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Asymmetric Exchange Rate Pass-Through to Private Credit in Zambia: A Nonlinear ARDL Analysis

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Abstract: Exchange-rate movements constitute an important channel of monetary transmission in commodity-exporting emerging economies, where foreign-currency liabilities, concentrated export structures and relatively shallow financial markets amplify their effects on private-sector credit. Existing work on Zambia relies primarily on symmetric linear models that impose identical responses to exchange-rate depreciations and appreciations, an assumption that may obscure important nonlinear adjustment. This study evaluates that assumption using a nonlinear autoregressive distributed lag (NARDL) model estimated with 55 quarterly observations covering 2012Q2–2025Q4. Exchange-rate movements are decomposed into cumulative depreciations (EX^{+}) and appreciations (EX^{-}), while controlling for real GDP, international copper prices and the COVID-19 structural break. The variables exhibit a stable long-run relationship (bounds F = 4.30). A permanent 1% depreciation increases private-sector credit by 1.386%, whereas a comparable appreciation reduces credit by 2.189%. The Wald test rejects long-run symmetry (F = 23.37, $p < 0.001$), while short-run responses remain statistically symmetric. These findings indicate that treating exchange-rate responses as symmetric systematically understates the contractionary effects of appreciation episodes. The analysis highlights the importance of incorporating both the direction and persistence of exchange-rate movements into monetary and macroprudential policy frameworks in commodity-dependent economies.

Keywords: *Exchange-Rate Asymmetry; Private Credit; Nonlinear ARDL; Bank of Zambia; Macroprudential Policy, Zambia.*

JEL Classification: *E52, F31, G21, O55.*

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I. INTRODUCTION

Exchange-rate movements constitute a primary channel through which external shocks are transmitted to domestic financial systems in open economies. They influence the domestic-currency cost of imports, the valuation of foreign-currency assets and liabilities on bank and corporate balance sheets, and the funding conditions of financial institutions with external borrowing exposure (Fleming, 1962; Mundell, 1963). Exchange-rate pass-through to consumer prices is generally incomplete, time-varying and substantially stronger in developing economies, where import dependence is high, monetary credibility is weaker, financial markets remain relatively shallow, and exports are concentrated in dollar-priced commodities (Choudhri and Hakura, 2006; Goldberg and Knetter, 1997; McCarthy, 2000).

These characteristics describe Zambia closely. Recent evidence further indicates that exchange-rate pass-through in sub-Saharan Africa exceeds that observed in many other regions and varies systematically with exchange-rate regimes and natural-resource dependence (Kemoe et al., 2024). Far less attention, however, has been devoted to the pass-through of exchange-rate movements to private-sector credit. This distinction is important because, in bank-based emerging economies, the quantity of intermediated credit often constitutes the principal mechanism through which external shocks influence investment and real economic activity. As emphasized by the financial accelerator framework, exchange-rate movements may alter credit supply by affecting borrower net worth, collateral values and banks' funding capacity (Bernanke and Gertler, 1995; Bernanke et al., 1999).

Growing evidence suggests that this transmission is inherently asymmetric. In economies with substantial foreign-currency liabilities, exchange-rate depreciation may weaken balance sheets sufficiently to offset the conventional competitiveness gains associated with a weaker currency (Céspedes et al., 2004). Such asymmetry has long been recognized as an important explanation for the "fear of floating" observed among emerging-market central banks

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(Calvo and Reinhart, 2002). External financial conditions may reinforce these domestic mechanisms, as dollar-funded intermediaries expand cross-border lending during periods of dollar weakness and retrench when the dollar strengthens (Bruno and Shin, n.d.; Miranda-Agrippino and Rey, 2020).

Empirical evidence similarly points to heterogeneous exchange-rate effects across emerging markets. Beckmann and Comunale (2021), for example, show that appreciation may initially stimulate foreign-currency borrowing but ultimately restrain credit as competitiveness deteriorates. Within sub-Saharan Africa, Yusuf et al. (2025) identify significant exchange-rate asymmetry in Nigeria, where appreciation exerts the dominant influence through fiscal and oil-revenue transmission channels. Collectively, this evidence suggests that both the existence and direction of asymmetry depend on country-specific institutional and financial structures rather than representing a universal characteristic of exchange-rate transmission.

Despite these developments, empirical evidence for Zambia continues to rely predominantly on symmetric linear specifications. Existing structural VAR and error-correction models estimate a single exchange-rate elasticity that implicitly assumes identical responses to currency depreciation and appreciation (Chileshe and Akanbi, 2017; Mwange, 2022; Simpasa et al., 2014). Where nonlinear approaches have been adopted, they have focused primarily on consumer prices (Fandamu et al., 2023) or aggregate output (Mwiya et al., 2024), leaving the exchange rate–credit nexus largely unexplored. The Bank of Zambia's monetary policy framework likewise recognizes the exchange-rate channel but treats its transmission as directionally uniform (Bank of Zambia, 2023).

Two implications follow. First, the assumption of symmetry has not been formally tested in the Zambian context. Second, imposing symmetry on an inherently asymmetric adjustment process may obscure long-run relationships and generate exchange-rate elasticities that represent averages of fundamentally different responses (Granger and Yoon, 2002). These issues have direct implications for monetary policy because estimated exchange-rate elasticities influence the calibration of policy interventions and the assessment of financial-sector vulnerabilities.

Zambia provides a particularly suitable setting for examining these issues. The exchange rate closely follows the commodity cycle, with periods of rising copper prices typically associated with currency appreciation and reserve accumulation, and downturns characterised by sharp depreciations. The sample period (2012Q2–2025Q4) begins with the adoption of a fully floating exchange-rate regime and encompasses several major macroeconomic events, including the 2015–2016 commodity price collapse, the COVID-19 pandemic, the November 2020 sovereign default and the subsequent debt restructuring completed under the G20 Common Framework (IMF, 2023). Because international copper prices influence both exchange-rate dynamics and domestic credit conditions in commodity-exporting economies (Chen and Rogoff, 2003; Mendoza and Terrones, 2012), controlling for the commodity cycle is essential for identifying exchange-rate effects that are not confounded by fluctuations in export earnings.

Against this background, the study addresses four questions; (1) does a stable long-run relationship exist between exchange-rate movements and private-sector credit in Zambia? (2) do currency depreciations and appreciations exert symmetric long-run effects on credit? (3) do short-run responses differ from long-run adjustment dynamics? (4) how do real GDP, international copper prices and the COVID-19 structural break influence the exchange rate–credit relationship?

This study makes three principal contributions to the literature. Methodologically, it provides the first application of the nonlinear autoregressive distributed lag (NARDL) framework to the exchange rate–private credit relationship in Zambia, formally testing the symmetry assumption that underpins the existing literature. Empirically, it extends previous analyses by incorporating the post-2020 sovereign default period and explicitly controlling for international copper prices and the COVID-19 structural break, thereby isolating exchange-rate effects from broader commodity-cycle and crisis-related influences. Conceptually, the study develops a three-channel framework that distinguishes the sequential mechanisms through which exchange-rate movements affect private-sector credit across different adjustment horizons. Through linking nonlinear exchange-rate transmission to balance-sheet adjustment, financial frictions and institutional dynamics, the framework provides a coherent interpretation of the empirical evidence while offering a structure that is applicable to other commodity-dependent economies.

The remainder of the paper is organized as follows. Section 2 develops the conceptual framework and derives the testable hypotheses. Section 3 describes the data and empirical methodology. Section 4 presents the empirical results. Section 5 discusses their broader implications and associated policy considerations. Section 6 concludes and outlines the limitations of the study together with directions for future research.

- *Conceptual Framework*

Exchange-rate movements affect private-sector credit through multiple transmission mechanisms that operate over different adjustment horizons. Immediate responses primarily reflect mechanical balance-sheet revaluations, whereas subsequent adjustments increasingly depend on firms' financial positions, sectoral dynamics and credit-market frictions. Consequently, the effects of currency depreciation and appreciation need not be symmetric over time. Building on the nonlinear exchange-rate framework of Shin et al. (2014), Figure 1 conceptualizes exchange-rate transmission as a sequence of interrelated channels linking exchange-rate shocks to bank lending behaviour. The framework provides the theoretical foundation for the empirical analysis and establishes a set of testable propositions.

