

Foreign Exchange Rate-Trade Balance Nexus in Sub-Saharan Africa

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Abstract: We examine the nexus between foreign exchange rate (FER) and trade balance in Sub-Saharan Africa (SSA). We utilize balanced annual panel data for 20 SSA countries spanning 2005–2024, sourced from the World Bank. To address endogeneity, unobserved country-specific effects, and dynamic panel bias, we apply the Generalized Method of Moments (GMM) estimator. Results reveal significant persistence in trade balance, with the lagged coefficient (0.215576) indicating that about 21.6% of past trade balance conditions persist into the current period, reflecting partial adjustment and structural inertia. Crucially, FER exhibits a negative and statistically significant effect (−0.899849), implying that a 10% depreciation leads to an approximate 9% deterioration in the trade balance, *ceteris paribus*. This contradicts the Marshall–Lerner condition and underscores the dominance of import dependence, weak export diversification, and structural rigidities in SSA economies. We conclude that currency depreciation is counterproductive to external balance in SSA. We therefore advocate for strong and stable currencies, alongside policies promoting export diversification, domestic production, and structural transformation to achieve sustainable trade balance outcomes.

Keywords: *GMM, Foreign exchange rate, Trade Balance, SSA*

1. Introduction

Sub-Saharan Africa (SSA) has experienced persistent deterioration in its trade balance since the mid-1970s, despite abundant natural resources and a historically vibrant role in global trade. Pre-colonial Africa was a major hub of commerce and food production, sustaining extensive trade networks such as the Trans-Saharan trade, the Trans-Atlantic trade, the Cape route, and long-distance trade along the East African coast. Commodities, including slaves, gold, ivory, spices, textiles, and agricultural produce, dominated exchange, positioning Africa as a critical supplier in the global economy (Austen, 1987; Hopkins, 1973). Historical narratives, even in biblical accounts, depict Africa as a destination for food and resources, underscoring its former productive strength and global relevance (Curtin, 1984). Early mercantilist views further recognized Africa's strategic importance as a source of wealth and raw materials for global accumulation.

However, the post-independence period, particularly from the 1970s onward, marked a structural reversal. The deterioration of trade balances coincided with the adoption of externally driven macroeconomic reforms, notably the International Monetary Fund (IMF) and World Bank-supported Structural Adjustment Programs (SAPs). Central to these reforms was currency devaluation, justified under conventional trade theories such as the Marshall–Lerner condition, which posits that depreciation should improve trade balances by boosting exports and reducing imports (Krugman & Obstfeld, 2009). Yet, in SSA, these policies often produced the opposite effect. Devaluation made imports significantly more expensive for domestic populations while simultaneously rendering local assets and goods disproportionately cheap to foreign actors, effectively enabling external purchasing power to dominate domestic economies. In extreme cases, foreigners could acquire goods and services at a fraction of their real value, reflecting deep distortions in exchange rate regimes and economic sovereignty (Stiglitz, 2002).

Classical trade theories, rooted in the works of Adam Smith and David Ricardo, advocated specialization and comparative advantage as pathways to mutual gains from trade (Smith, 1776; Ricardo, 1817). However, their application in SSA has been constrained by structural rigidities, weak industrial bases, and persistent dependence on primary commodity exports. Rather than fostering competitive export sectors, exchange rate devaluation has often entrenched import dependence and undermined domestic production capacity. Consequently, the expected gains from trade liberalization and currency adjustments have remained elusive.

Despite extensive empirical literature on exchange rates and trade balance, a critical gap persists regarding the dynamic and structural implications of exchange rate movements in SSA. Many studies assume the validity of conventional theoretical frameworks without adequately accounting for Africa's unique economic structure, characterized by low export diversification, high import elasticity, and limited value addition. Furthermore, limited attention has been paid to the persistence effects and dynamic adjustments inherent in trade balance behavior.

We address these gaps by re-examining the foreign exchange rate–trade balance nexus in SSA using a dynamic panel framework. By employing the Generalized Method of Moments (GMM) and recent panel data (2005–2024), our study provides robust insights into the extent to which exchange rate movements influence trade outcomes in the region. The rationale is to challenge orthodox policy prescriptions and offer evidence-based alternatives that prioritize structural transformation, currency stability, and economic sovereignty. In doing so, we contribute to a growing body of literature advocating for a rethinking of exchange rate policy in Africa, not merely as a tool for price adjustment, but as a central pillar of sustainable development and external sector resilience.

