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FOREIGN EXCHANGE RATES AND TRADE BALANCE IN SUB-SAHARAN AFRICA

Nahabwe Patrick Kagambo John[1], Kagarura Willy Rwamparagi[2], Munyambonera Ezra[3]
[1]*Kabale University*
[2]*Kabale University*
[3]*Kabale University*

ABSTRACT
This study investigates the relationship between foreign exchange rates and trade balance in Sub-Saharan Africa from 2005 to 2022 using secondary World Bank data and an Auto Regressive Distributed Lags (ARDL) model. Trade balance serves as the dependent variable, while foreign exchange rates is the independent variable. Results indicate a statistically significant relationship, reflecting both short- and long-run dynamics. In the short term, a 10% increase in exchange rates worsens the trade balance by 7.5% (coefficient = -0.7543). However, the long-run coefficient (0.4580) shows a 4.6% improvement, demonstrating a J-curve adjustment pattern. Cointegration test confirm a long-term equilibrium between the variables. Model selection criteria and a low standard error further validate the model's robustness. Policy recommendations include prudent monetary and fiscal strategies to manage exchange rates and trade deficits. Short-term trade policies, like targeted subsidies can mitigate immediate impacts, while enhancing export competitiveness and regional trade integration supports long-term improvements.
KEY WORDS: *Foreign exchange rates, Trade Balance, Sub-Saharan Africa*

INTRODUCTION

Trade balance is a cornerstone of macroeconomic stability, influencing critical areas such as foreign exchange management, fiscal sustainability, and economic growth. For Sub-Saharan Africa (SSA), trade deficits have persisted for over five decades, reflecting structural imbalances in production and trade patterns. Most SSA economies depend heavily on the export of primary commodities, which are vulnerable to global price volatility, while importing high-value manufactured goods. This structural dependency exacerbates trade deficits and leaves economies susceptible to external shocks, inflationary pressures, and mounting debt burdens (World Bank, 2022; IMF, 2023).

Persistent trade deficits in SSA pose critical challenges to development. Despite efforts to enhance trade through regional agreements and policy reforms, exchange rate fluctuations remain a significant determinant of trade performance. Exchange rate depreciation is often viewed as a tool to boost exports and correct trade deficits. However, in SSA, short-term adjustments frequently exacerbate trade imbalances before long-term benefits materialize, reflecting the "J-curve" phenomenon (Bahmani-Oskooee & Hegerty, 2022). This duality underscores the complexity of exchange rate dynamics and their varying impacts on trade balances.

Rationale for this study stems from the urgent need to bridge gaps in understanding the exchange rate–trade balance relationship in SSA, especially given the region's unique economic and structural challenges. Existing research often generalizes findings from developed or emerging economies, overlooking SSA-specific dynamics such as reliance on aid, limited export diversification, and weak industrial bases. By employing panel data from 2005 to 2022 and applying Auto Regressive Distributed Lags (ARDL) models, this study seeks to provide empirical insights into the short- and long-term effects of exchange rate movements on trade balances in SSA. The findings aim to guide policy interventions that stabilize exchange rates, enhance trade competitiveness, and support sustainable economic growth in the region.

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LITERATURE REVIEW

Globally, the relationship between exchange rates and trade balance has been extensively explored. Studies often focus on the "J-curve effect", where currency depreciation initially worsens trade balance before yielding improvements over time. Magee (1973) first documented this phenomenon, attributing initial deficits to inelastic short-term responses of export and import volumes to price changes. More recently, Bahmani-Oskooee and Hegerty (2022) found mixed evidence of the J-curve in advanced and emerging economies, citing variations in export structures and levels of economic diversification. Empirical work by Freund and Pierola (2012) highlighted that export growth is highly sensitive to exchange rate movements in developing economies, especially where production relies on imported inputs.

In Sub-Saharan Africa (SSA), the dynamics between exchange rates and trade balances are influenced by the region's dependency on primary commodities and weak industrialization. Odhiambo (2021) found that exchange rate depreciation often fails to improve trade balances due to limited export diversification and persistent supply-side constraints. This is consistent with studies by the African Development Bank (AfDB, 2020), which emphasize that structural bottlenecks, such as inadequate infrastructure and high transaction costs, dilute the potential benefits of exchange rate adjustments. Furthermore, empirical analyses by Bahmani-Oskooee and Hegerty (2022) highlight significant variations across Sub-Saharan African countries, particularly between resource-rich and resource-scarce economies, in the impact of exchange rate fluctuations on trade balances.