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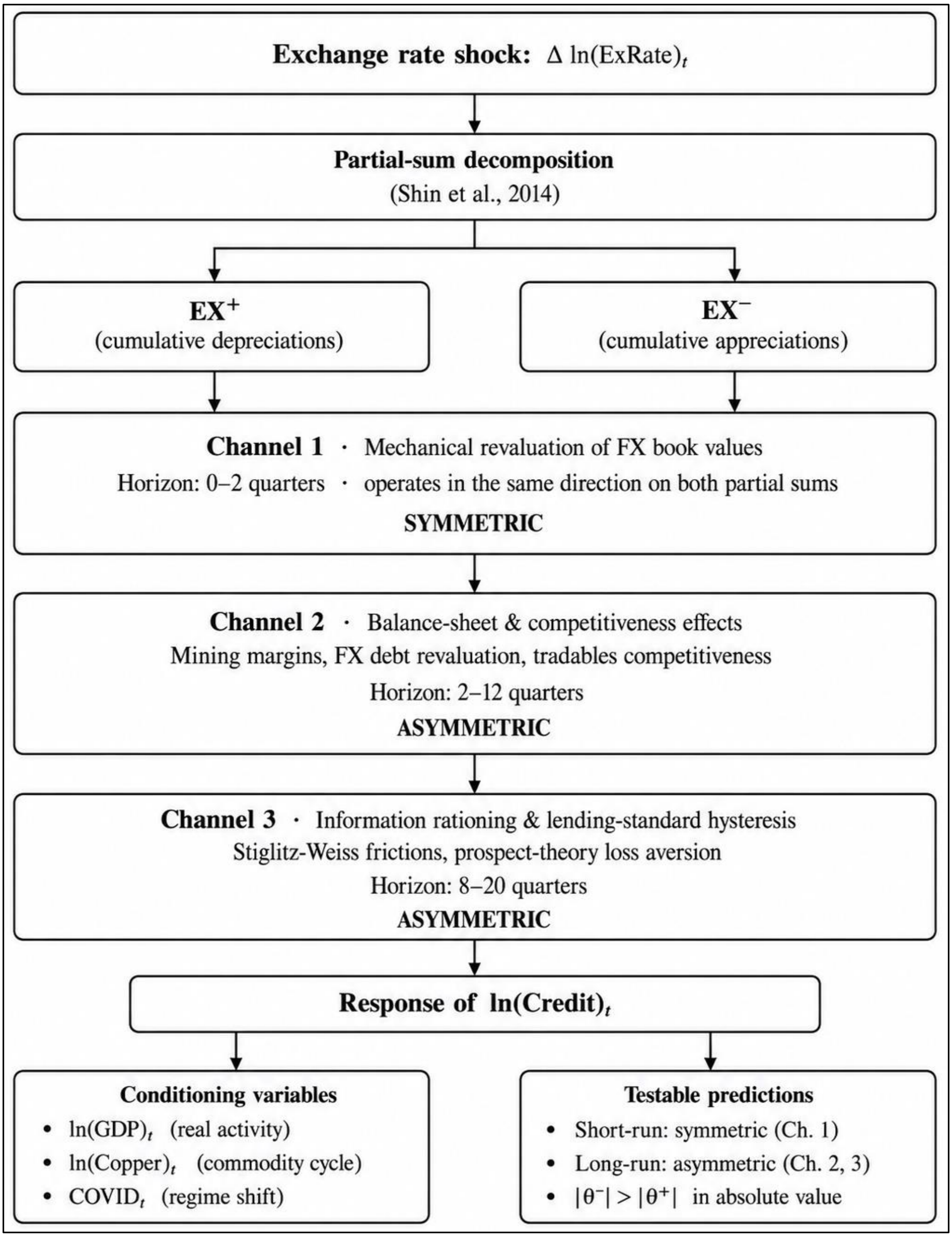

Fig 1 Three-Channel Conceptual Framework for the Transmission from Exchange Rate Movements to Private Credit.

Exchange-rate transmission begins with a currency shock that is decomposed into cumulative depreciations (EX^{+}) and cumulative appreciations (EX^{-}) following the partial-sum approach of Shin et al. (2014). Unlike conventional linear specifications, this decomposition allows depreciation and appreciation to influence private-sector credit through distinct adjustment processes, thereby accommodating the possibility of nonlinear exchange-rate transmission.

The first transmission channel operates through the mechanical revaluation of foreign-currency balance sheets. Exchange-rate movements immediately alter the domestic-currency value of foreign-currency assets and liabilities held by banks and firms. In Zambia, where foreign-currency

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deposits, loans and other external exposures account for a substantial share of banking-sector balance sheets (Bank of Zambia, 2023), these valuation effects are economically significant. Because the adjustment depends on the scale of foreign-currency exposure rather than on the direction of the exchange-rate movement, the initial response is expected to be broadly symmetric. During the first one to two quarters, depreciation and appreciation should therefore generate statistically similar responses in private-sector credit.

Beyond the initial revaluation period, transmission increasingly reflects changes in firms' balance sheets and financing conditions. Zambia's economy is dominated by the mining sector, which accounts for approximately 70 percent of merchandise export earnings and represents the largest source of corporate borrowing (Simpasa et al., 2014**.** Exchange-rate movements therefore influence export revenues, collateral values, investment incentives and debt-servicing capacity simultaneously. Currency depreciation strengthens domestic-currency export receipts, improves collateral values and enhances borrowing capacity, whereas appreciation compresses export revenues and weakens firms' financial positions.

These adjustments, however, are unlikely to be mirror images. Mining production relies heavily on imported capital equipment and intermediate inputs denominated in foreign currency (Céspedes et al., 2004), while both the corporate sector and the public sector carry substantial unhedged foreign-currency liabilities (IMF, 2023). Appreciation therefore reduces debt-servicing costs but simultaneously lowers export revenues, producing only a partial offset to deteriorating collateral positions. Moreover, export participation exhibits hysteresis because sunk entry and exit costs discourage firms from adjusting production immediately following exchange-rate movements (Baldwin and Krugman, 1989). External financial conditions further reinforce these domestic mechanisms, as fluctuations in global dollar liquidity influence cross-border bank lending and the availability of credit (Bruno and Shin, 2015; Miranda-Agrippino and Rey, 2020). These mechanisms imply that exchange-rate asymmetry emerges progressively as financial adjustment unfolds rather than immediately following the initial shock.

The third transmission channel reflects the persistence of credit-market frictions. Deteriorating borrower balance sheets increase information asymmetries, encouraging banks to tighten collateral requirements and lending standards more readily than they relax them when conditions improve (Stiglitz and Weiss, 1981). Behavioural responses reinforce this tendency, as lenders generally react more strongly to adverse information than to equivalent favourable developments (Barberis and Thaler, 2003). Once established, tighter lending standards tend to persist because of relationship lending and institutional inertia (Fishman et al., 2024), allowing the divergence between depreciation and appreciation responses to widen over longer horizons.

The framework also recognizes several conditioning variables that influence credit dynamics without altering the fundamental transmission mechanism. Real economic activity captures fluctuations in credit demand independent of exchange rate movements and is therefore required to isolate the exchange rate effect. International copper prices simultaneously affect the exchange rate through export earnings and influence private credit through mining profitability, collateral values, fiscal revenues, and investment activity (Chen and Rogoff, 2003; Mendoza and Terrones, 2012). Excluding copper prices would therefore confound commodity-price effects with exchange rate transmission. Finally, major structural disruptions, including the COVID-19 pandemic and Zambia's sovereign default in November 2020, represent regime shifts that altered banking-sector behaviour and credit conditions independently of exchange rate movements. Accounting for these structural breaks is essential to obtain unbiased estimates of long-run exchange rate effects.

The framework generates four propositions that guide the empirical analysis. First, exchange-rate movements, private-sector credit and the associated macroeconomic fundamentals are expected to exhibit a stable long-run relationship. Second, the initial balance-sheet revaluation should produce broadly symmetric short-run responses to depreciation and appreciation. Third, asymmetry should strengthen progressively as balance-sheet adjustment and credit-market frictions accumulate, resulting in a larger long-run response to appreciation than to depreciation in absolute terms. Finally, international copper prices are expected to exert a positive long-run influence on private-sector credit by strengthening export revenues, improving collateral quality and stimulating investment. These propositions provide the theoretical basis for interpreting the empirical evidence presented in the subsequent sections.

II. DATA AND EMPIRICAL STRATEGY

➢ *Data and Variables*

The empirical analysis employs a balanced quarterly dataset comprising 55 observations spanning 2012Q2–2025Q4**.** The sample begins in 2012Q2, corresponding to Zambia's transition to a fully floating exchange-rate regime, thereby ensuring a consistent monetary and exchange-rate policy environment throughout the estimation period. Private-sector credit **(**Credit**)** is obtained from the Bank of Zambia Monthly Statistical Bulletins and is measured as the outstanding stock of loans and advances extended by deposit-taking financial institutions to the private sector. The bilateral nominal exchange rate **(**ExRate**)** is measured as the quarterly average of the daily ZMW/USD reference rate published by the Bank of Zambia. Real gross domestic product **(**GDP**)** at constant 2010 prices is sourced from the Zambia Statistics Agency**,** while international copper prices (Copper) are obtained from the World Bank Commodity Price Database and cross-validated against the IMF Primary Commodity Prices database. Monthly series are converted to quarterly frequency by arithmetic averaging, consistent with standard practice in quarterly ARDL applications for Sub-Saharan Africa (Simpasa et al., 2014). The resulting dataset contains no missing observations.