2. Literature Review

Empirical evidence at the global level presents mixed findings on the exchange rate–trade balance relationship. Studies such as Rose (1991) and Bahmani-Oskooee & Niroomand (1998) find limited support for the Marshall–Lerner condition in the short run but stronger effects in the long run. Similarly, the J-curve effect has been widely observed in developed and emerging economies, though its magnitude and timing vary significantly across countries (Bahmani-Oskooee & Ratha, 2004). Conversely, some studies report that exchange rate depreciation may worsen trade balances, particularly in economies with high import dependence and inelastic demand structures (Arize et al., 2000). These findings suggest that structural factors, rather than price effects alone, play a critical role in determining trade outcomes.

In SSA, empirical literature largely challenges conventional theory. Studies by Edwards (1988) and Elbadawi (1994) highlight that exchange rate devaluation under Structural Adjustment Programs often failed to generate sustained improvements in trade balances. Instead, many SSA economies experienced worsening external positions due to their heavy reliance on imports and limited export diversification.

More recent studies, such as Bahmani-Oskooee & Gelan (2012) and Onafowora (2003), provide evidence that the Marshall–Lerner condition rarely holds in SSA, especially in the short to medium term. Depreciation tends to increase the import bill, particularly for essential goods such as machinery, fuel, and intermediate inputs, thereby offsetting any gains from export competitiveness. Furthermore, weak supply-side responses, infrastructural constraints, and low value addition limit the capacity of SSA countries to expand exports following depreciation.

Country-level studies within SSA reinforce the regional narrative. For instance, studies on countries such as Nigeria, Kenya, and Uganda show that exchange rate depreciation often leads to trade balance deterioration rather than improvement (Agenor, 1991; Musila & Newark, 2003). In Uganda, empirical evidence suggests that the import elasticity is relatively high, while export responsiveness to exchange rate changes remains weak due to structural bottlenecks and limited industrial capacity.

Additionally, IMF and World Bank-driven devaluation policies have been criticized for exacerbating external vulnerabilities. While intended to restore competitiveness, these policies often reduced the real purchasing power of domestic agents while making local assets cheaper for foreign investors, thereby deepening economic dependency (Stiglitz, 2002).

The foreign exchange rate–trade balance nexus is grounded in several competing theoretical perspectives. The elasticity approach, anchored in the Marshall–Lerner condition, posits that currency depreciation improves the trade balance if the sum of export and import demand elasticities exceeds unity (Krugman & Obstfeld, 2009). Closely related is the J-curve hypothesis, which suggests that trade balance initially deteriorates following depreciation before improving over time due to delayed quantity adjustments (Bahmani-Oskooee & Ratha, 2004).

The absorption approach (Alexander, 1952) emphasizes that trade balance outcomes depend on the relationship between national income and domestic absorption (consumption + investment + government expenditure). Under this framework, depreciation only improves the trade balance if it reduces domestic absorption relative to output. Meanwhile, the monetary approach links trade imbalances to disequilibrium in money supply and demand, viewing exchange rate movements as reflections of broader macroeconomic imbalances (Frenkel & Johnson, 1976).

Classical trade theories also provide foundational insights. Adam Smith's theory of absolute advantage and David Ricardo's theory of comparative advantage argue that countries benefit from specialization and trade (Smith, 1776; Ricardo, 1817). However, in SSA, structural rigidities, commodity dependence, and limited industrialization constrain the realization of these theoretical gains. The Structuralist and Dependency theories further challenge orthodox views by arguing that developing economies remain locked into unfavorable trade patterns, exporting primary commodities while importing high-value manufactured goods (Prebisch, 1950; Singer, 1975).

Our study conceptualizes trade balance as a function of mainly the foreign exchange rate, where currency movements influence export competitiveness and import demand. While exchange rate depreciation is generally expected to improve the trade balance, the effect may vary due to structural rigidities and adjustment lags in Sub-Saharan Africa (Bahmani-Oskooee & Ratha, 2004; Onafowora, 2003). To address potential endogeneity arising from reverse causality and omitted variables, the study employs the Generalized Method of Moments (GMM), which provides more reliable and consistent estimates (Arellano & Bond, 1991).

3. Data and Method

We adopt a quantitative, explanatory research design to empirically examine the relationship between foreign exchange rate and trade balance in Sub-Saharan Africa (SSA). The design is appropriate as it enables rigorous testing of theoretical propositions using econometric techniques and facilitates causal inference based on observed macroeconomic relationships. A panel data framework is employed, combining both cross-sectional (countries) and time-series (years) dimensions, which enhances variability, reduces collinearity among variables, and improves estimation efficiency.