At the country-specific level, studies on Uganda, Kenya, and Tanzania highlight comparable challenges. For instance, Kasekende and Atingi-Ego (2008) examined Uganda's trade performance, finding that reliance on low-value agricultural exports constrains the benefits of currency depreciation. Similarly, Were (2001) analyzed East African economies and demonstrated that weak industrialization across the region limits the ability to capitalize on competitive exchange rates for export growth. These findings underscore the importance of addressing structural bottlenecks through localized trade and industrial policies.

This study draws on the elasticity approach to balance of payments, which posits that trade balance responsiveness to exchange rate changes depends on the price elasticity of demand for exports and imports (Marshall-Lerner Condition). Additionally, the monetary approach to the balance of payments highlights the role of macroeconomic stability, suggesting that trade imbalances reflect broader monetary disequilibria (Frenkel & Johnson, 1976). These theories provide a foundation for understanding how exchange rate policies interact with trade balances in SSA.

DATA AND METHODS

This study employs a quantitative research design to examine the relationship between foreign exchange rates and trade balance in Sub-Saharan Africa from 2005 to 2022. Auto Regressive Distributed Lag (ARDL) model is used, as it is effective in analyzing both short- and long-term relationships, particularly when variables exhibit mixed levels of integration (Pesaran et al., 2001). This design is well-suited for economic studies where data stationarity varies across countries and periods.

The study focuses on 20 Sub-Saharan African countries (Appendix 7) selected based on data availability from the World Bank Development Indicators database (World Bank, 2022). The sample represents a mix of economies, capturing the diversity of exchange rate regimes and trade balances across the region. Variables include the foreign exchange rate (independent variable) and trade balance (dependent variable).

ARDL model is specified as follows:

$$TB_{it} = \alpha_0 + \sum_{p-1}^{k} \alpha_p \Delta TB_{i(t-p)} + \sum_{p-1}^{k} \beta_q \Delta FER_{i(t-q)} + \gamma TB_{i(t-1)} + \delta FER_{i(t-1)} + \varepsilon_{it} \quad \ldots\ldots\ldots(1)$$

Where;

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

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

Δ: First difference operator

α_p and β_q : Short-term coefficients

γ and δ: Long-term coefficients

ε_{it} : Error term. (Pesaran, Shin, and Smith (2001); Nkoro and Uko (2016))

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Pedroni Residual Cointegration test determines cointegration between variables (Pesaran et al., 2001), confirming the existence of a stable long-term relationship. In this context, model selection criteria such as the Akaike Information Criterion (AIC) and Schwarz Criterion (SC) ensure the optimal specification of the ARDL model. These criteria help select the model that best fits the data by balancing model complexity and goodness of fit (Nkoro & Uko, 2016).

Dependent Variable: 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, Obstfeld, & Melitz, 2018; Salvatore, 2016).
Independent Variable: Foreign exchange rate (FER), Official exchange rate (LCU per US$, period average) (World Bank 2022).

ARDL model's ability to handle mixed levels of integration and its suitability for small sample sizes make it appropriate for this study (Nkoro & Uko, 2016). Panel data analysis enhances the generalizability of findings, while the use of secondary data ensures reliability. These methods align with the study's objective to provide actionable insights into the interplay between foreign exchange rates and trade balances across Sub-Saharan Africa.

The conceptual framework examines the interplay between foreign exchange rates (independent variable) and trade balance (dependent variable) within SSA. Short- and long-term effects are modeled using ARDL and cointegration techniques to capture dynamic relationships. Unit root tests, including the Augmented Dickey-Fuller and Phillips-Perron tests, assess the stationarity of the data (Dickey & Fuller, 1981; Phillips & Perron, 1988).

RESULTS

Descriptive statistics provide valuable insights into the central tendencies and variability of the study variables. The key statistics for LNTB (trade balance) and LNFER (foreign exchange rate) are summarized in Appendix 1. The average values for LNTB (22.723) and LNFER (4.958) suggest moderate levels of trade balance and foreign exchange rates throughout the study period. The standard deviations, 1.303 for LNTB and 2.031 for LNFER, reflect considerable variability across the sample countries and years, implying that both trade balance and foreign exchange rates differ substantially from country to country.

