



Asymmetric Effect of Exchange Rate Fluctuations on Domestic Credit in Nigeria: A Nonlinear Autoregressive Distributed Lag (NARDL) Analysis

Blessed Chukwuagoziem Nwankwo¹, Celestine Sunday Ogonna Okaro², Ibeanusi Sylvanus Chigozie³

^{1,2,3}Department of Banking and Finance, Nnamdi Azikiwe University Awka, Nigeria.

Correspondence: *sylvanusibeanusi@gmail.com*

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Abstract

Nigeria's naira has undergone repeated large adjustments, most recently through the foreign-exchange (FX) market reforms of 2023–2024, while private-sector credit remains a binding constraint on investment. Whether credit responds symmetrically to appreciation and depreciation is unresolved, although balance-sheet theory predicts that it should not. The study tests whether appreciation and depreciation of the naira have asymmetric short-run and long-run effects on domestic credit to the private sector. A symmetric ARDL model is compared with a NARDL model in which the log exchange rate is decomposed into cumulative depreciation and appreciation partial sums. Cointegration is tested with the bounds approach using critical values; asymmetry with Wald tests; dynamic multipliers trace the response of credit to depreciation and appreciation. Extensions include a multiple-threshold (size) decomposition, a dynamic OLS cross-check, recursive estimation, a mediation analysis, Toda–Yamamoto causality tests and an out-of-sample forecast comparison. Quarterly observations, 2000Q1–2025Q4. The bounds tests indicate a long-run relationship ($F = 5.19$; 5% upper bound 3.69). A 10% depreciation lowers credit by about 3.3% in the long run. The appreciation coefficient is positive, the opposite of the theoretical sign, and statistically indistinguishable from zero ($p = 0.405$). Long-run symmetry is not rejected ($F = 2.41$, $p = 0.124$) and short-run symmetry is not rejected ($p = 0.865$), but a dynamic OLS cross-check and several robustness specifications are less clear-cut. With only 15 appreciation quarters, the symmetry test has limited power, so non-rejection is weak evidence of symmetry. The results show that depreciation is costly for private credit: a 10% depreciation is associated with a long-run fall in credit of about 3.3%, most of it within a year, whereas the data cannot establish that appreciation restores it. Policy should therefore aim to contain disorderly depreciation, require banks to report the currency composition of their loans, monitor unhedged FX borrowing and stress-test loan books against 10% and 20% depreciations, while treating the appreciation channel as unproven.

Keywords: Exchange rate; domestic credit; asymmetry; NARDL; bank lending; Nigeria.

1. Introduction

Credit to the private sector finances working capital, investment and trade, and in Nigeria it is supplied largely by deposit money banks (DMBs) (Adeleke and Awodumi, 2018). The International Monetary Fund (IMF) continues to stress that structural impediments to private-credit extension must be addressed if growth is to be sustained (IMF, 2025). Understanding what moves bank credit is therefore central to Nigeria's growth and financial-stability agenda.

The exchange rate is among the most important and least well-measured of these forces. Depreciation raises the naira value of FX liabilities, erodes borrowers' net worth, raises credit risk for banks and passes through to prices and, ultimately, policy rates. Appreciation works through the same channels in the opposite direction. Where borrowers hold FX debt against naira income, depreciation can reduce leverage and lending, and the firm-level literature broadly finds depreciations to be contractionary when FX debt is large (Aguiar, 2005; Serena and Sousa, 2017; Kalemli-Özcan, Liu and Shim, 2021), although not universally (Bleakley and Cowan, 2008).

Nigeria is a demanding test. The naira has moved between managed and more flexible regimes, with parallel windows, large discrete adjustments and a major set of FX-market reforms that, according to the IMF (2025), improved the functioning of the foreign-exchange market. For financial intermediation, the key question is not only how large exchange-rate movements are, but whether their direction matters. Models with occasionally binding borrowing constraints imply that balance-sheet effects bite in depreciations but are muted in appreciations (Aghion, Bacchetta and Banerjee, 2001; Céspedes, Chang and Velasco, 2004; Mendoza, 2010). A linear model that imposes one coefficient on both directions can then mask a strong effect in one direction with a weak effect in the other.