We utilize balanced annual panel data for 20 Sub-Saharan African countries over the period 2005–2024. The selection of countries is guided by data availability and consistency across all variables to ensure robustness of estimation. All data are sourced from the World Development Indicators (WDI) database of the World Bank, which provides reliable and internationally comparable macroeconomic data. The key variables are:

The dependent variable is trade balance (TB), measured as exports minus imports in absolute terms ($TB = |X - M|$), reflects the difference between a country's exports (X) and imports (M) and is a key indicator of a nation's economic health and external sector performance (Krugman et al., 2018; Salvatore, 2016; Nahabwe et al., 2025). The independent variable is Foreign Exchange Rate (FER), Official exchange rate (local currency units per US dollar), capturing currency valuation. (World Bank 2024).

The use of a balanced panel ensures that each country has complete observations across the study period, thereby avoiding biases associated with missing data and enhancing the consistency of results. To capture the dynamic nature of trade balance adjustment, the study specifies a dynamic panel model as follows:

$$TB_{it-1} = \alpha_0 + \alpha_1 TB_{it-1} + \beta_1 FER_{it} + \varepsilon_{it} \dots\dots\dots(1)$$

Where:

TB_{it} : Trade balance in country i at time t

TB_{it-1} : Lagged dependent variable capturing trade balance persistence

FER_{it} : Foreign exchange rate in country i at time t

ε_{it} : Error term.

TB and FER are first transformed using natural logarithms to enhance econometric reliability and interpretability. Logarithmic transformation compresses large numerical scales and reduces the influence of extreme values, which are common in cross-country macroeconomic data. For instance, while the absolute distance between 10 and 10^{10} is enormous, their logarithmic values differ modestly (from 1 to 10), making relationships more stable and comparable. This transformation also helps linearize potentially nonlinear relationships, mitigate heteroskedasticity, and allows estimated coefficients to be interpreted as elasticities, which is particularly useful for policy analysis in international trade and investment studies (Wooldridge, 2010; Baltagi, 2021).

We employ the Generalized Method of Moments (GMM), specifically the Arellano–Bond difference GMM estimator, to estimate the dynamic panel model. This approach is appropriate for addressing endogeneity arising from reverse causality and simultaneity between trade balance and foreign exchange rate movements (Arellano & Bond, 1991; Roodman, 2009). By utilizing internal instruments based on lagged values of endogenous variables, GMM yields consistent and efficient estimates in the presence of unobserved country-specific effects and measurement errors (Blundell & Bond, 1998). The baseline specification incorporates a lagged dependent variable to capture persistence in trade balance dynamics, alongside the foreign exchange rate as the key explanatory variable.

The empirical analysis proceeds by presenting descriptive statistics, followed by estimation of the dynamic GMM model to identify the effect of exchange rate movements on trade balance. Lagged values of the foreign exchange rate are used as instruments under the assumption of no correlation with the contemporaneous error term, satisfying the orthogonality condition required for identification (Arellano & Bover, 1995; Bowsher, 2002). Estimation is conducted using a two-step GMM framework with robust standard errors to correct for heteroskedasticity and autocorrelation (Wooldridge, 2010). Instrument validity is assessed using the Hansen J-test of over-identifying restrictions, while Arellano–Bond serial correlation tests are applied to confirm model consistency, with careful control of instrument count to avoid proliferation (Roodman, 2009).

GMM estimator is expressed as:

$$\hat{\theta}_{GMM} = \underset{\theta}{\operatorname{argmin}} \left[\frac{1}{n} \sum_{i=1}^n g(X_i, \theta) \right]' W_n \left[\frac{1}{n} \sum_{i=1}^n g(X_i, \theta) \right] \dots\dots\dots (2)$$

Where:

$g(X_i, \theta) = \frac{1}{n} \sum_{i=1}^n Z_i' \varepsilon_i(\theta)$ is the vector of moment conditions,

W_n : A consistent estimate of the weighting matrix,

θ : Vector of structural parameters (Arellano & Bond 1991; Blundell & Bond 1998).

To ensure the validity and reliability of the estimates, several diagnostic tests are conducted. The Arellano–Bond serial correlation tests (AR(1) and AR(2)) are applied to detect autocorrelation in the differenced residuals (Arellano & Bond, 1991), while the Sargan/Hansen test of over-identifying restrictions assesses the validity of the instruments (Hansen, 1982). Instrument proliferation is carefully controlled to avoid overfitting bias (Roodman, 2009) and robust standard errors are employed to correct for heteroskedasticity (Wooldridge, 2010).

