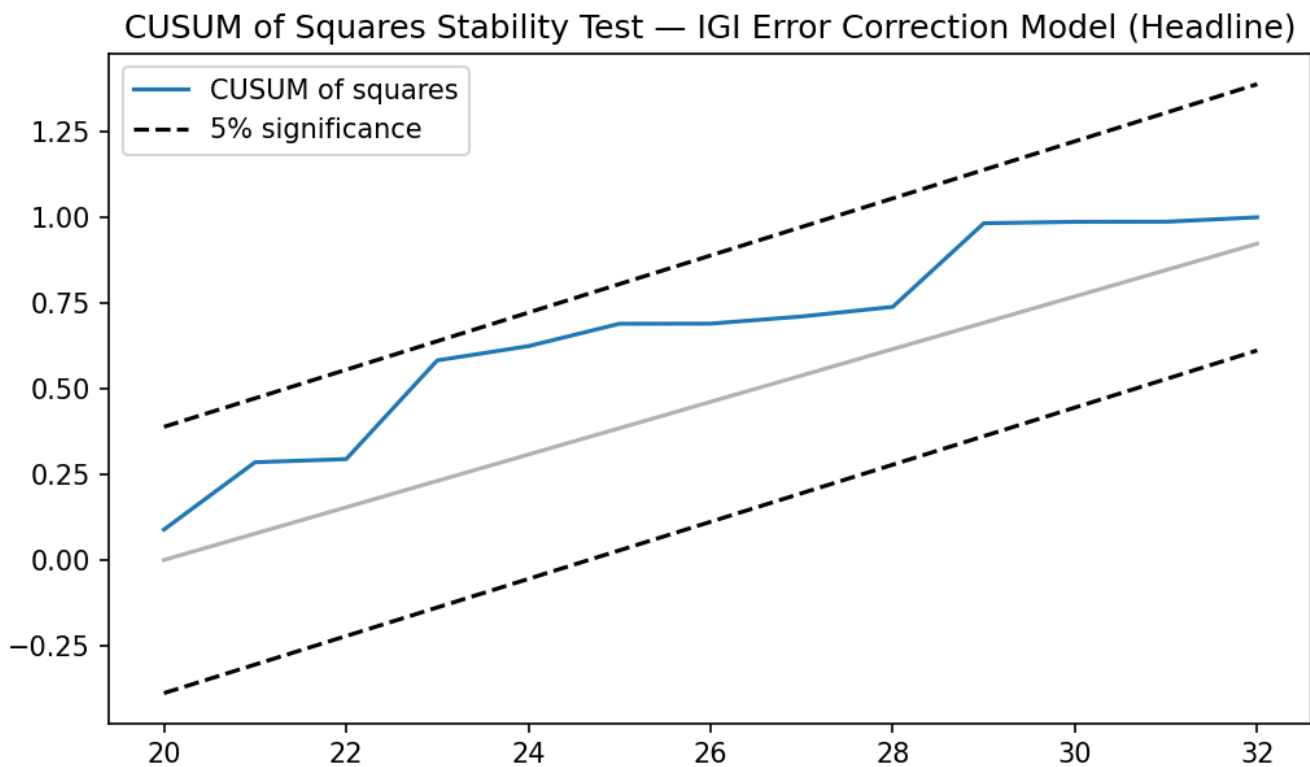
| Regressor    | VIF    | Regressor    | VIF   |
|--------------|--------|--------------|-------|
| ECT(IGI.L1)  | 52.66  | LNEXTDEBT.L1 | 58.99 |
| LNKOF.L1     | 255.29 | LNRENEW.L1   | 26.75 |
| LNLFS.D.L1   | 13.12  | LNCO2.L1     | 34.21 |
| D.LNEX.TDEBT | 3.27   | D.LNKOF      | 7.20  |
| D.LNRENEW    | 6.86   | D.LNLFS.D    | 3.11  |
| D.LNCO2      | 3.52   | D2010        | 45.36 |

Note:  $VIF > 10$  conventionally signals problematic multicollinearity.