Evidence on Nigeria is thin on this point. Adeleke and Awodumi (2018) estimate a linear ARDL model of bank credit supply, which imposes symmetry by construction. The closest study, Yusuf *et al.* (2025), applies NARDL to the exchange rate and domestic credit over 1973–2022 and reports that appreciation shocks have stronger and more persistent effects than depreciations. Its abstract does not indicate that short- and long-run asymmetry are tested separately or that results are checked against alternative credit and exchange-rate measures. This paper addresses those points within a bank-lending and balance-sheet framework, and adds two elements that a credible asymmetry study needs: bounds critical values matched to the sample and an explicit discussion of the limited statistical power of the asymmetry test given how few appreciation episodes the data contain.

Problem statement.

Existing Nigerian evidence either assumes symmetry or does not establish whether, and at which horizon, appreciation and depreciation differ in their effects on private credit. Policy that depends on the exchange rate, whether through intervention, FX-market reform or prudential supervision, requires this distinction.

Objectives and questions.

The study (i) estimates the effect of exchange-rate fluctuations on domestic credit; (ii) tests whether appreciation and depreciation have asymmetric effects; (iii) separates short-run from long-run effects and the speed of adjustment; (iv) tests whether the two effects differ statistically; and (v) assesses robustness to alternative credit and exchange-rate measures, lag structures, samples, structural breaks, inference methods and estimators. Correspondingly: *Do exchange-rate movements affect credit? Do appreciation and depreciation differ? How large and how fast are the effects? Are the differences statistically distinguishable? Do the conclusions survive robustness checks?*

2. Institutional Background

The exchange rate is defined as the price of one US dollar in naira (NGN/USD); an increase is a depreciation. Nigeria's external position is shaped by oil-market conditions, and the IMF (2025) warns that a further fall in oil prices or higher financing costs would aggravate exchange-rate pressures. Over the study window the exchange-rate regime moved from heavily managed arrangements towards greater flexibility, with a move to a more flexible regime in 2016 and a package of FX-market reforms in 2023–2024 that the IMF (2025) credits with improving the functioning of the foreign-exchange market. Calvo and Reinhart (2002) document that emerging-market authorities often resist exchange-rate movements because of the balance-sheet consequences of liability dollarisation (“fear of floating”); this is the policy reason why the direction of exchange-rate changes matters for credit.

Domestic credit to the private sector comprises financial resources that financial corporations provide to households and firms, mainly bank loans, and is the standard indicator of financial depth. Because bank credit is a principal source of business finance in Nigeria (Adeleke and Awodumi, 2018), the supply behaviour of banks and the balance sheets of their borrowers are the relevant transmission channels. A purely accounting channel deserves mention: where part of the loan book is FX-denominated, depreciation mechanically raises the naira value of outstanding credit, so nominal credit can rise even if new lending falls. Real credit and the credit-to-GDP ratio are therefore used in the robustness analysis (Section 6.8).

3. Literature Review

3.1 Theoretical channels

Four channels link the exchange rate to credit. The **borrower balance-sheet channel**: firms borrowing in foreign currency but earning naira revenue suffer a rise in debt burden when the naira depreciates, lowering net worth and collateral values (Calvo, 1998; Krugman, 1999). The **bank balance-sheet and credit-risk channel**: exchange-rate risk of borrowers becomes credit risk for banks, tightening loan supply (Kashyap and Stein, 2000). The **global-liquidity channel**: dollar movements alter global banks' leverage constraints and cross-border lending (Bruno and Shin, 2015). The **price and policy channel**: pass-through of depreciation to inflation can prompt monetary tightening and change the real value of credit (Burstein and Gopinath, 2014; Gopinath *et al.*, 2020).