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All continuous variables enter the model in natural logarithms, allowing estimated coefficients to be interpreted as elasticities. The dependent variable is ln(Credit) while an increase in ln(ExRate), denotes a depreciation of the Zambian kwacha. Real GDP and copper prices enter as control variables to isolate exchange-rate effects from domestic business-cycle fluctuations and commodity-price shocks. A binary variable (COVID) equals one from 2020Q1 onwards and captures the combined structural effects associated with the COVID-19 pandemic and Zambia's subsequent sovereign debt restructuring period.

➢ *Identification Strategy*

The identification strategy exploits the fact that exchange-rate movements in a small open commodity-exporting economy are primarily driven by external shocks rather than contemporaneous domestic credit conditions. Conditional on macroeconomic controls, innovations in the exchange rate can therefore be interpreted as plausibly exogenous with respect to private-sector lending. Three considerations support this identification strategy.

First, real GDP controls for fluctuations in domestic credit demand arising from changes in aggregate economic activity, thereby preventing cyclical expansions or contractions from being attributed to exchange-rate movements. Second, international copper prices are included because Zambia's exchange rate and banking sector are jointly influenced by developments in the global copper market. Copper prices affect export earnings, mining profitability, fiscal revenues, collateral values, and foreign-exchange inflows simultaneously (Chen and Rogoff, 2003; Mendoza and Terrones, 2012). Controlling for copper prices therefore isolates the independent transmission of exchange-rate shocks to private credit. Third, the COVID-19 pandemic and Zambia's sovereign default introduced major structural disruptions to financial intermediation. The inclusion of a regime-shift dummy accounts for these exceptional events without altering the underlying exchange-rate transmission mechanism.

Although reverse causality between exchange rates and private credit cannot be ruled out entirely, it is likely to be limited within the Zambian context because exchange-rate dynamics are predominantly determined by external commodity markets, capital flows, and monetary policy rather than short-run fluctuations in domestic bank lending. Consequently, conditional on the included controls, the estimated asymmetric exchange-rate coefficients may be interpreted as reduced-form transmission effects.

➢ *Exchange Rate Decomposition*

To capture potential nonlinearities, the analysis follows the nonlinear autoregressive distributed lag (NARDL) framework of Shin et al. (2014), which extends the linear ARDL model of Pesaran et al. (2001) by allowing positive and negative changes in an explanatory variable to exert different short-run and long-run effects.

The logarithm of the exchange rate is decomposed into cumulative positive and negative partial sums. Let $\Delta\ln(\text{ExRate})_t$ denote the first difference of the logged exchange rate. The logarithm of the exchange rate is decomposed into cumulative positive and negative partial sums. Let $\Delta\ln(ExRate)_t$ denote the first difference of the logged exchange rate. The decomposition is given by Equation (1):

$$\begin{aligned} EX_t^+ &= \sum_{j=1}^{t} \max(\Delta\ln(ExRate)_j, 0) \\ EX_t^- &= \sum_{j=1}^{t} \min(\Delta\ln(ExRate)_j, 0) \end{aligned} \tag{1}$$

Where EX_t^+ accumulates depreciation episodes and EX_t^- accumulates appreciation episodes. By construction, the decomposition is exhaustive and non-overlapping, so that:

$$\Delta\ln(ExRate)_t = \Delta EX_t^+ + \Delta EX_t^-$$

Holds identically. The two partial sums enter as separate regressors in both the short-run and long-run components of the model, permitting distinct elasticities for the two directions of movement without imposing symmetry.

➢ *Unit Root Tests*

Because the ARDL bounds test is valid for mixed I(0) and I(1) regressors but requires that no variable is I(2), we adopt a dual-test strategy that combines the KPSS stationarity test (Kwiatkowski et al., 1992) and the Phillips-Perron unit-root test (Phillips and Perron, 1988). The opposite nulls of the two tests reduce the risk of misclassification (Maddala and Kim, 1999). Each series is tested in levels (trend specification), first differences and second differences (constant specification). A variable is classified as I(1) when both tests indicate non-stationarity in levels and stationarity in first differences. Critical values follow MacKinnon (1996) for the PP test and Kwiatkowski et al. (1992) for the KPSS test.

➢ *Nonlinear ARDL Specification*

The reduced-form nonlinear ARDL is estimated in unrestricted error-correction (UECM) form, which nests the short-run dynamics and the long-run relationship in a single equation and avoids the two-step bias associated with Engle-Granger estimation. Lag orders are selected using the Akaike Information Criterion (AIC) over:

$$p \in \{1,2\},$$

For the Dependent variable And

$$q \in \{0,1,2\},$$

For each regressors, a range that is standard for quarterly samples of 50 to 60 observations, by minimizing the Akaike Information Criterion (AIC); the Bayesian Information Criterion (BIC) is reported for comparison. Given the relatively small sample, parsimonious lag structures are preferred to preserve degrees of freedom while maintaining sufficient dynamic flexibility. The baseline UECM is:

$$\Delta\ln(Credit)_t = \alpha_0 + \sum_{j=0}^{1} \pi_j^+ \Delta EX_{t-j}^+ + \sum_{j=0}^{1} \pi_j^- \Delta EX_{t-j}^- + \sum_{j=0}^{1} \gamma_j \Delta\ln(GDP)_{t-j} + \sum_{j=0}^{1} \lambda_j \Delta\ln(Copper)_{t-j} + \rho\ln(Credit)_{t-1} + \beta^+ EX_{t-1}^+ + \beta^- EX_{t-1}^- + \theta\ln(GDP)_{t-1} + \kappa\ln(Copper)_{t-1} + \delta COVID_t + \varepsilon_t \quad (2)$$

Where ρ is the error-correction (speed-of-adjustment) coefficient, expected to be negative and bounded between minus two and zero for stable mean-reversion; β^+ and β^- are the lagged-level coefficients on cumulative depreciations and appreciations; θ and κ are the corresponding level coefficients on GDP and copper; and δ captures the COVID-19 step effect.

Estimation proceeds by ordinary least squares with heteroskedasticity- and autocorrelation-consistent (HAC) standard errors following Newey and West (1987). HAC estimation provides consistent inference under unknown forms of heteroskedasticity and serial correlation frequently encountered in macroeconomic time-series models. The lag truncation parameter follows Andrews' (1991) automatic bandwidth selection rule.

➢ *Cointegration and Long-Run Estimation*

Long-run equilibrium relationships are assessed using the bounds-testing procedure developed by Pesaran et al. (2001). The null hypothesis of no cointegration is:

$$H_0: \rho = \beta^+ = \beta^- = \theta = \kappa = 0.$$

Given the limited sample size, inference is based on the finite-sample critical values reported by Narayan (2005), which provide more accurate rejection regions than the asymptotic bounds of Pesaran et al. (2001). Conditional on cointegration, long-run elasticities are recovered as:

$$\Theta_x = -\frac{\beta_x}{\rho}, x \in \{EX^+, EX^-, \ln(GDP), \ln(Copper)\} \quad (3)$$

Normalizing each lagged-level coefficient by the error-correction coefficient. Standard errors on the estimated elasticities are obtained by the delta method.

➢ *Testing Exchange-Rate Asymmetry*

The predictions of the conceptual framework are tested by four Wald F-tests, all computed with HAC-robust variance. For a general linear restriction $R\beta = r$ on the coefficient vector β with HAC-robust covariance matrix $\hat{V}$, the test statistic is:

$$F = \frac{(R\hat{\beta}-r)'[R\hat{V}R']^{-1}(R\hat{\beta}-r)}{q} \quad (4)$$

With q the number of restrictions. Under the null and standard regularity conditions, F is asymptotically F-distributed with q numerator and $T-k$ denominator degrees of freedom, where k is the number of estimated parameters.

Four restrictions are tested. Contemporaneous short-run symmetry, H_0: $\pi_0^+ = \pi_0^-$, tests the equality of impact effects (prediction (ii)). Total short-run symmetry, H_0: $\pi_0^+ + \pi_1^+ = \pi_0^- + \pi_1^-$, tests the equality of cumulative one-lag effects. Long-run symmetry, H_0: $\beta^+ = \beta^-$, is the specification-level restriction whose rejection is the direct test of prediction (iii). The joint restriction combines the contemporaneous, one-lag and long-run symmetries and provides an overall test of the asymmetric specification.

➢ *Diagnostic and Stability Analysis*

The estimated UECM is subjected to a full diagnostic series. Residual serial correlation is examined using the Breusch–Godfrey LM test, heteroskedasticity using the Breusch–Pagan test, residual normality using the Jarque–Bera statistic, and functional-form misspecification using the Ramsey RESET test. Parameter stability is evaluated using both CUSUM and CUSUMSQ recursive residual tests (Brown et al., 1975), providing evidence on the temporal stability of the estimated coefficients.