The choice of a dynamic panel GMM framework is motivated by both theoretical and empirical considerations. Theoretically, trade balance adjustment is inherently dynamic, with past outcomes influencing current performance. Empirically, Sub-Saharan African economies exhibit structural rigidities, policy endogeneity, and cross-country heterogeneity, necessitating an estimation technique capable of addressing these complexities. Compared to static panel models, GMM provides more reliable and policy-relevant estimates in the presence of endogenous regressors and persistence effects (Blundell & Bond, 1998), making it well-suited for analyzing the foreign exchange rate–trade balance nexus in the region.

4. Results and Discussion

Descriptive statistics (Appendix 1) reveal important distributional characteristics of the variables. The mean value of the foreign exchange rate (LNFER) is 5.003 with a standard deviation of 2.025, indicating substantial

variability across countries and over time. The trade balance (LNTB) has a mean of 22.787 and a lower standard deviation of 1.315, suggesting relatively moderate dispersion.

Skewness values show that LNFER is slightly negatively skewed (−0.251), while LNTB is positively skewed (0.559), indicating asymmetry in the data. Kurtosis results reveal that LNFER is platykurtic (1.795), whereas LNTB is mildly leptokurtic (3.542), suggesting the presence of extreme values in trade balance observations. The Jarque–Bera statistics for both variables are statistically significant ($p < 0.01$), confirming non-normality. Such deviations from normality are common in macroeconomic panel data, particularly in developing economies characterized by volatility and structural breaks (Baltagi, 2021).

Stationarity properties of trade balance (LNTB) and foreign exchange rate (LNFER) are examined using the Augmented Dickey–Fuller (ADF) unit root test (Appendices 2–6). Results indicate that LNTB and LNFER are non-stationary in levels, as the null hypothesis of a unit root cannot be rejected at conventional significance levels ($p > 0.05$). Upon first differencing, the null hypothesis of a unit root is rejected for both LNTB and LNFER ($p < 0.05$), indicating that they become stationary. Accordingly, both trade balance and foreign exchange rate are found to be integrated of order one, $I(1)$. This common order of integration supports the adoption of a dynamic panel GMM estimator, which is well-suited for handling non-stationary panel data in levels, addressing endogeneity, and capturing dynamic adjustments in macroeconomic relationships (Dickey & Fuller, 1979; Arellano & Bond, 1991; Baltagi, 2021).

Generalized Method of Moments (GMM) model results (Appendix 7)

$$\widehat{DLNTB} = 0.215576DLNTB_{it-1} - 0.8998491DLNFER \dots\dots\dots (3)$$

Hence,

$$\hat{\theta}_{GMM} = \begin{bmatrix} 0.215576 \\ -0.899849 \end{bmatrix}$$

The dynamic GMM estimation shows that the lagged trade balance is positive and statistically significant, with a coefficient of 0.215576, implying that approximately 21.6% of past trade balance conditions persist into the current period. This confirms the presence of partial adjustment dynamics and inertia in external sector performance, consistent with dynamic trade models (Arellano & Bond, 1991; Roodman, 2009).

The key finding is that the foreign exchange rate (LNFER) has a negative and statistically significant coefficient of −0.899849. This implies that a 10% increase in the exchange rate (currency depreciation) leads to approximately a 9% deterioration in the trade balance, *ceteris paribus*. This result contradicts the Marshall–Lerner condition, which predicts an improvement in trade balance following depreciation (Krugman & Obstfeld, 2009).

Robustness checks confirm the reliability of the model. Residual diagnostics indicate non-normality, with leptokurtic behavior and a Jarque–Bera probability of 0.00, leading to rejection of the null hypothesis of normality. However, this does not invalidate GMM estimates, as the estimator relies on moment conditions rather than distributional assumptions (Baltagi, 2021; Arellano & Bond, 1991).

The Hansen J-statistic yields a probability value of 0.48, indicating failure to reject the null hypothesis of instrument validity. This confirms that the instruments are exogenous and appropriately specified, mitigating concerns of over-identification (Roodman, 2009).

The Arellano–Bond serial correlation tests show statistically significant first-order autocorrelation (AR(1): $p < 0.05$), which is expected in first-differenced models, and no second-order autocorrelation (AR(2): $p > 0.05$), confirming the consistency of the GMM estimator and the validity of moment conditions (Arellano & Bond, 1991).