Asymmetry arises when borrowing constraints bind only occasionally. In Aghion, Bacchetta and Banerjee (2001), Céspedes, Chang and Velasco (2004) and Mendoza (2010), constraints tighten sharply in depreciations or sudden stops but are slack in booms, so balance-sheet effects appear in depreciations and not in appreciations. Kiyotaki and Moore (1997) and Bernanke, Gertler and

Gilchrist (1999) supply the mechanism: falling collateral values reduce credit, which feeds back to asset values. Asymmetry can also arise from bank behaviour, since loan-loss recognition is abrupt while the relaxation of credit standards is gradual.

Credit outcomes also depend on whether exchange-rate movements shift loan demand or loan supply. On the demand side, depreciation raises the naira cost of imported inputs and working-capital needs, which can raise nominal borrowing even as creditworthiness falls; on the supply side, banks facing higher expected losses ration credit. The net effect on nominal credit therefore depends on which force dominates and on the currency denomination of the loan book, which is why the empirical sign is open and why Adeleke and Awodumi (2018) can find a positive long-run exchange-rate effect in a linear model while balance-sheet theory predicts the opposite for borrowers with FX debt. A model that separates directions is a first step towards disentangling these forces, although only loan-level data can identify demand and supply separately.

3.2 Empirical evidence

The 21 studies in Table 1 are reviewed below by theme. Each is appraised on the same criteria: the outcome studied, the sample and data, the identification strategy, the main finding, its limitations, and what it implies for the exchange-rate–credit relationship in Nigeria.

3.2.1 Firm balance-sheet evidence

Aguiar (2005) asks whether firms exposed to foreign-currency debt cut investment after the 1994–95 Mexican devaluation. Using firm-level data around a single devaluation, he finds that firms with heavy short-term FX debt invested less than comparable firms. The strength of the design is the sharp timing of the shock, which separates the balance-sheet effect from slow-moving confounders; the limitations are that the evidence comes from one episode in one country and from firms large enough to have FX access. For Nigeria the paper supplies the key signed prediction ($\theta_+ < 0$ for exposed borrowers) and the reminder that exposure, not depreciation alone, drives the result. Pratap, Lobato and Somuano (2003) study the same Mexican setting with an emphasis on debt composition: how the currency and maturity mix of liabilities conditions the balance-sheet effect of exchange-rate and interest-rate volatility. Their contribution is to show that the aggregate sign of the exchange-rate effect cannot be read off without the composition of debt. Its limitation for present purposes is that it is a firm-level study of one economy. It motivates the caveat in Section 5.5: aggregate data on nominal credit cannot reveal composition, so an aggregate NARDL estimates a weighted average of exposed and unexposed borrowers.

Echeverry et al. (2003) examine Colombian firms and ask whether those with dollar debt were ‘punished’ during devaluations. They report a negative balance-sheet effect on firm performance even though dollar debt was not large for most firms, which suggests that modest exposures can matter. The finding is informative for Nigeria because it implies that a measurable aggregate effect does not require a heavily dollarised credit market. The study’s limitation is its restriction to firms with available balance-sheet data, which tilts the sample towards larger firms. Bleakley and Cowan (2008) are the principal dissent. Using firm data from several Latin American economies in the 1990s, they find that dollar debt does not depress investment after depreciation once the competitiveness gains of firms with foreign-currency revenue are taken into account: the balance-sheet loss and the export gain offset each other. This is a methodological as well as an empirical point, since studies that omit the revenue side overstate the contraction. It bears on Nigeria through

the composition of the borrower base: if borrowers with FX revenue are a small share of bank credit, the offset is weak and the Aguiar-type sign is more likely to dominate. Whether that is so is an empirical question that aggregate data cannot settle.