For LNTB, the positive skewness value of 0.608 indicates a right-skewed distribution, meaning most observations are concentrated at the lower end of the scale, with fewer extreme high values. This aligns with the findings of Rosenbaum & Rubinfeld (2001), who suggested that trade balance data often exhibits right-skewness due to economic imbalances. In contrast, LNFER shows negative skewness (-0.255), suggesting that the foreign exchange rate data is more heavily clustered toward the higher end, with fewer extreme low values, as observed in studies such as Glick & Hutchison (2000) on exchange rate fluctuations.

Both variables exhibit leptokurtic distributions, with kurtosis values greater than 3, indicating higher peaks and fatter tails than a normal distribution. The kurtosis for LNTB is 3.596, and for LNFER, it is 1.785. These findings suggest that both variables are more prone to extreme values compared to a normal distribution (Emery, 1994). The Jarque-Bera test statistics for both variables (27.542 for LNTB and 26.073 for LNFER) have associated probability values near zero, confirming that both variables deviate significantly from normality, with LNTB exhibiting a more pronounced departure.

Auto Regressive Distributed Lag (ARDL) model results (Appendix: 5)

$$\widehat{TB}_{it} = 5.877283 + 0.156654TB_{i(t-p)} - 0.754274FER_{i(t-q)} + 0.457974FER_{i(t-1)} \quad \text{……..(2)}$$

Auto Regressive Distributed Lag (ARDL) model above, reveals a statistically significant relationship between foreign exchange rates and trade balance in Sub-Saharan Africa. Key findings include:

The constant term (5.877283) indicates the baseline level of the trade balance when the foreign exchange rate and other explanatory variables are held constant. This positive constant suggests that in the absence of changes in the foreign exchange rate, trade balance would be approximately 5.88 units. It essentially reflects the long-term equilibrium level of the trade balance when external factors are not influencing it.

The short-run coefficient of foreign exchange rates is negative (-0.754), indicating that a 10% depreciation in exchange rates leads to a 7.5% deterioration in trade balances. This suggests that Sub-Saharan countries face immediate challenges in adjusting trade balances following exchange rate fluctuations.

The short-run coefficient of lagged trade balance is positive (0.156654), indicating that a 10% increase in the previous period's trade balance contributes to a 1.57% improvement in the current trade balance. This suggests a degree of persistence in trade balance adjustments, where past performance has a direct, reinforcing impact on current outcomes.

The long-run coefficient was positive (0.458), implying that a 10% depreciation improves trade balance by 4.6% over time. This result aligns with the J-curve effect, where initial trade deficits worsen due to lags in export and import adjustments but improve in the long run as exports become more competitive.

Pedroni Residual Cointegration test (Appendix 6) confirms the existence of a long-term relationship between foreign exchange rates and trade balance, indicating a stable equilibrium over time. The test results reveal a failure to reject the null hypothesis of no cointegration, even though the variables are integrated of different orders (I(1) and I(0), respectively). This finding validates the ARDL approach as a suitable method for analyzing both short- and long-run dynamics. The results underscore a persistent and stable linkage between foreign exchange rates and trade balance adjustments, reflecting the interconnected economic dynamics within Sub-Saharan economies.

Diagnostic diagnostics reveal that the standard error of regression (0.124) is significantly lower than the standard deviation of the dependent variable (0.169), suggesting that the model effectively explains variations in trade balance. Information Criteria: Akaike (AIC), Schwarz (SC), and Hannan-Quinn (HQ) criteria are all negative and minimized, indicating optimal model fit. Unit root tests (Appendices 2, 3, and 4) confirm that the variables are stationary at different integration orders, addressing potential non-stationarity issues.

Normality test (Appendix 7) show no significant deviations, affirming the reliability of the estimated ARDL model. The results align with the J-curve hypothesis, demonstrating that trade balance initially deteriorates due to adverse short-term pressures but improves in the long term as economies adjust to changes in foreign exchange rates. These findings highlight the importance of designing adaptive trade policies that cushion immediate economic impacts while leveraging the long-term benefits of exchange rate adjustments.