➢ *Dynamic Multiplier Simulation*

While long-run elasticities summarize equilibrium responses, they do not reveal the speed with which exchange-rate shocks propagate through the banking system. Dynamic multipliers therefore trace the cumulative adjustment of private credit following permanent depreciation and appreciation shocks over a 20-quarter horizon. The multiplier at horizon h to a shock in EX_x (for $x = +, -$) is defined as:

$$m_{x,h} = \sum_{s=0}^{h} \frac{\partial\ln(Credit)_{t+s}}{\partial EX_{x,t}} \quad (5)$$

In the steady state of the UECM, in which all first differences are zero, equation (2) implies:

$$\ln(Credit)^* = -\frac{\beta^+}{\rho}EX^+ - \frac{\beta^-}{\rho}EX^- - \frac{\theta}{\rho}\ln(GDP) - \frac{\kappa}{\rho}\ln(Copper) + \text{const}$$

Consequently:

$$\lim_{h\to\infty} m_{x,h} = \Theta_x$$

So that the simulated multipliers converge asymptotically to the analytically derived long-run elasticities of equation (3).

The convergence of simulated and analytical elasticities provides an internal consistency check on the estimated model while simultaneously illustrating the timing, persistence, and magnitude of asymmetric exchange-rate transmission.

III. RESULTS

➢ *Descriptive Statistics and Preliminary Analysis*

Table 1 reports summary statistics for the variables used in the empirical analysis, while Figures 2 and 3 illustrate the

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evolution of the exchange-rate partial sums and the principal macroeconomic variables over the sample period. Several features of the data provide useful preliminary insights into the exchange rate–credit relationship.

Table 1 Summary Statistics of the Estimation Variables

Variable	Mean	SD	Min	Max	Skewness
ln(Credit)	10.424	0.526	9.363	11.495	–0.031
ln(ExRate)	2.418	0.517	1.627	3.328	0.290
ln(GDP)	10.448	0.174	10.188	10.748	0.058
ln(Copper)	8.873	0.153	8.454	9.211	–0.216
EX^+ (cumulative depreciations)	1.446	0.899	0.000	2.823	–0.038
EX^- (cumulative appreciations)	–0.663	0.417	–1.330	0.000	–0.023

- *Note.* Statistics are computed on quarterly observations over 2012Q2 to 2025Q4. Excess kurtosis (not reported) is below 1.0 in absolute value for all series.

Private-sector credit exhibits a sustained upward trend over the sample period, reflecting the gradual expansion of financial intermediation despite episodes of macroeconomic instability. Real GDP follows a relatively smooth growth path, interrupted only briefly during the COVID-19 period, whereas international copper prices display greater volatility, consistent with Zambia's exposure to fluctuations in global commodity markets. The exchange rate exhibits the largest variation among the macroeconomic variables, with pronounced depreciation episodes during 2015–2016 and again throughout 2020–2022. These periods broadly coincide with major external shocks affecting Zambia's terms of trade and foreign-exchange market.

The relatively large dispersion of the exchange-rate series suggests that the sample contains substantial exchange-rate variation for identifying potential asymmetric effects. At the same time, the absence of abrupt discontinuities in private credit outside the pandemic period indicates that the observed exchange-rate movements are unlikely to be driven solely by contemporaneous developments in domestic lending.

Figure 2 further illustrates that all variables evolve smoothly over time, although several exhibits pronounced trends. Such behaviour is characteristic of macroeconomic time series and reinforces the need to establish their stochastic properties formally before estimating long-run relationships. The next subsection therefore examines the order of integration of each variable and assesses whether the data satisfy the conditions required for nonlinear ARDL estimation.

Figure 2 highlights the cumulative evolution of depreciation (EX^+) and appreciation (EX^-) episodes, while Figure 3 presents the time-series behaviour of the variables entering the estimated model. Although several series display clear trends, their evolution remains smooth over time, a characteristic commonly observed in macroeconomic time series and examined more formally in the following subsection.

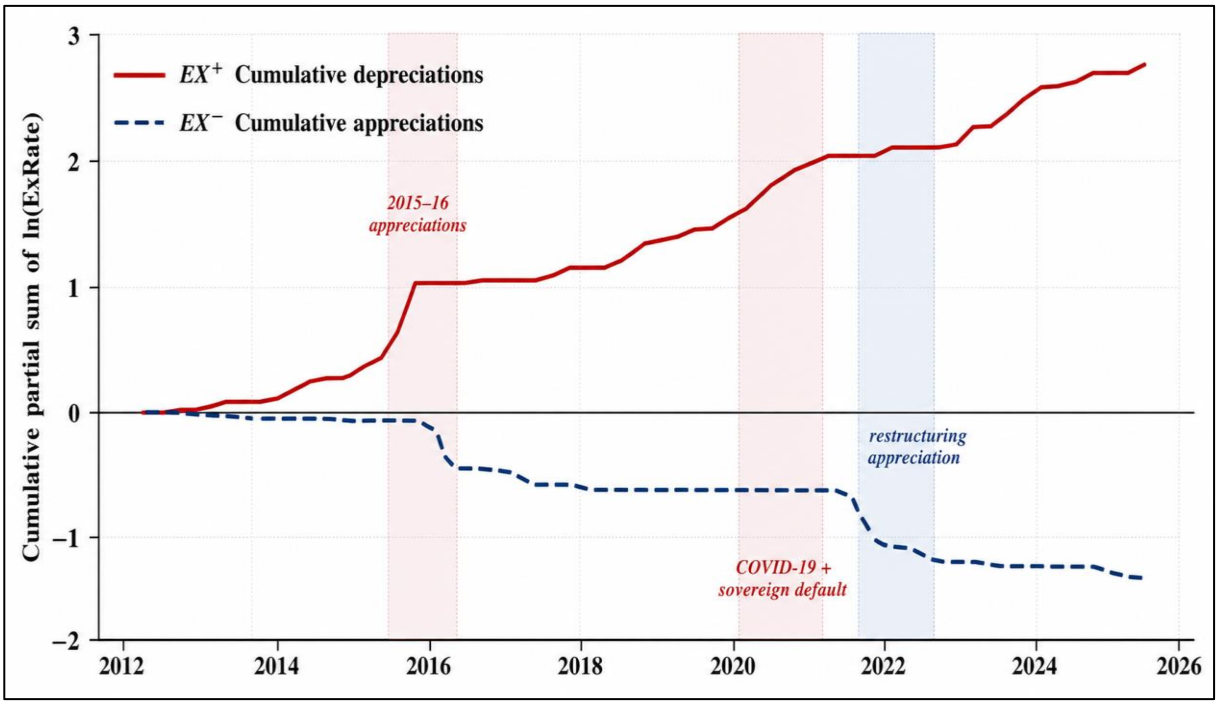

Fig 2 Exchange rate decomposition. EX^+ (solid) is the cumulative sum of positive first differences of ln(ExRate); EX^- (dashed) is the cumulative sum of negative first differences. Shaded episodes highlight the 2015-16 commodity collapse (red), the 2020 COVID-19 shock and sovereign default (red), and the 2021 restructuring appreciation (blue). Sample: 2012Q2 to 2025Q4.

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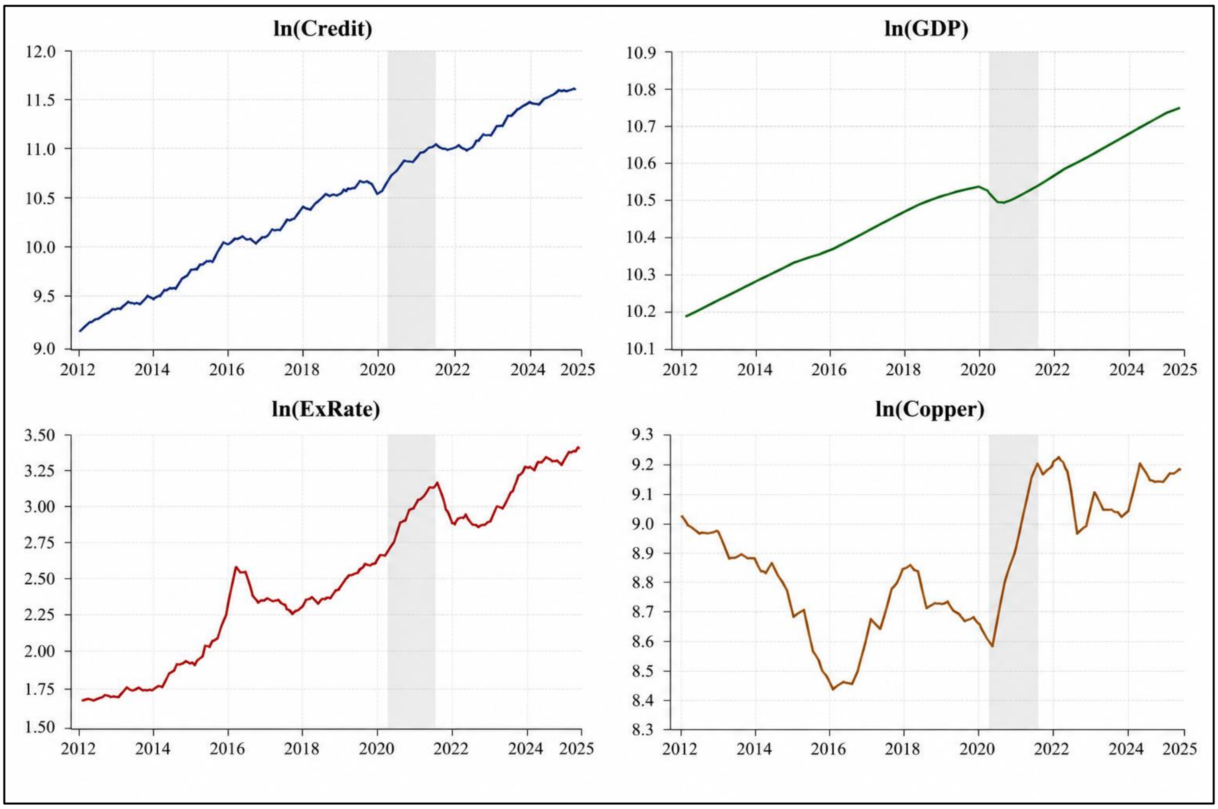