The findings provide strong evidence that challenges conventional exchange rate theory. The persistence of trade balance, as indicated by the significant lagged coefficient, is consistent with prior studies emphasizing gradual adjustment and path dependency in trade dynamics (Bahmani-Oskooee & Ratha, 2004).

However, the most novel and striking finding is the negative impact of exchange rate depreciation on trade balance in SSA, which directly contradicts the Marshall–Lerner condition. While standard theory predicts that depreciation enhances export competitiveness and improves trade balance, this study finds that depreciation instead worsens external balances. This aligns with earlier regional evidence suggesting that devaluation policies in Africa have often been ineffective or counterproductive (Edwards, 1988; Elbadawi, 1994).

This outcome can be attributed to structural constraints in SSA economies. First, high import dependence, particularly for essential goods such as fuel, capital equipment, and intermediate inputs, implies that depreciation significantly raises import costs. Second, limited export diversification and weak industrial capacity constrain the ability of these economies to expand exports in response to favorable price changes. Third, inelastic demand structures reduce the responsiveness of both imports and exports to exchange rate movements (Onafowora, 2003; Bahmani-Oskooee & Gelan, 2012).

Unlike many previous studies that focus on short-run dynamics, this study employs a dynamic panel framework over an extended period (2005–2024), demonstrating that the adverse effects of depreciation persist beyond the short run. This supports structuralist and dependency perspectives, which argue that developing economies are constrained by unequal trade structures and external vulnerabilities (Prebisch, 1950; Singer, 1975).

Furthermore, the findings raise critical concerns about the effectiveness of exchange rate policies promoted under Structural Adjustment Programs. While currency devaluation was intended to restore external balance, the evidence suggests that it may have instead exacerbated trade deficits and reinforced economic dependency, particularly in economies with weak productive bases (Stiglitz, 2002).

5. Conclusion and Recommendations

Limitations

Despite the methodological rigor employed, this study is subject to several limitations relating to research design, sample selection, data, and analytical procedures.

First, the study adopts a quantitative panel design, which, while suitable for identifying empirical relationships, limits deeper institutional and country-specific insights. The heterogeneity of Sub-Saharan African (SSA) economies arising from differences in policy regimes, resource endowments, and structural conditions may not be fully captured within a generalized panel framework (Baltagi, 2021). Consequently, important contextual nuances could be overlooked.

Secondly, the sample is restricted to 20 SSA countries due to data availability and consistency requirements. Although the use of a balanced panel enhances estimation reliability, it potentially introduces sample selection bias, as countries with incomplete data, often fragile or conflict-affected economies, are excluded. This may limit the generalizability of the findings across the entire SSA region.

Thirdly, the study relies on secondary data from the World Development Indicators, which, despite being widely and standardized, may suffer from measurement errors, data revisions, and reporting inconsistencies across countries. Additionally, the use of aggregate macroeconomic indicators may mask sectoral dynamics, particularly differences between commodity and non-commodity trade.

Fourthly, while the Generalized Method of Moments (GMM) estimator effectively addresses endogeneity and dynamic panel bias, it is not without limitations. Results can be sensitive to instrument selection and proliferation, potentially weakening the power of over-identification tests such as the Hansen test (Roodman, 2009). Although efforts were made to control instrument count, some degree of finite-sample bias may persist.

Fifthly, the model specification, though theoretically grounded, may be subject to omitted variable bias. Factors such as institutional quality, trade policies, and global shocks such as commodity price fluctuations or financial crises were not explicitly modeled, yet they may significantly influence trade balance outcomes (Arellano & Bond, 1991).

Finally, the assumption of homogeneous slope coefficients across countries may be restrictive, given the structural diversity of SSA economies. The impact of exchange rate movements on trade balance may vary across countries depending on their level of development, export structure, and policy frameworks.

Conclusion

We re-examine the foreign exchange rate–trade balance nexus in Sub-Saharan Africa (SSA) within a dynamic and structurally grounded framework. Moving beyond conventional theoretical assumptions, we demonstrate that exchange rate movements in SSA operate within a context shaped by deep structural constraints, including persistent import dependence, weak productive capacity, and limited export diversification (Edwards, 1988; Elbadawi, 1994; Onafowora, 2003). As such, the effectiveness of exchange rate adjustments cannot be understood in isolation from these underlying economic realities.