DISCUSSION

Results of this study contribute to the growing body of literature on the relationship between foreign exchange rates and trade balance in Sub-Saharan Africa. Our findings align with some previous studies that suggest a significant short- and long-term relationship between exchange rates and trade balances (Bahmani-Oskooee & Alse, 1993; Bleaney & Greenaway, 2001). Specifically, the observed short-run negative coefficient (-0.754274) for foreign exchange rates indicates that an increase in the exchange rate initially worsens the trade balance, a phenomenon consistent with the J-curve effect. This result mirrors findings from studies by Rose (1991) and Arize (2002), who similarly found that the trade balance deteriorates in the short run after a currency depreciation before improving in the long run.

In the long run, the positive coefficient (0.457974) suggests that an increase in the exchange rate can improve the trade balance, supporting the J-curve scenario, where trade balances adjust over time in response to exchange rate fluctuations. This result aligns with the study by Bahmani-Oskooee and Hegerty (2022), which identified long-term beneficial effects of currency depreciation on trade balances in emerging and advanced economies.

However, the unique contribution of this study lies in its focus on Sub-Saharan Africa, a region often characterized by high economic volatility, structural imbalances, and trade deficits (Asongu, 2014). The study highlights that despite the challenges faced by Sub-Saharan economies, exchange rate adjustments do have significant long-term effects on trade balance, which may not be immediately evident due to short-term trade frictions. This is an important insight for policymakers, as it suggests that, while currency devaluation might worsen trade balances in the short run, it could lead to more favorable trade outcomes in the long term, supporting the adoption of more flexible exchange rate policies.

Additionally, the findings underscore the need for tailored trade policies in Sub-Saharan Africa that not only focus on currency stabilization but also address structural issues such as trade barriers, supply-side constraints, and export diversification, which have historically hindered the region's ability to benefit fully from exchange rate adjustments (Narayan, 2004).

In terms of methodological contributions, the study validates the use of the ARDL model in capturing both short-term and long-term dynamics between exchange rates and trade balance, even when the variables exhibit different orders of integration (I(0) and I(1)), as confirmed by the Pedroni cointegration test. This methodological robustness contrasts with previous studies that predominantly used traditional cointegration techniques, which may not be as effective in capturing the nuances of the relationship between exchange rates and trade balances in regions like Sub-Saharan Africa (Pesaran et al., 2001).

In conclusion, while the study confirms the well-established relationship between exchange rates and trade balances, it adds a regional dimension that highlights the unique challenges faced by Sub-Saharan Africa. The findings are particularly valuable for shaping policies that foster long-term economic stability, suggesting that short-term trade imbalances caused by exchange rate fluctuations should not deter policies aimed at long-term trade improvements.

LIMITATIONS

While this study provides valuable insights into the relationship between foreign exchange rates and trade balance in Sub-Saharan Africa, there are several limitations to be considered that could have impacted the findings.

First, the study uses secondary data from the World Bank, which may have limitations in terms of accuracy and consistency across countries. Variations in data reliability, especially in nations with weaker statistical systems, could influence the robustness of the results, as highlighted by Jerven (2013) and Deaton (2010). Moreover, the use of annual data may mask shorter-term fluctuations that could be important in understanding the full dynamics of trade balance adjustments to exchange rate changes (Frankel, 2009). Quarterly or monthly data could have provided a more detailed view of these relationships.

Secondly, the study relies on the ARDL approach, which, while suitable for models with variables integrated of different orders, assumes linear relationships between the variables. The potential for non-linearities or structural breaks over time in the exchange rate–trade balance relationship was not considered. Structural changes, such as political or economic crises, might have had significant effects on the trade balance but were not accounted for in this model. This oversight could have led to an underestimation or overestimation of the true relationship (Bleaney & Greenaway, 2001).

Additionally, the study does not consider the impact of external factors, such as global commodity prices or international trade agreements, which can significantly influence trade balances in Sub-Saharan Africa. These external variables may not be adequately captured by the model, thus limiting the comprehensiveness of the analysis (Asongu, 2014). Furthermore, the study does not address the role of other domestic factors, such as infrastructure development, which could also mediate the effects of exchange rate changes on trade balance.

Finally, the model assumes homogeneity across all Sub-Saharan African countries, ignoring the significant economic and structural differences between these countries. Some countries in the region may experience different economic dynamics that are not captured by a single regional model (Narayan, 2004). Future research could benefit from a country-specific analysis or a multi-country analysis with disaggregated data to better understand the heterogeneity in the exchange rate–trade balance relationship within the region.