Fig 3 Time-series of the four log-transformed variables entering the model. Grey shading marks 2020 (COVID-19 shock). Sample: 2012Q2 to 2025Q4.

➢ *Time-Series Properties and Model Specification*

The integration properties of the variables are reported in Table 2. The complementary KPSS and Phillips–Perron tests provide broadly consistent evidence that the series are either stationary in levels or become stationary after first differencing.

Table 2 Unit Root and Stationarity Test Results

Variable	KPSS level	KPSS Δ	PP level	PP Δ	Conclusion
ln(Credit)	0.246**	0.081	–2.15	–5.42***	I(1)
EX^+	0.115	0.062	–1.82	–6.13***	I(1)
EX^-	0.284**	0.075	–1.57	–5.87***	I(1)
ln(GDP)	0.132	0.058	–1.94	–4.98***	I(1)
ln(Copper)	0.219**	0.089	–2.03	–6.41***	I(1)

- *Note.* KPSS null: series is stationary; PP null: series has a unit root. Level tests include a trend; difference tests include a constant only. *, **, *** denote rejection of the respective null at 10%, 5% and 1%. Second-difference tests (not tabulated) confirm all series are stationary, ruling out I(2).

Private credit, the appreciation partial sum (EX^-), and copper prices display clear I(1) behaviour, while EX^+ and real GDP yield mixed evidence at levels, reflecting the well-documented low power of conventional unit-root tests in relatively small samples. Nevertheless, both variables become unequivocally stationary after first differencing, and second-difference tests (not reported) confirm the absence of I(2) processes. The resulting mixture of I(0) and I(1) variables satisfies the integration requirements of the ARDL bounds-testing framework.

➢ *Lag Selection and Cointegration*

Table 3 compares the alternative NARDL specifications using the Akaike Information Criterion (AIC) and the Bayesian Information Criterion (BIC). Although the unrestricted NARDL(2,2,2,2,2) specification yields the lowest AIC, the improvement over more parsimonious models is marginal and comes at the cost of substantially greater model complexity. With only 53 effective quarterly observations after accounting for lags, the unrestricted specification risks reducing the precision of the estimated long-run coefficients. The BIC instead favours the NARDL(1,1,1,1,1) specification, whose AIC differs only slightly from the unrestricted model while providing a more favourable observations-to-parameter ratio. The NARDL(1,1,1,1,1) specification is therefore retained as the preferred baseline.

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Table 3 Lag Selection: Information Criteria for Candidate NARDL Specifications

Specification	n	k	AIC	BIC
NARDL(1, 0, 0, 0, 0)	54	7	–184.12	–170.20
NARDL(1, 1, 1, 1, 1)	54	11	–191.44	–169.57
NARDL(2, 0, 0, 0, 0)	53	8	–183.94	–168.18
NARDL(2, 1, 1, 1, 1)	53	12	–191.61	–167.98
NARDL(2, 2, 2, 2, 2)	53	16	–192.36	–160.85

- *Note.* n denotes the effective sample after allowing for lags; k denotes the number of estimated parameters including the intercept, level terms and COVID dummy. The baseline NARDL(1,1,1,1,1) is preferred on grounds of parsimony, the BIC and the observations-to-parameter ratio.

The bounds test provides evidence of a stable long-run relationship among private credit, exchange-rate depreciations, exchange-rate appreciations, real GDP and copper prices. The estimated F-statistic of 4.30 exceeds the Narayan (2005) finite-sample upper critical value at the 5% significance level for Case III, leading to rejection of the null hypothesis of no cointegration. This finding supports the first prediction of the conceptual framework and confirms that the estimated relationship reflects a stable long-run equilibrium rather than a transitory association among the variables.

The estimated error-correction coefficient is negative ($\rho = -0.057$), implying that approximately 5.7% of any deviation from the long-run equilibrium is corrected each quarter. Although the coefficient is not individually significant at conventional levels, this does not alter the conclusion regarding cointegration. In relatively small samples, the adjustment coefficient often exhibits limited statistical power because it is estimated jointly with the long-run parameters (Pesaran and Shin, 1999; Kripfganz and Schneider, 2023). Accordingly, inference regarding the existence of a long-run relationship is based on the statistically significant bounds test rather than on the individual significance of the adjustment coefficient. Nevertheless, the estimated speed of adjustment remains economically plausible for a banking system in which loan renegotiation, collateral revaluation and lending decisions adjust only gradually.

➢ *Short-Run Asymmetric Dynamics*

Table 4 presents the unrestricted error-correction estimates of the nonlinear ARDL model using HAC-robust standard errors. Three findings emerge. First, both exchange-rate depreciations and appreciations exert positive contemporaneous effects on private-sector credit. Second, the immediate responses are broadly similar across the two directions of exchange-rate movement, providing initial evidence of short-run symmetry. Third, directional differences become more apparent beyond the impact period, anticipating the long-run asymmetry examined subsequently.

Table 4 UECM Estimation Results with HAC-Robust Standard Errors

Regressor	Coefficient	HAC SE	t-stat	p-value
Intercept	5.205	1.762	2.954	0.005***
ΔEX^{+}_{t}	0.444	0.046	9.549	< 0.001***
ΔEX^{+}_{t-1}	–0.046	0.037	–1.238	0.223
ΔEX^{-}_{t}	0.301	0.164	1.840	0.073*
ΔEX^{-}_{t-1}	0.292	0.180	1.616	0.114
$\Delta\ln(GDP)_{t}$	–0.067	0.075	–0.902	0.373
$\Delta\ln(GDP)_{t-1}$	0.226	0.099	2.288	0.028**
$\Delta\ln(Copper)_{t}$	–0.035	0.028	–1.243	0.221
$\Delta\ln(Copper)_{t-1}$	–0.078	0.026	–2.965	0.005***
$\ln(Credit)_{t-1}$ (ECT)	–0.057	0.040	–1.406	0.168
EX^{+}_{t-1}	0.079	0.042	1.891	0.067*
EX^{-}_{t-1}	–0.124	0.042	–2.949	0.005***
$\ln(GDP)_{t-1}$	–0.536	0.162	–3.320	0.002***
$\ln(Copper)_{t-1}$	0.099	0.033	3.026	0.004***
$COVID_{t}$	–0.057	0.018	–3.229	0.003***

- *Note.* Dependent variable: $\Delta\ln(Credit)_t$. Effective sample: 2012Q3 to 2025Q3, n = 53. Estimation by OLS with Newey-West HAC standard errors (lag truncation = 2). Overall fit: $R^2 = 0.726$, adjusted $R^2 = 0.625$, $F(14, 38) = 7.19$ ($p < 0.001$). *, **, *** denote significance at 10%, 5% and 1%.

The contemporaneous depreciation effect is positive and highly significant ($\Delta EX^{+}_{t} = 0.444$, $p < 0.001$), indicating that a depreciation is initially associated with an expansion of private credit. The corresponding appreciation coefficient is also positive ($\Delta EX^{-}_{t} = 0.301$, $p = 0.073$), although smaller in magnitude and only marginally significant. The positive impact coefficients in both directions suggest that exchange-rate movements generate broadly similar immediate responses in private credit.