The overarching conclusion is that exchange rate policy, as traditionally prescribed, has not functioned as a reliable instrument for correcting external imbalances in SSA. Instead, the interaction between currency dynamics and structural vulnerabilities has often reinforced existing trade deficits rather than alleviating them (Stiglitz, 2002; Bahmani-Oskooee & Gelan, 2012). This underscores the inadequacy of relying solely on price-based adjustment mechanisms in economies where supply-side rigidities and external dependencies dominate.

Accordingly, our study highlights the need for a paradigm shift in policy orientation from exchange rate-centered adjustment strategies toward a broader development approach anchored in structural transformation (Prebisch, 1950; Singer, 1975). Sustainable improvement in trade balance requires strengthening domestic production systems, enhancing value addition, and fostering export competitiveness within diversified sectors. In this regard, exchange rate stability rather than persistent depreciation emerges as a more supportive macroeconomic condition for long-term external sector resilience (Krugman & Obstfeld, 2009; Baltagi, 2021).

Ultimately, our study contributes to the ongoing debate by emphasizing that the trade balance challenge in SSA is fundamentally structural rather than merely monetary. Addressing it demands coordinated policy efforts that integrate exchange rate management with industrial, trade, and institutional reforms aimed at restoring Africa's productive capacity and repositioning it within the global economy (Elbadawi, 1994; Stiglitz, 2002).

Recommendations

Based on the findings of our study, several recommendations are proposed to guide policy, programmatic interventions, and future research in Sub-Saharan Africa (SSA):

Given that depreciation worsens trade balances in SSA, policymakers should focus on maintaining a stable and credible exchange rate regime. Stability reduces external vulnerability, mitigates inflationary pressures, and fosters investor confidence (Edwards, 1988; Stiglitz, 2002).

Governments should implement strategies to diversify exports beyond primary commodities, including incentives for manufacturing, agro-processing, and value-added industries. Diversification enhances resilience against external shocks and reduces over-reliance on volatile global markets (Prebisch, 1950; Onafowora, 2003).

Strategic import substitution policies and development of domestic production capabilities should be encouraged to reduce reliance on imported essential goods, which amplifies trade balance vulnerability during currency depreciation (Elbadawi, 1994).

Exchange rate management should be complemented by reforms targeting industrialization, infrastructure, and institutional capacity. A holistic approach strengthens competitiveness, mitigates structural rigidities, and enhances long-term trade performance (Singer, 1975; Krugman & Obstfeld, 2009).

Governments and development agencies should promote programs that add value to raw exports locally, thereby increasing foreign exchange earnings and improving trade balance sustainability.

Encouraging intra-regional trade through frameworks like the African Continental Free Trade Area (AfCFTA) can reduce external dependency, expand markets for locally produced goods, and buffer the impact of exchange rate fluctuations.

Programs targeting small and medium enterprises with technical assistance, financing, and market access support can foster export competitiveness and reduce reliance on imported goods.

Future research could conduct in-depth, country-level studies to account for heterogeneity in economic structures, policy frameworks, and institutional quality across SSA. Investigating how exchange rate fluctuations affect specific sectors and commodity exports will provide granular insights for targeted policy interventions. Research assessing the long-term impact of industrial, trade, and institutional reforms on the trade balance and exchange rate dynamics could guide sustainable policy design.

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APPENDICES

Appendix 1: Descriptive statistics

	LNFER	LNTB
Mean	5.003224	22.78683
Median	6.100319	22.72746
Maximum	8.452155	26.52293
Minimum	1.061114	20.05782
Std. Dev.	2.025074	1.315174
Skewness	-0.250653	0.558564
Kurtosis	1.795181	3.541903
Jarque-Bera	28.3816	25.69394
Probability	0.000001	0.000003
Sum	2001.29	9114.733
Sum Sq. Dev.	1636.269	690.1437
Observations	400	400

Appendix 2: Unit root test, LNTB (in Level)

Panel unit root test: Summary

Series: LNTB

Date: 04/07/26 Time: 14:46

Sample: 2005 2024

Exogenous variables: Individual effects

User-specified lags: 1

Newey-West automatic bandwidth selection and Bartlett kernel

Balanced observations for each test

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-3.36325	0.0004	20	360
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-0.78989	0.2148	20	360
ADF - Fisher Chi-square	50.4277	0.1249	20	360
PP - Fisher Chi-square	58.0121	0.0326	20	380

** Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution. All other tests assume asymptotic normality.

Appendix 3: Unit root test, LNTB (in first difference)

Panel unit root test: Summary

Series: D(LNTB)