In conclusion, while this study provides useful insights, it is subject to these limitations, and future research should seek to address these shortcomings by incorporating more detailed data, considering non-linear relationships, and accounting for external and domestic factors that may influence the trade balance in Sub-Saharan Africa.

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CONCLUSION

This study explored the relationship between foreign exchange rates and trade balance in Sub-Saharan Africa over the period 2005 – 2022, employing the ARDL approach to analyze both short- and long-term dynamics. The findings reveal a statistically significant relationship, with foreign exchange rate fluctuations playing a critical role in shaping the trade balance. The short-run analysis highlighted a negative impact of foreign exchange rate changes on trade balance, while the long-run analysis suggested a positive adjustment over time, embodying a typical J-curve scenario. These results underscore the complexity of the trade balance dynamics in the region, reflecting both immediate economic pressures and longer-term adjustments.

The study contributes to existing literature by providing empirical evidence of the interdependence between exchange rate movements and trade balances, particularly in the context of Sub-Saharan Africa, where persistent trade deficits have been a long-standing issue. While previous studies have explored similar relationships globally (Krugman & Obstfeld, 2009; Rose, 2015), this study offers a region-specific perspective, emphasizing the need for region-tailored policy interventions.

However, the study is not without limitations, including the use of annual data and the exclusion of other macroeconomic factors such as global commodity prices and trade policies, which may further influence the trade balance. Future research could build on this foundation by incorporating more granular data, considering external shocks, and examining the heterogeneity of effects across different countries in the region.

Overall, the study's findings highlight the importance of adopting adaptive policies that can mitigate the short-term adverse effects of foreign exchange rate fluctuations while leveraging the long-term benefits for trade balance improvement. Policymakers should focus on creating stable exchange rate environments and strategic trade policies that support sustainable economic growth and reduce the region's dependency on external shocks.

RECOMMENDATIONS

Based on the findings of this study, several policy, program, and research recommendations are proposed to address the challenges and opportunities presented by the relationship between foreign exchange rates and trade balances in Sub-Saharan Africa.

To mitigate the short-term adverse effects of exchange rate fluctuations on trade balance, policymakers should prioritize measures that stabilize the exchange rate, such as effective foreign exchange reserves management and building a robust financial infrastructure. This will help reduce the volatility of exchange rates, which can have negative implications for trade balances (Calvo & Reinhart, 2002).

Policymakers should design flexible trade policies that not only respond to immediate shocks but also capitalize on long-term benefits. These policies should be aimed at improving the competitiveness of local industries and diversifying exports to minimize the trade deficit (Aghion et al., 2001). Moreover, exchange rate adjustments should be coupled with trade facilitation measures and infrastructure improvements to enhance export capacity.
To reduce dependency on volatile foreign exchange rates, it is crucial for Sub-Saharan African countries to diversify their export markets and product offerings. Strengthening trade agreements with non-traditional partners and focusing on value-added exports could be key strategies to improve trade balances (World Bank, 2020).

Given the influence of external factors such as trade agreements on trade balances, it is recommended that Sub-Saharan African countries invest in programs that enhance the negotiation capacity of trade representatives, enabling them to secure favorable terms and reduce the impact of adverse exchange rate movements (UNCTAD, 2018).

Governments should support export promotion programs that encourage the growth of sectors with high export potential, including agriculture, manufacturing, and services. Such programs can help mitigate the negative short-term effects of exchange rate fluctuations by ensuring that countries have a steady flow of exports that support a favorable trade balance.

Future studies should explore the effects of exchange rate volatility on trade balance at a more granular level, utilizing monthly or quarterly data rather than annual data to capture the nuances of short-term dynamics. This would allow for

a more precise understanding of the temporal effects of foreign exchange rate fluctuations on trade balances (Bergstrand & Egger, 2018).

It would be beneficial for future research to consider incorporating external factors such as global commodity prices, international trade policies, and geopolitical risks, which also play critical roles in influencing trade balances. This would provide a more comprehensive view of the complex relationship between exchange rates and trade balances in Sub-Saharan Africa.