Serena and Sousa (2017) extend the question to roughly 1,000 firms in 36 emerging economies over 1998–2014 and ask whether depreciation is contractionary for firm-level investment, with FX debt as the conditioning variable. Their breadth is the main strength: results do not hinge on one episode. The limitation is the focus on firms with the financial reporting that cross-country databases require, which may not represent small borrowers who rely on bank credit. The study supports treating contractionary effects as conditional on FX debt rather than universal, which is how the hypotheses in Section 4.1 are framed. **Kalemli-Özcan, Liu and Shim (2021)** use firm data for ten Asian economies over 2002–2015 and show that leverage responds asymmetrically: firms with more FX debt de-lever when the home currency depreciates and re-lever when it appreciates, but the depreciation effect is much larger (in their FX-loan specification a depreciation of 10% or more reduces leverage by 0.1517, against a rise of 0.0265 after an appreciation of the same size). This is the closest firm-level analogue of the question asked here and the main empirical support for expecting $|\theta^+| > |\theta^-|$. Its limitation is that leverage is not credit supply: lower leverage can reflect either weaker borrower demand or tighter lending, so the evidence is about borrower balance sheets rather than banks.

3.2.2 Bank-level and global-funding evidence

Niepmann and Schmidt-Eisenlohr (2022) move to the lender's side with loan-level data from US banks. They find that a 10% depreciation of the borrower's currency raises the probability that a loan to a firm with foreign-currency debt becomes past due by 42 basis points relative to a loan in local currency, against a baseline of about 20 basis points. The study is persuasive because it observes the same bank's loans in different currencies, which controls for bank characteristics. Its limitation is that the setting is lending by US banks abroad, not domestic lending in a dollarising economy. The relevance is the credit-risk channel: exchange-rate risk of borrowers becomes loan-loss risk for banks, which supplies a mechanism for a supply-side contraction after depreciation. Kashyap and Stein (2000) use a very large panel of US banks to show that the response of lending to monetary policy depends on bank balance-sheet strength, with weakly capitalised or less liquid banks responding more. The paper does not concern exchange rates, but it is the standard evidence that bank lending responds to shocks through bank balance sheets. For this study it justifies the inclusion of money and reserves as controls and the interpretation of the error-correction speed as a measure of how quickly banks adjust.

Bruno and Shin (2015) link dollar movements to cross-border lending through global banks' leverage: dollar depreciation relaxes leverage constraints and increases lending to borrowers abroad. **Avdjiev, Du, Koch and Shin (2019)** connect dollar strength to bank leverage, cross-border dollar lending and deviations from covered interest parity, while **Cerutti, Claessens and Ratnovski (2017)** document how global push factors, rather than local pull factors alone, drive cross-border bank flows. Taken together, these studies show that the credit effects of exchange-rate changes can arise from the funding side as well as from borrower balance sheets. Their limitation for Nigeria is that they concern cross-border bank flows and globally active banks; Nigerian credit is largely supplied by domestic banks funded by naira deposits, so the global-liquidity channel is likely to be

indirect, operating through the availability of FX funding to banks and through trade finance. They also warn that appreciation need not mirror depreciation, because leverage constraints bind unevenly.

3.2.3 Currency exposure, policy and pass-through

Calvo and Reinhart (2002) show that many emerging-market authorities limit exchange-rate movements far more than their announced regimes imply, and attribute this ‘fear of floating’ to liability dollarisation and limited credibility. Its relevance is policy-theoretic: if authorities fear depreciation because of balance-sheet effects, depreciation is likely to be the costlier direction. The study does not estimate credit effects, so it supports the prior but not the magnitude. **Lane and Shambaugh (2010)** construct measures of the currency composition of international balance sheets and show how exchange-rate movements generate valuation effects. The measures underline that the data needed for a direct test of the balance-sheet channel in Nigeria, namely the currency composition of bank assets and borrower liabilities, are not available in standard quarterly series.