Date: 04/07/26 Time: 14:47

Sample: 2005 2024

Exogenous variables: Individual effects

User-specified lags: 1

Newey-West automatic bandwidth selection and Bartlett kernel

Balanced observations for each test

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-8.17086	0.0000	20	340
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-6.35184	0.0000	20	340
ADF - Fisher Chi-square	112.028	0.0000	20	340
PP - Fisher Chi-square	146.681	0.0000	20	360

** Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution. All other tests assume asymptotic normality.

Appendix 4: Unit root test, LNFER (in Level)

Panel unit root test: Summary

Series: LNFER

Date: 04/07/26 Time: 14:48

Sample: 2005 2024

Exogenous variables: Individual effects

User-specified lags: 1

Newey-West automatic bandwidth selection and Bartlett kernel

Balanced observations for each test

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	1.56496	0.9412	20	360
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	5.34094	1.0000	20	360
ADF - Fisher Chi-square	14.7314	0.9999	20	360
PP - Fisher Chi-square	8.31841	1.0000	20	380

** Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution. All other tests assume asymptotic normality.

Appendix 5: Unit root test, LNFER (in first difference)

Panel unit root test: Summary

Series: D(LNFER)

Date: 04/07/26 Time: 14:48

Sample: 2005 2024

Exogenous variables: Individual effects

User-specified lags: 1

Newey-West automatic bandwidth selection and Bartlett kernel

Balanced observations for each test

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-7.56359	0.0000	20	340
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-6.43966	0.0000	20	340
ADF - Fisher Chi-square	113.624	0.0000	20	340
PP - Fisher Chi-square	130.304	0.0000	20	360

** Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution. All other tests assume asymptotic normality.

Appendix 6: Generalized Method of Moments (GMM) model results

Dependent Variable: D(LNTB)

Method: Panel Generalized Method of Moments

Transformation: First Differences

Date: 04/07/26 Time: 15:00

Sample (adjusted): 2008 2024

Periods included: 17

Cross-sections included: 20

Total panel (balanced) observations: 340

White period (period correlation) instrument weighting matrix

White period (cross-section cluster) standard errors & covariance (d.f. corrected)

Standard error and t-statistic probabilities adjusted for clustering

Instrument specification: @DYN(D(LNTB),-2) (-1)

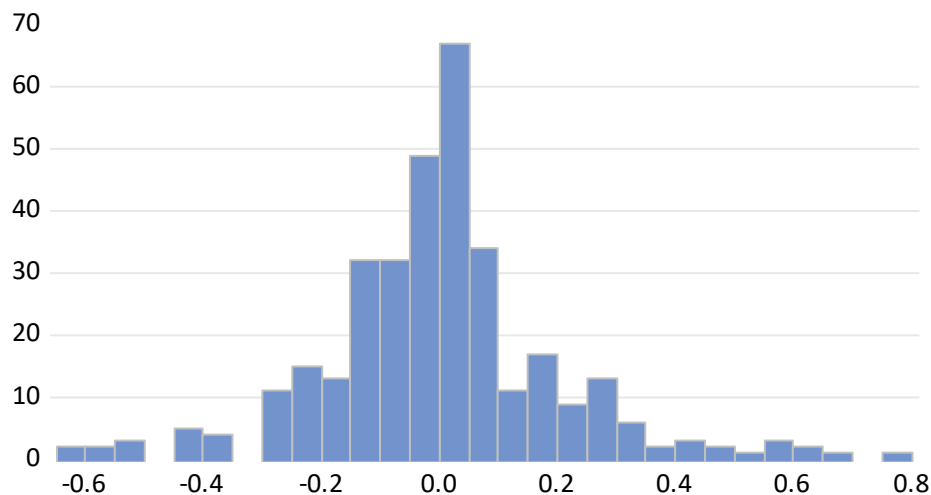
Constant added to instrument list.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LNTB(-1))	0.215576	0.016977	12.69836	0.0000
D(LNFER)	-0.899849	0.085609	-10.51115	0.0000

Effects Specification

Cross-section fixed (first differences)