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APPENDICES

Appendix 1: Descriptive statistics

	LNTB	LNFER
Mean	22.72312	4.958466
Median	22.66982	6.100319
Maximum	26.29797	8.317795
Minimum	20.05782	1.061114
Std. Dev.	1.303215	2.030916
Skewness	0.608428	-0.25531
Kurtosis	3.596138	1.7845
Jarque-Bera	27.54177	26.0726
Probability	0.000001	0.000002
Sum	8180.323	1785.048
Sum Sq. Dev.	609.7144	1480.738
Observations	360	360

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

Panel unit root test: Summary
Series: LNTB
Date: 12/03/24 Time: 15:53
Sample: 2005 2022
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*	-6.10733	0.0000	20	320
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-3.31145	0.0005	20	320
ADF - Fisher Chi-square	70.6565	0.0020	20	320
PP - Fisher Chi-square	90.7962	0.0000	20	340

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

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Appendix 3: Unit root test, LNFER (in Level)

Panel unit root test: Summary
Series: LNFER
Date: 12/03/24 Time: 15:54
Sample: 2005 2022
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*	0.66502	0.7470	20	320
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	3.68407	0.9999	20	320
ADF - Fisher Chi-square	15.4263	0.9998	20	320
PP - Fisher Chi-square	21.7212	0.9918	20	340

** 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 First difference)

Panel unit root test: Summary
Series: D(LNFER)
Date: 12/03/24 Time: 15:58
Sample: 2005 2022
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*	-8.66530	0.0000	20	300
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-7.79663	0.0000	20	300
ADF - Fisher Chi-square	133.799	0.0000	20	300
PP - Fisher Chi-square	151.758	0.0000	20	320

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

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Appendix 5: Auto Regressive Distributed Lag (ARDL) model results

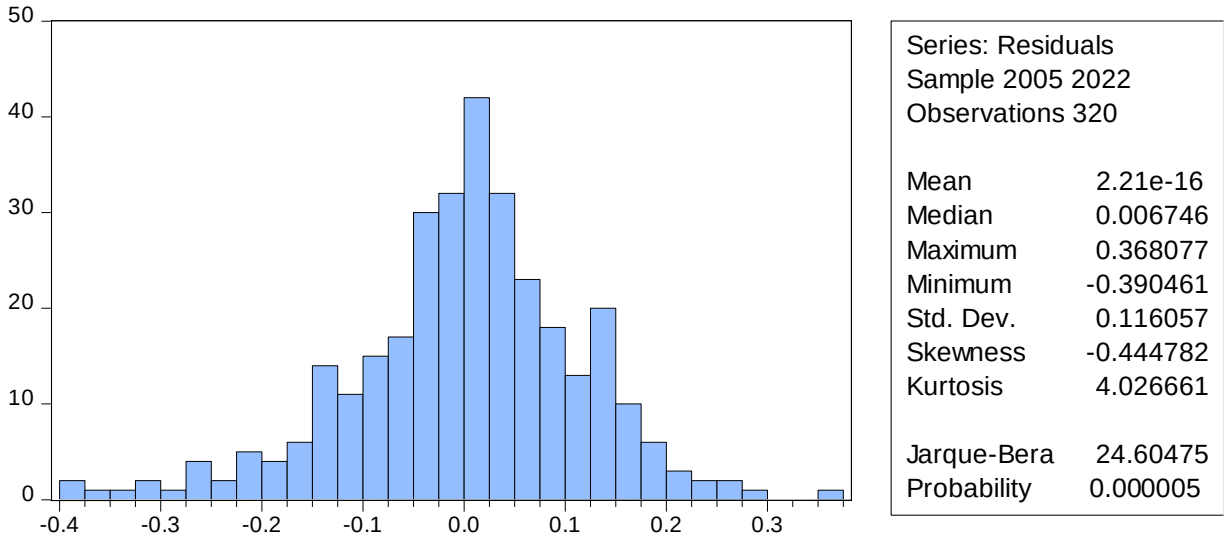
Dependent Variable: D(LNTB)
Method: ARDL
Date: 12/03/24 Time: 16:12
Sample: 2007 2022
Included observations: 320
Maximum dependent lags: 4 (Automatic selection)
Model selection method: Akaike info criterion (AIC)
Dynamic regressors (4 lags, automatic): LNFER
Fixed regressors: C
Number of models evalulated: 16
Selected Model: ARDL(2, 1)
Note: final equation sample is larger than selection sample

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
Long Run Equation				
LNFER	0.457974	0.075796	6.042203	0.0000
Short Run Equation				
COINTEQ01	-0.290167	0.059804	-4.851984	0.0000
D(LNTB(-1))	0.156654	0.061214	2.559120	0.0110
D(LNFER)	-0.754274	0.130373	-5.785529	0.0000
C	5.877283	1.128395	5.208534	0.0000

Mean dependent var	0.063305	S.D. dependent var	0.169028
S.E. of regression	0.124098	Akaike info criterion	-1.054884
Sum squared resid	4.296709	Schwarz criterion	-0.180511
Log likelihood	270.8791	Hannan-Quinn criter.	-0.707217

*Note: p-values and any subsequent tests do not account for model selection.