Gopinath *et al.* (2020) show that the dominant-currency paradigm, in which trade is invoiced mainly in dollars, makes the dollar exchange rate central to pass-through to import prices. For Nigeria, a large importer of goods priced in dollars, this suggests that depreciation raises costs and inflation broadly and quickly, which in turn affects real credit and interest rates; it justifies including inflation as a control and checking real credit. **Delatte and López-Villavicencio (2012)** estimate asymmetric pass-through for four large economies and find that depreciations are passed through to prices more than appreciations in the long run, and **Kemoe *et al.* (2024)** find, for Sub-Saharan Africa, that pass-through is about eight times stronger in depreciations than in appreciations and larger for large depreciations. Both establish that exchange-rate asymmetry is an empirical regularity in prices, and the evidence of Kemoe *et al.* is regionally relevant. Their limitation is that prices, not credit, are the outcome; they motivate, but do not substitute for, a credit-specific test. **Bahmani-Oskooee and Fariditavana (2015)** apply NARDL to trade balances for Canada, China, Japan and the United States and find asymmetric effects, which illustrates the usefulness of the method.

3.2.4 Evidence for Nigeria

Adeleke and Awodumi (2018) estimate a linear ARDL for bank credit supply over 1970–2015 and report positive long-run effects of the exchange rate, money supply, net foreign liabilities and real GDP and a negative effect of the price level. Its strengths are the long sample and the attention to bank-credit determinants; its limitations are that linearity precludes any test of asymmetry and that a positive exchange-rate coefficient on nominal credit is open to the valuation interpretation discussed in Section 2. **Yusuf *et al.* (2025)** apply NARDL to exchange rate and domestic credit over 1973–2022 and report stronger and more persistent appreciation effects than depreciation effects and an ineffective interest rate. It is the nearest comparator. Its sample spans very different regimes, and the published abstract does not indicate how short-run asymmetry or alternative credit measures were handled, so its ordering of the two effects cannot be taken as settled; it is nonetheless the main reason the question deserves a power-aware test.

Ajide and Lawanson (2012) model private investment in Nigeria with ARDL and identify the exchange rate and credit to the private sector among its long-run determinants, linking the credit question to real activity. **Yola, Iliyasu and Mustapha (2025)** use an asymmetric ARDL for private

investment and report that positive exchange-rate shocks are stronger than negative ones. These investment studies are one step removed from credit, but they matter for two reasons: they show that asymmetric exchange-rate effects have been reported for Nigerian real outcomes, and they suggest that any credit-side asymmetry should be visible in investment. They share a limitation with the credit studies: aggregate national data and, judging from their published abstracts, no analysis of the power of the asymmetry test.

3.2.5 Methods literature

Shin, Yu and Greenwood-Nimmo (2014) introduced the partial-sum NARDL, which allows asymmetric long-run and short-run effects within an error-correction model, and **Pal and Mitra (2016)** extended it to multiple thresholds, which this paper uses to separate small from large depreciations. Pesaran, Shin and Smith (2001) supply the bounds approach on which cointegration testing rests; the critical values used here address the concern that tabulated values do not match the sample.

Three regularities emerge from the 21 studies. First, adverse balance-sheet effects of depreciation are well documented where FX debt is large and the borrower lacks a natural hedge, and are weak or absent where exporters gain competitiveness (Aguilar, 2005; Bleakley and Cowan, 2008). Second, where direction has been tested, depreciation effects exceed appreciation effects (Kalemli-Özcan, Liu and Shim, 2021; Delatte and López-Villavicencio, 2012; Kemoe *et al.*, 2024), although the Nigerian credit study reports the opposite ordering (Yusuf *et al.*, 2025). Third, almost all of the evidence is on firms, prices or trade rather than on aggregate bank credit, and Nigerian evidence on credit in this review is limited to two studies. The contrast between the theoretical prior (depreciation dominates) and the one Nigerian asymmetric estimate (appreciation dominates) is what makes a careful, power-aware test of asymmetry valuable.