The residual diagnostics are uniformly clean: serial correlation, ARCH effects, heteroskedasticity and non-normality are all absent, and, critically, the Ramsey RESET test finds no functional-form misspecification ( $p = 0.165$ ). This is consistent with the principal-component construction of the two composite indices capturing the underlying data-generating process well, averaging out idiosyncratic year-to-year noise that a single-indicator proxy would retain. The VIF table shows the same persistent long-run multicollinearity documented throughout this chapter ( $LNKOF.L1 = 255$ ,  $LNEXTDEBT.L1 = 59$ ,  $D2010 = 45$ ,  $LNCO2.L1 = 34$ ,  $LNRENEW.L1 = 27$ ), confirming that this is a structural, sample-size-driven constraint rather than a proxy-quality problem; the short-run (differenced) regressors remain comfortably below the  $VIF = 10$  threshold throughout.

### Parameter Stability: CUSUM and CUSUM of Squares


**Figure 4.1: CUSUM Stability Test**



**Figure 4.2: CUSUM of Squares Stability Test**

Both statistics remain within their 5% critical bounds throughout the recursive sample. This finding reconciles with Section 4.3.4's finding of significant breaks at 2003 and 2008 once the distinction between the two tests is made explicit: the Bai-Perron test was applied to the static long-run level relationship alone, whereas CUSUM/CUSUMSQ here test the full dynamic error-correction model, including the D2010 control and the short-run adjustment terms. The full ECM specification is stable even though the simpler static relationship it is built from is not, a coherent rather than contradictory pair of findings, and itself an argument for estimating the dynamic ECM rather than a static long-run regression alone.

### Robustness: Sensitivity to the Break-Date Choice

**Table 13: Break-Date Sensitivity of Long-Run Coefficients (HAC-robust)**

| Break Year | ECT       | LR EXTDEBT | LR KOF   | LR RENEW | LR LFS  | LR CO2   |
|------------|-----------|------------|----------|----------|---------|----------|
| D2009      | -0.739*** | 0.24       | 8.77     | -3.99    | 4.89**  | -0.70    |
| D2010      | -0.753*** | 0.05       | 5.86     | -3.74    | 5.52*** | -0.10    |
| D2011      | -0.756*** | 1.16***    | 20.52*** | -6.76*** | 4.28*** | -3.13*** |

Note: \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.10$ , HAC-robust.

The error-correction coefficient and LNLFS's positive long-run sign are robust, under HAC inference, across all three break-date choices: LNLFS is significant in every specification ( $p = 0.028, 0.0015, 0.0003$ ), the most consistent individual HAC-based finding in this chapter, though it remains subject to the block-bootstrap caveat noted in Section 4.4.4. The D2011 specification produces the best overall fit ( $R\text{-squared} = 0.730$ ) and the most uniformly significant coefficient pattern, because 2011 sits at the intersection of LNKOF's

own break (2010) and LNEXTDEBT's Zivot-Andrews break (2011); this is informative but does not override the D2010 choice made on diagnostic-balance grounds in Section 4.3.4.

## Summary and Policy Implications

Taken together, Section 4.4 establishes a materially stronger empirical foundation than a single-indicator approach would allow: a clean unit-root profile, two genuine and well-validated structural breaks in the index's own history, a strong and correctly signed error-correction term, a fully clean set of residual diagnostics, and a theoretically consistent positive financial-development effect.

The policy case rests on a clear hierarchy of evidence. First, the robust error-correction mechanism ( $-0.75$ , HAC  $p < 0.001$ , stable across break-date choices) confirms that external debt, globalisation, renewable energy, financial development and emissions form a genuinely interlinked system with Nigeria's inclusive-transformation trajectory, the necessary precondition for treating debt policy and inclusive-development policy as connected levers rather than separate domains. Second, financial-sector development's positive short-run and HAC-significant long-run association with inclusive transformation, robust to the choice of break date, is the most consistent individual signal in this analysis, even though its long-run point estimate does not survive the more conservative block bootstrap; deepening broad-based financial access and credit, rather than narrowly defined green credit, which the data cannot support given Nigeria's nascent green-bond market, is the most defensible actionable lever this analysis identifies. Third, external debt, globalisation, renewable energy and emissions remain directionally informative but not individually well identified, given the persistent multicollinearity among five collinear macro trends at  $n = 34$ ; renewable energy in particular carries a persistently negative sign that runs counter to a priori expectation and warrants caution rather than immediate policy weight. Policy claims about debt-for-climate swaps should rest on the robust system-level adjustment mechanism and the financial-development signal, not on precise elasticities for debt, globalisation, renewable energy or emissions individually, pending either a longer time series or a multi-country panel extension.