Appendix 5: Normality test



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Appendix 6: Cointegration test

Pedroni Residual Cointegration Test
Series: LNTB LNFER
Date: 12/03/24 Time: 16:17
Sample: 2005 2022
Included observations: 360
Cross-sections included: 20
Null Hypothesis: No cointegration
Trend assumption: No deterministic trend
User-specified lag length: 1
Newey-West automatic bandwidth selection and Bartlett kernel

Alternative hypothesis: common AR coefs. (within-dimension)

	Statistic	Prob.	Weighted Statistic	Prob.
Panel v-Statistic	0.163523	0.4351	0.080163	0.4681
Panel rho-Statistic	-1.062543	0.1440	-1.355916	0.0876
Panel PP-Statistic	-4.166302	0.0000	-4.879193	0.0000
Panel ADF-Statistic	-6.580493	0.0000	-7.116657	0.0000

Alternative hypothesis: individual AR coefs. (between-dimension)

	Statistic	Prob.
Group rho-Statistic	0.720031	0.7642
Group PP-Statistic	-4.517864	0.0000
Group ADF-Statistic	-7.570638	0.0000

Cross section specific results

Phillips-Peron results (non-parametric)

Cross ID	AR(1)	Variance	HAC	Bandwidth	Obs
Angola	0.615	0.081775	0.108644	1.00	17
Benin	0.497	0.044949	0.037896	11.00	17
Burkina Faso	0.630	0.069103	0.064552	3.00	17
Cabo Verde	0.287	0.020408	0.015589	16.00	17
Gambia, The	0.385	0.008823	0.009527	1.00	17
Kenya	0.414	0.013868	0.013868	0.00	17
Madagascar	0.320	0.029315	0.016400	16.00	17
Mali	0.492	0.035383	0.027295	4.00	17
Mauritania	0.576	0.035998	0.035998	0.00	17
Namibia	0.590	0.013883	0.013883	0.00	17
Niger	0.681	0.027026	0.028712	2.00	17
Rwanda	0.666	0.011566	0.015798	1.00	17
Senegal	0.544	0.039980	0.035623	4.00	17
Seychelles	0.468	0.028474	0.028011	2.00	17
Sierra Leone	0.840	0.046529	0.089287	2.00	17
South Africa	0.374	0.017382	0.011193	5.00	17
Tanzania	0.681	0.022162	0.028566	1.00	17
Togo	0.658	0.020099	0.020099	0.00	17
Uganda	0.619	0.026767	0.035997	1.00	17
Zambia	0.582	0.042573	0.042573	0.00	17

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Augmented Dickey-Fuller results (parametric)

Cross ID	AR(1)	Variance	Lag	Max lag	Obs
Angola	0.434	0.061366	1	--	16
Benin	0.248	0.036374	1	--	16
Burkina Faso	0.500	0.064358	1	--	16
Cabo Verde	-0.019	0.016785	1	--	16
Gambia, The	0.148	0.008086	1	--	16
Kenya	0.269	0.012871	1	--	16
Madagascar	-0.163	0.015258	1	--	16
Mali	0.335	0.034321	1	--	16
Mauritania	0.471	0.033831	1	--	16
Namibia	0.521	0.013049	1	--	16
Niger	0.548	0.020653	1	--	16
Rwanda	0.609	0.007883	1	--	16
Senegal	0.235	0.031619	1	--	16
Seychelles	0.337	0.028918	1	--	16
Sierra Leone	0.753	0.023441	1	--	16
South Africa	0.085	0.015474	1	--	16
Tanzania	0.570	0.017658	1	--	16
Togo	0.544	0.019130	1	--	16
Uganda	0.496	0.019601	1	--	16
Zambia	0.604	0.041629	1	--	16

Appendix 7: 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