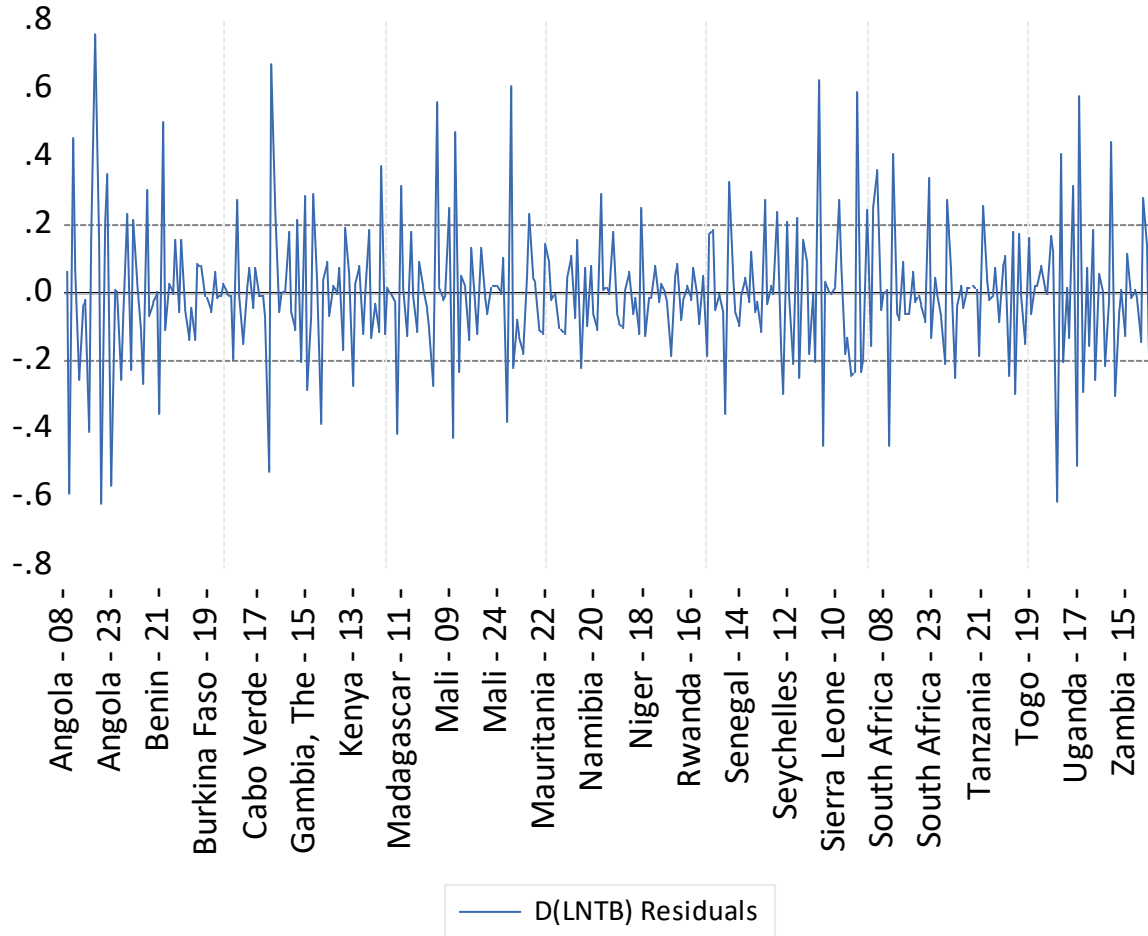
Mean dependent var	-0.003348	S.D. dependent var	0.206568
S.E. of regression	0.200405	Sum squared resid	13.57486
J-statistic	17.63408	Instrument rank	20
Prob(J-statistic)	0.479992		

Appendix 7: Normality test

Series: Standardized Residuals
Sample 2008 2024
Observations 340

Mean 0.000861
Median -3.31e-15
Maximum 0.764083
Minimum -0.615793
Std. Dev. 0.200108
Skewness 0.281631
Kurtosis 5.038123

Jarque-Bera 63.34212
Probability 0.000000

Appendix 8: Graph of residuals**Appendix 9: Serial Correlation Test**

Arellano-Bond Serial Correlation Test

Equation: EQ01

Date: 04/07/26 Time: 15:02

Sample: 2005 2024

Included observations: 340

Test order	m-Statistic	rho	SE(rho)	Prob.
AR(1)	-3.331784	-5.580599	1.674958	0.0009
AR(2)	-0.958727	-1.396052	1.456151	0.3377

Appendix 10: List of Sub-Saharan Africa countries in the study

Angola	Gambia, The	Mauritania	Senegal	Tanzania
Benin	Kenya	Namibia	Seychelles	Togo
Burkina Faso	Madagascar	Niger	Sierra Leone	Uganda
Cabo Verde	Mali	Rwanda	South Africa	Zambia