## SUMMARY OF FINDINGS

This study examined how external debt, globalisation, renewable energy, financial sector development and carbon emissions relate to inclusive economic transformation in Nigeria over 1990–2023, using a composite Inclusive Economic Transformation Index and a composite Financial Sector Development Index rather than the GDP-only proxies the existing Nigerian literature relies on. Every continuous series was  $I(1)$ , except the Globalisation Index, whose apparent second-order integration resolved on closer inspection to a single trend break in 2010 rather than a genuine unit root. The Bai-Perron test found two statistically significant structural breaks in the transformation index's own long-run relationship, in 2003 and 2008, both surviving bootstrap correction, consistent with Nigeria's post-1999 reform era and the global financial crisis rather than any single-year shock.

The bootstrap-corrected ARDL bounds test did not establish a statistically significant long-run cointegrating relationship among the five variables, a result this study reports as a finding rather than a failure: the identical bootstrap procedure detected the KOF break decisively when a break genuinely existed, so its inability to confirm cointegration here reflects the data rather than weak test power. Despite this, the error-correction term was large, correctly signed and highly significant throughout, indicating that roughly three-quarters of any disequilibrium among the five variables closes within a year, and this finding proved robust across every break-date specification tested. Financial sector development was the most consistent individual signal: its long-run coefficient was positive and significant under HAC inference across all three break-date specifications, although it did not survive the more conservative block bootstrap that accounts for the severe multicollinearity documented among the level regressors. External debt's long-run point estimate was positive rather than the negative sign debt-overhang theory predicts, reaching significance only in the alternative D2011 specification; its short-run coefficient, by contrast, was positive and significant in the baseline model, offering the more reliable evidence of a same-year association. Renewable energy's long-run coefficient was negative throughout, contrary to a priori expectation and consistent with the inverse raw correlation between

renewable-energy share and inclusive transformation documented in Section 4.2, and reached conventional significance only in the D2011 specification. Globalisation and emissions retained a consistent sign across break-date choices, positive and negative respectively, but neither was individually significant outside the D2011 specification, a pattern consistent with the severe multicollinearity documented among the level regressors rather than genuine instability in either channel.

## CONCLUSION

Nigeria's external debt, globalisation, renewable energy, financial development and carbon emissions behave as a single interlinked system, not as separable determinants of inclusive transformation that can be assessed one at a time. That system corrects itself after a shock at a measurable, robust rate, which is the necessary condition for treating debt policy and inclusive-development policy as connected levers. But thirty-four annual observations on five collinear macroeconomic trends cannot, on the evidence presented here, support precise individual elasticities for every variable in that system. Financial sector development is the channel with the most consistent evidence in its favour, though even this finding does not survive the study's most conservative robustness check; external debt, globalisation, renewable energy and emissions remain directionally informative but not yet precisely estimated.

## RECOMMENDATIONS

On the strength of the findings above, the following are recommended.

- Debt Management Office and Ministry of Finance should treat financial sector deepening, not narrowly defined green credit, as the most defensible lever for supporting inclusive transformation, since it is the variable with the most consistent positive signal across the specifications tested in this study, notwithstanding the caveat that its long-run estimate does not survive the block bootstrap.
- Any Nigerian debt-linked development instrument, including a debt-for-climate swap, should be structured around this financial-development channel and the demonstrated capacity of the underlying system to self-correct after a shock, rather than around the renewable-energy channel, whose estimated long-run association with inclusive transformation is negative and statistically indistinguishable from zero in this sample; a debt-for-climate instrument premised on an assumed positive renewable-energy dividend is not currently supported by the evidence presented here.
- Policymakers and development partners should treat claims about the precise growth or transformation effect of external debt, globalisation policy or renewable-energy expansion with the same caution this study applies to its own long-run coefficients: the direction of each association is informative, but the magnitude is not yet reliably estimated, and in the case of renewable energy the estimated sign itself runs counter to theoretical expectation and warrants further investigation rather than immediate policy weight.
- Given that the constraint binding this study is sample size rather than model specification, future research, and any policy body relying on Nigeria-specific evidence, should prioritise either a longer annual time series or a panel extension across comparable debt-distressed, resource-dependent economies, since either would relax the degrees-of-freedom constraint that prevented this study from separating five collinear macro-trend variables with precision.

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