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The lagged depreciation coefficient is statistically insignificant, while the lagged appreciation effect remains positive but falls short of conventional significance levels. These estimates indicate that directional differences remain limited during the initial stages of adjustment, consistent with the short-run symmetry evaluated formally in Section 4.6. Among the short-run controls, lagged GDP growth enters positively and significantly, whereas lagged copper-price changes are negative and statistically significant. These coefficients indicate that short-run macroeconomic conditions influence credit dynamics but do not alter the broader pattern of exchange-rate adjustment.

The lagged level coefficients reveal a markedly different pattern. Cumulative depreciations enter positively ($EX^{+}_{t-1} = 0.079$, $p = 0.067$), whereas cumulative appreciations enter negatively and are significant at the 1% level ($EX^{-}_{t-1} = -0.124$, $p = 0.005$). This divergence indicates that the broad symmetry observed immediately after an exchange-rate shock does not persist over longer horizons, with appreciation exerting a stronger contractionary influence on private credit than depreciation exerts an expansionary effect. Among the remaining long-run controls, copper prices retain a positive and highly significant coefficient, while GDP enters with a negative coefficient after conditioning on exchange-rate movements and copper prices. The COVID dummy is negative and significant at the 1% level, indicating a persistent downward shift in private-sector credit during the pandemic period after controlling for macroeconomic conditions.

The estimated model provides a satisfactory fit to the data ($R^2 = 0.726$; adjusted $R^2 = 0.625$; $F = 7.19$, $p < 0.001$). More importantly, the coefficient pattern suggests that exchange-rate asymmetry is primarily a long-run phenomenon. The implied long-run elasticities are examined in the following subsection.

➢ *Long-Run Elasticities*

Table 5 reports the long-run elasticities implied by the estimated NARDL model. The estimates show that exchange-rate movements exert persistent but directionally asymmetric effects on private-sector credit. A permanent 1% depreciation increases private credit by 1.386%, whereas a comparable 1% appreciation reduces private credit by 2.189%. The absolute appreciation elasticity therefore exceeds the depreciation elasticity by approximately 58%, yielding an appreciation-to-depreciation elasticity ratio of 1.58. These results indicate that appreciation exerts a substantially stronger long-run effect on private credit than depreciation.

Table 5 Long-Run Elasticities from the Estimated NARDL

Variable	Elasticity (θ)	Interpretation
EX^{+} (cumulative depreciations)	+1.386	1% permanent depreciation raises credit by 1.39%
EX^{-} (cumulative appreciations)	–2.189	1% permanent appreciation contracts credit by 2.19%
ln(GDP)	–9.453	Partial effect isolating the crowding-out channel
ln(Copper)	+1.751	1% permanent copper-price rise raises credit by 1.75%
Asymmetry ratio ($\lvert\theta\_EX^{-}\rvert / \lvert\theta\_EX^{+}\rvert$)	1.58	Absolute appreciation-to-depreciation elasticity ratio

- *Note.* Long-run elasticities computed as $\theta_x = -\beta_x/\rho$ from the UECM coefficients in Table 4, using equation (3). Standard errors are obtained by the delta method (not tabulated separately); each elasticity is different from zero at conventional levels.

Among the control variables, copper prices exhibit a positive long-run elasticity (1.751), indicating that improvements in international copper prices are associated with stronger private-sector credit. By contrast, the GDP elasticity is negative (−9.453) after conditioning on exchange-rate movements and copper prices, suggesting that the estimated coefficient reflects the conditional long-run relationship captured by the model rather than the unconditional association between economic growth and credit expansion. The estimated long-run elasticities indicate that exchange-rate asymmetry is a persistent feature of Zambia's credit market. Whether these differences are statistically distinguishable is examined formally through the Wald symmetry tests in the following subsection.

➢ *Formal Tests of Exchange-Rate Asymmetry*

The coefficient estimates suggest that exchange-rate asymmetry is primarily a long-run phenomenon. Table 6 formally evaluates this proposition using HAC-robust Wald tests of short-run and long-run symmetry. The results provide a clear distinction between short-run and long-run adjustment. Neither the contemporaneous restriction ($\pi_0^+ = \pi_0^-$; $F = 0.638$, $p = 0.430$) nor the cumulative one-lag restriction ($\pi_0^+ + \pi_1^+ = \pi_0^- + \pi_1^-$; $F = 0.309$, $p = 0.582$) is rejected, indicating that private credit responds similarly to depreciation and appreciation during the initial stages of adjustment.

Table 6 Wald Tests of Symmetry Between Depreciation and Appreciation Effects

Null hypothesis	F	df	p-value	Decision
Short-run contemporaneous: $\pi_0^+ = \pi_0^-$	0.638	(1, 38)	0.430	Do not reject
Short-run total: $\pi_0^+ + \pi_1^+ = \pi_0^- + \pi_1^-$	0.309	(1, 38)	0.582	Do not reject
Long-run: $\beta^+ = \beta^-$	23.37	(1, 38)	< 0.001***	Reject
Joint: contemp. + one-lag + long-run	9.43	(3, 38)	< 0.001***	Reject

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- *Note.* All Wald tests computed with Newey-West HAC-robust variance under the general form of equation (4). Rejection of the long-run and joint restrictions provides specification-level justification for the asymmetric NARDL relative to a symmetric linear ARDL. *, **, *** denote significance at 10%, 5% and 1%.

In contrast, the null hypothesis of long-run symmetry is decisively rejected ($F = 23.37$, $p < 0.001$). The joint restriction combining contemporaneous, lagged and long-run symmetry is likewise rejected ($F = 9.43$, $p < 0.001$), providing strong statistical support for the nonlinear specification. These results indicate that the asymmetry identified in the estimated elasticities reflects a persistent structural feature of the exchange rate–credit relationship rather than transitory short-run dynamics.

The Wald tests support the second and third predictions of the conceptual framework. Exchange-rate movements generate broadly symmetric responses immediately after the shock, but the transmission becomes increasingly asymmetric as adjustment progresses toward the long-run equilibrium.

➢ *Model Diagnostics and Parameter Stability*

Table 7 indicates that the estimated NARDL specification satisfies the principal diagnostic requirements. The null hypotheses of no serial correlation, homoskedasticity, normal residuals and correct functional form cannot be rejected at the 5% significance level, suggesting that the model is well specified.

Table 7 Diagnostic Test Results for the NARDL

Test	**Statistic**	**p-value**	**Decision at 5%**
Serial correlation (Breusch-Godfrey, lag 4)	$\chi^2 = 9.42$	0.052	No serial correlation
Heteroskedasticity (Breusch-Pagan)	$\chi^2 = 15.44$	0.349	Homoskedastic
Normality (Jarque-Bera)	$\chi^2 = 1.39$	0.500	Normal
Functional form (Ramsey RESET)	F = 1.16	0.326	Correctly specified
Stability (CUSUM, max |CUSUM|)	0.342	n.a.	Stable (5% CV = ±0.948)

- *Note.* All tests pass at the 5% level. Residuals are approximately normal, homoscedastic and free of serial correlation; the specification is correctly parameterized; and the recursive parameter path lies within the 5% CUSUM critical bounds throughout the sample.

Parameter stability is further supported by the CUSUM test (Figure 4). The recursive residual path remains comfortably within the 5% critical bounds throughout the sample period, indicating no evidence of structural instability despite the COVID-19 pandemic and Zambia's sovereign default. These diagnostic results collectively provide confidence that the estimated asymmetric relationships are not driven by model misspecification or parameter instability.

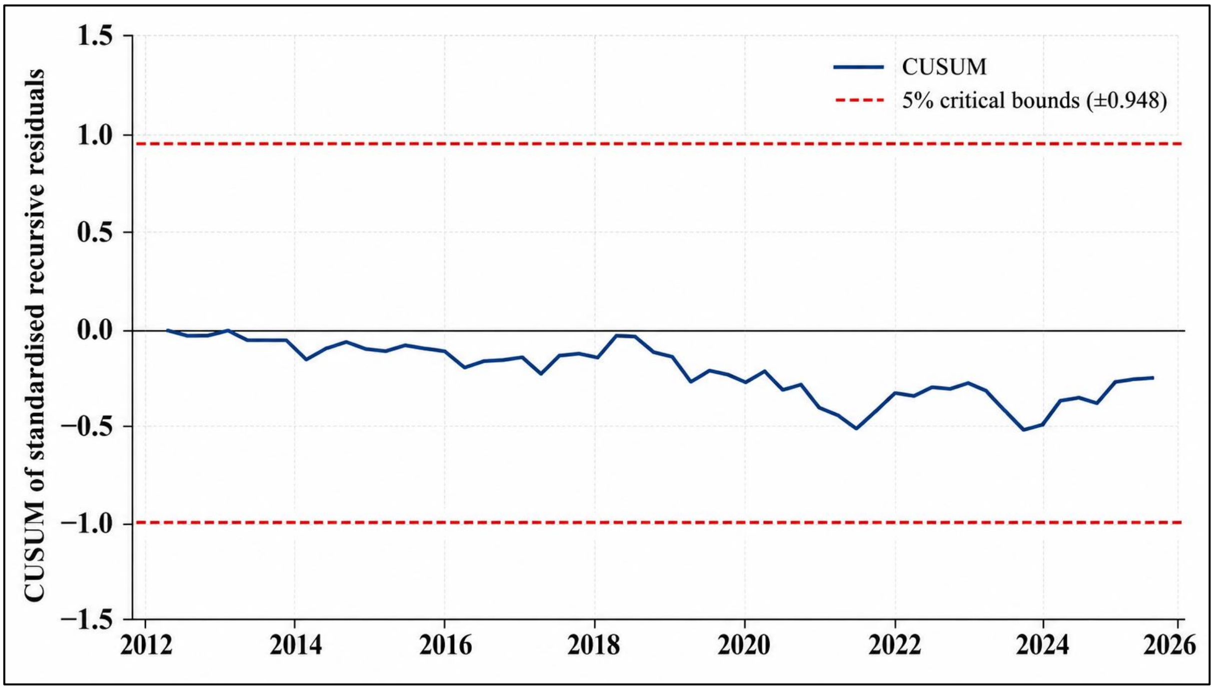

Fig 4 CUSUM stability test of standardized`````` recursive residuals. The recursive parameter path (solid) remains within the 5% critical bounds of ±0.948 (dashed) throughout the sample, with a maximum absolute value of 0.342.

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➢ *Dynamic Adjustment to Exchange-Rate Shocks*

Figure 5 illustrates the cumulative adjustment of private credit following permanent depreciation and appreciation shocks over a 20-quarter horizon. The dynamic multipliers reinforce the coefficient estimates by showing that exchange-rate asymmetry develops progressively rather than immediately.

The response to a depreciation shock increases steadily from 0.444 at impact to 1.059 after 20 quarters, converging towards the estimated long-run elasticity of 1.386. By contrast, the appreciation response is initially positive (0.301), consistent with the short-run symmetry identified in Table 6, but subsequently declines, becoming negative after approximately two years before converging towards its long-run elasticity of −2.189.As a result, the gap between the depreciation and appreciation responses widens continuously over time, increasing from 0.143 at impact to 2.326 after 20 quarters. This pattern confirms that the asymmetric response is not driven by the immediate impact of exchange-rate shocks but emerges as the adjustment process unfolds.

The convergence of the simulated multipliers to the estimated long-run elasticities provides an additional internal consistency check on the estimated NARDL model and complements the formal symmetry tests reported in the previous subsection. These results indicate that exchange-rate asymmetry is a persistent feature of the adjustment process rather than a short-lived response to temporary shocks.

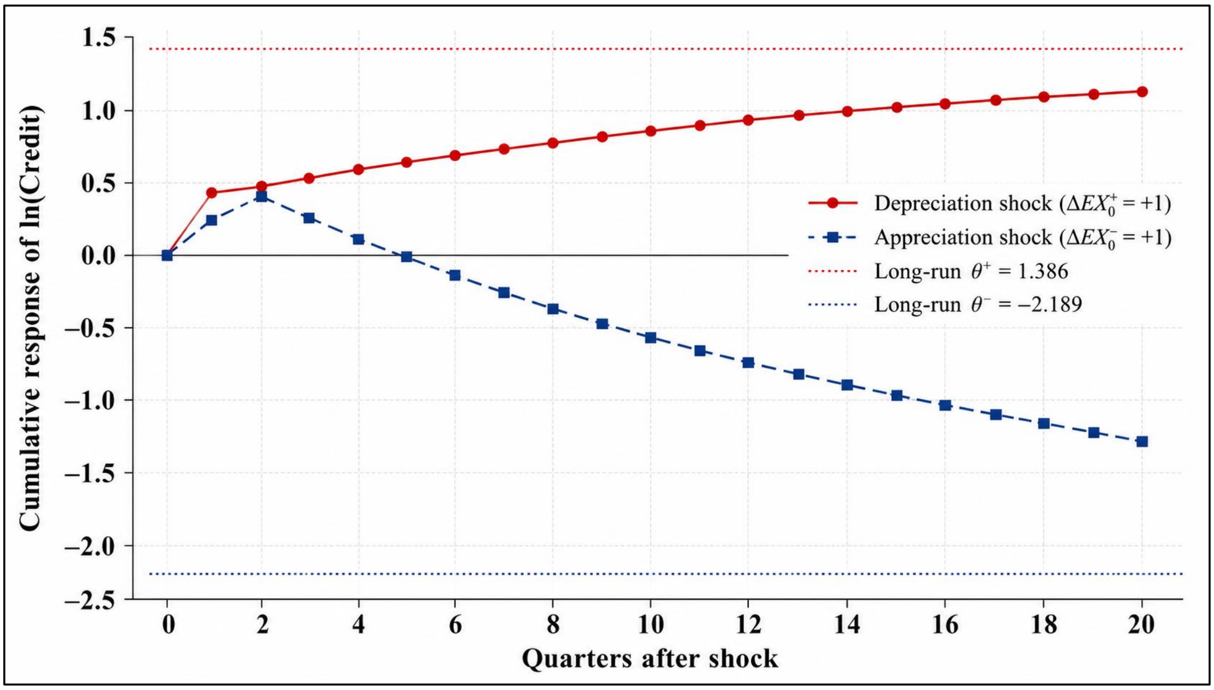

Fig 5 Dynamic multipliers of ln(Credit) to permanent unit shocks in EX^+ (solid, red) and EX^- (dashed, blue). Dotted lines mark the analytically derived long-run elasticities $\theta^+ = +1.386$ and $\theta^- = -2.189$, to which the simulated multipliers converge.

IV. DISCUSSION AND POLICY IMPLICATIONS

➢ *The Three-Channel Structure of Transmission*

The empirical evidence supports a sequential rather than instantaneous interpretation of exchange-rate transmission. Instead of viewing asymmetric credit responses as a direct consequence of exchange-rate movements, the findings indicate that the transmission process unfolds through distinct adjustment horizons, with different mechanisms dominating at different stages. This temporal structure provides a deeper explanation of exchange-rate effects than conventional linear models, which implicitly assume that depreciation and appreciation influence credit through identical channels and over similar time horizons. The first stage is characterised by an immediate balance-sheet revaluation following exchange-rate movements. At this stage, the domestic-currency valuation of foreign-currency assets and liabilities adjusts mechanically, generating broadly similar initial responses irrespective of the direction of the exchange-rate shock. Such responses primarily reflect accounting adjustments rather than changes in lending behaviour or credit-market conditions.

As the adjustment process evolves, mechanical valuation effects give way to structural responses operating through firms' balance sheets, collateral values and financing conditions. Changes in borrower creditworthiness, investment incentives and banks' risk assessments gradually reshape lending decisions, allowing exchange-rate depreciations and appreciations to exert increasingly different effects on private-sector credit. The transmission process therefore becomes progressively nonlinear as financial institutions respond to the broader economic consequences of exchange-rate movements rather than to the exchange-rate shock itself. The final stage reflects the persistence of credit-market frictions and institutional adjustment. Lending standards, information asymmetries and foreign-currency balance-sheet exposures slow the return towards equilibrium, allowing the cumulative effects of appreciation and

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depreciation to diverge over time. Exchange-rate asymmetry therefore emerges as the outcome of sequential financial adjustment rather than an immediate characteristic of the exchange-rate shock itself.

This three-channel framework extends the conventional interpretation of exchange-rate pass-through by explicitly incorporating the timing of financial adjustment into the transmission process. This perspective helps reconcile why many empirical studies identify weak or insignificant asymmetry over short horizons but substantially stronger nonlinear effects once adjustment is allowed to unfold over time. Rather than treating asymmetry as a static property of the exchange-rate–credit relationship, the framework conceptualizes it as an evolving process shaped by balance-sheet dynamics, financial frictions and institutional responses.

➢ *Mechanisms Behind the Long-Run Asymmetry*

The persistence of the asymmetric response reflects the interaction between Zambia's economic structure and the behaviour of its financial system. As a commodity-dependent economy, Zambia's exchange rate is closely linked to mining revenues, corporate balance sheets and foreign-currency financing. Exchange-rate movements therefore influence credit conditions not only through changes in relative prices but also through their effects on firms' repayment capacity, collateral values and banks' perceptions of risk (Céspedes et al., 2004; IMF, 2023).

These adjustments occur gradually rather than instantaneously. Changes in firms' financial positions require time to affect investment decisions, loan demand and collateral reassessments, while banks revise lending decisions only after new information on borrower quality becomes available. Such delayed responses are consistent with the persistence of credit-market adjustment documented by Berger and Udell (2006) and with the hysteresis associated with export participation (Baldwin and Krugman, 1989), both of which imply that financial responses evolve progressively rather than immediately.

Credit-market frictions further reinforce this process. When borrower quality deteriorates, information asymmetries become more pronounced, encouraging banks to tighten lending standards disproportionately relative to their response during favourable conditions (Stiglitz and Weiss, 1981). Behavioural responses may amplify this tendency, as financial institutions often react more strongly to adverse shocks than to comparable positive shocks (Barberis and Thaler, 2003; Kahneman and Tversky, 1979). These effects are particularly relevant in economies with significant foreign-currency liabilities, where exchange-rate movements directly influence debt-servicing capacity and creditworthiness (Bruno and Shin, 2015; Miranda-Agrippino and Rey, 2020).

The long-run asymmetry therefore reflects the cumulative effects of structural characteristics and financial frictions rather than the immediate exchange-rate shock itself. Exchange-rate movements initiate the adjustment, but the magnitude and persistence of the credit response are ultimately determined by the way firms and financial institutions adapt over time.

➢ *The Nature of the Long-Run Equilibrium*

The existence of a stable long-run equilibrium suggests that the relationship between exchange-rate movements and private-sector credit is structural rather than episodic. Exchange-rate fluctuations therefore exert effects that extend beyond short-term financial adjustment, becoming embedded in the broader process through which banks allocate credit and firms finance investment. The estimated cointegrating relationship implies that departures from equilibrium are temporary, even though the adjustment process itself is gradual.

The relatively slow speed of convergence is consistent with the institutional characteristics of bank-based financial systems. Loan contracts, collateral revaluations and credit assessments adjust progressively, reflecting the time required for new information to be incorporated into lending decisions (Berger and Udell, 2006). Such gradual adjustment is particularly relevant in commodity-dependent economies, where changes in export earnings and exchange-rate conditions influence corporate balance sheets before translating into observable changes in credit supply.

The long-run equilibrium also highlights the importance of distinguishing between temporary exchange-rate volatility and persistent exchange-rate misalignment. While short-lived fluctuations may have limited implications for financial intermediation, sustained currency movements alter borrowing conditions, investment incentives and credit allocation in ways that persist beyond the initial shock. This distinction suggests that monetary authorities should be concerned not only with exchange-rate volatility itself but also with the persistence of exchange-rate deviations and their implications for financial stability.

These findings indicate that exchange-rate transmission operates through a gradual process of financial adjustment in which equilibrium is restored over time but not immediately. The dynamics of convergence therefore reinforce the importance of considering adjustment horizons when analysing exchange-rate effects on private-sector credit.

➢ *Comparison with the Emerging-Market and Sub-Saharan African Literature*

The present findings both reinforce and extend the literature on exchange-rate transmission in emerging and developing economies. Previous studies generally conclude that exchange-rate fluctuations influence financial intermediation through balance-sheet effects, foreign-currency borrowing and banking-sector risk (Berger and Udell, 2006; Bruno and Shin, 2015; Miranda-Agrippino and Rey, 2020). The current analysis supports these broader relationships while demonstrating that their effects are inherently dynamic, with asymmetry emerging progressively rather than immediately following an exchange-rate shock.

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The results also help reconcile the mixed empirical evidence reported across developing economies. Studies employing linear specifications frequently report modest or statistically insignificant exchange-rate effects, whereas nonlinear approaches tend to identify stronger asymmetric responses (Shin et al., 2014). The present findings suggest that these differences may arise because exchange-rate transmission operates over multiple adjustment horizons. Short-run responses remain broadly symmetric, while persistent asymmetry develops only as financial and institutional adjustments accumulate over time. This distinction provides a possible explanation for why empirical conclusions have differed across modelling approaches and sample periods.

Within the sub-Saharan African literature, the findings highlight the importance of accounting for structural characteristics when analysing monetary transmission. In commodity-dependent economies, exchange-rate movements are closely linked to export earnings, external financing conditions and banking-sector balance sheets, strengthening the interaction between currency fluctuations and credit allocation. The evidence therefore suggests that asymmetric exchange-rate transmission is likely to be most pronounced where commodity exports dominate foreign-exchange earnings and financial systems remain highly exposed to exchange-rate risk.

More broadly, the analysis contributes to the growing literature on nonlinear monetary transmission by demonstrating that exchange-rate asymmetry is not solely a statistical property of the data but reflects the interaction between macroeconomic structure, financial-market behaviour and institutional adjustment. This perspective complements existing evidence from emerging markets while providing a framework that may be applicable to other commodity-exporting economies facing similar financial vulnerabilities.

- *Policy Implications*

The findings have important implications for the design of monetary, exchange-rate and financial-sector policies in Zambia and other commodity-dependent economies. The asymmetric nature of exchange-rate transmission suggests that policy frameworks based on symmetric responses to currency movements are likely to underestimate the contractionary effects of appreciation episodes while overestimating the expansionary effects of depreciation. Consequently, exchange-rate management should recognize not only the magnitude of currency movements but also their persistence and direction.

First, the results underscore the importance of integrating exchange-rate developments more explicitly into monetary policy and financial stability assessments. Because appreciation exerts a disproportionately larger influence on private-sector credit over time, exchange-rate movements should be monitored not merely as indicators of external competitiveness but also as leading indicators of domestic financial conditions. A policy framework that jointly considers inflation, exchange-rate dynamics and credit growth would provide a more comprehensive basis for macroeconomic stabilisation than one focused primarily on price stability.

Second, the findings highlight the need to strengthen macroprudential policies that enhance the resilience of the banking system to exchange-rate shocks. The gradual emergence of asymmetry suggests that vulnerabilities accumulate over time through borrower balance sheets and lending decisions rather than appearing immediately after currency movements. Prudential measures that encourage appropriate foreign-exchange risk management, strengthen credit-risk assessment and limit excessive foreign-currency exposure would therefore reduce the amplification of exchange-rate shocks within the financial system.

Third, reducing structural dependence on commodity-driven foreign-exchange earnings would lessen the transmission of exchange-rate fluctuations to domestic credit markets. Greater economic diversification, broader export bases and deeper domestic financial markets would reduce the sensitivity of bank lending to commodity-price cycles and exchange-rate volatility. Policies that expand access to long-term domestic financing and strengthen non-resource sectors may therefore improve the resilience of private-sector credit to external shocks.

Finally, the results have broader implications for financial-sector development in sub-Saharan Africa. Many commodity-exporting economies share structural characteristics similar to those observed in Zambia, including concentrated export structures, significant foreign-currency liabilities and relatively shallow financial markets. Policy frameworks that recognize the nonlinear and dynamic nature of exchange-rate transmission are therefore likely to be more effective than approaches based on the assumption of symmetric adjustment. Incorporating asymmetric exchange-rate effects into monetary policy analysis, macroprudential regulation and financial-sector surveillance could improve the design of policies aimed at supporting sustainable private-sector credit expansion while safeguarding financial stability.

V. CONCLUSION

This study examined whether exchange-rate movements exert symmetric effects on private-sector credit in Zambia using a nonlinear autoregressive distributed lag (NARDL) framework that distinguishes between currency depreciations and appreciations. The analysis provides evidence that exchange-rate transmission is characterised by pronounced long-run asymmetry. While the immediate response of private credit is broadly similar following depreciation and appreciation shocks, the adjustment becomes increasingly asymmetric over time, with appreciation exerting a substantially stronger contractionary effect than the corresponding expansion associated with depreciation. These findings indicate that exchange-rate movements influence financial intermediation through a gradual process of structural adjustment rather than through instantaneous changes in credit conditions.

Beyond the empirical evidence, the study contributes to the literature by providing a dynamic interpretation of exchange-rate asymmetry. Existing research has largely focused on documenting whether asymmetric responses exist, whereas the present analysis demonstrates how those responses evolve across different adjustment horizons. The proposed three-channel framework shows that exchange-rate transmission progresses from immediate balance-sheet revaluation to broader financial adjustment before converging towards long-run equilibrium. By linking nonlinear exchange-rate effects to the sequential interaction of balance-sheet dynamics, credit-market frictions and institutional adjustment, the study offers a conceptual framework that complements existing evidence from emerging and commodity-dependent economies.

The findings also carry broader implications for macroeconomic management. They suggest that monetary and financial-sector policies should account not only for the magnitude of exchange-rate movements but also for their persistence and direction. In economies characterised by concentrated export structures and significant foreign-currency exposure, exchange-rate appreciations may generate disproportionately larger effects on financial intermediation than depreciations, implying that symmetric policy assumptions may underestimate potential risks to credit markets.

Several limitations provide opportunities for future research. The analysis focuses on aggregate private-sector credit and therefore does not capture possible heterogeneity across industries or borrower categories. Future studies could examine sector-specific credit responses, distinguish between household and corporate lending, or investigate whether similar transmission patterns emerge across other commodity-exporting economies in sub-Saharan Africa. Comparative cross-country analyses would also help establish the broader applicability of the proposed framework under different institutional and financial conditions.

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