Table 1. *Summary of the empirical studies reviewed*

Study	Country and sample	Method	Main finding relevant to this paper
Aguilar (2005)	Mexican firms; 1994–95 devaluation	Firm panel, investment	Heavy short-term FX debt associated with lower investment after devaluation
Pratap *et al.* (2003)	Mexican firms	Firm-level analysis	Debt composition conditions balance-sheet effects of exchange-rate movements
Echeverry *et al.* (2003)	Colombian firms; 1990s	Firm-level analysis	Negative balance-sheet effect on performance despite limited dollar debt
Bleakley and Cowan (2008)	Latin American firms	Firm panel	Dollar debt need not depress investment once exporters' competitiveness gains are counted
Kalemli-Özcan *et al.* (2021)	Ten Asian economies; 2002–2015	Firm leverage (ORBIS)	Depreciation effect on leverage larger than appreciation effect
Serena and Sousa (2017)	~1,000 firms, 36 EMEs; 1998–2014	Firm-level investment regressions	Depreciation can be contractionary, conditional on FX debt

Niepmann and Schmidt-Eisenlohr (2022)	US bank loans	Loan-level credit risk	10% depreciation raises past-due probability of FX-debt firms by 42 bp (baseline 20 bp)
Kashyap and Stein (2000)	US banks	Bank-level panel	Bank balance-sheet strength shapes lending response to shocks
Bruno and Shin (2015)	Cross-border banking	Panel, leverage and flows	Dollar depreciation relaxes global bank leverage; cross-border lending rises
Avdjiev *et al.* (2019)	Global banks, dollar	Panel, leverage and CIP deviations	Dollar strength linked to bank leverage constraints and cross-border dollar lending
Cerutti *et al.* (2017)	Cross-border bank flows	Panel	Global push factors drive cross-border bank flows
Calvo and Reinhart (2002)	Emerging markets	Cross-country	Pervasive fear of floating tied to liability dollarisation
Lane and Shambaugh (2010)	Large cross-country panel; 1990–2004	Currency-composition measures	Measures valuation effects of exchange-rate changes on external balance sheets
Gopinath *et al.* (2020)	Trade-price data	Dominant-currency model	Dollar invoicing makes the dollar rate central to pass-through
Delatte and López-Villavicencio (2012)	Four major economies	Asymmetric ARDL	Depreciations passed through to prices more than appreciations in the long run
Kemoe <i>et al.</i> (2024)	Sub-Saharan Africa; monthly	Pass-through estimation	Pass-through eight times stronger in depreciations; larger for large depreciations
Bahmani-Oskooee and Fariditavana (2015)	Canada, China, Japan, USA	NARDL, trade balance	Exchange-rate effects asymmetric; more evidence of J-curve
Adeleke and Awodumi (2018)	Nigeria; 1970–2015	Linear ARDL, bank credit	Exchange rate, money, net foreign liabilities, GDP raise credit; prices lower it
Yusuf *et al.* (2025)	Nigeria; 1973–2022	NARDL, domestic credit	Appreciation shocks stronger and more persistent than depreciations
Ajide and Lawanson (2012)	Nigeria; 1970–2010	ARDL, private investment	Exchange rate and private credit among long-run determinants
Yola *et al.* (2025)	Nigeria	NARDL, private investment	Positive exchange-rate shocks stronger than negative shocks

Notes. EMEs = emerging-market economies; CIP = covered interest parity. Findings are paraphrased from the cited sources; details for each study are in the reference list.

3.3 Literature gap

Three gaps emerge. First, linear models for Nigeria impose symmetry (Adeleke and Awodumi, 2018). Second, the asymmetric evidence for Nigeria (Yusuf *et al.*, 2025) concerns long-run effects over a long, regime-heterogeneous sample, and it is not clear from the abstract that short-run asymmetry, uncertainty around dynamic responses or robustness to alternative measures were examined. Third, the published abstracts of the NARDL studies reviewed do not indicate that any of

them quantifies how reliably the asymmetry test can detect an asymmetry given the imbalance between depreciation and appreciation episodes. This study addresses these gaps; it does not claim to be the first study of asymmetric exchange-rate effects on Nigerian credit.

4. Theoretical and Conceptual Framework

Credit and balance-sheet channels. Financial frictions amplify shocks to borrowing costs and credit availability (Bernanke and Gertler, 1995); within the bank lending channel, shocks to bank funding and capital affect loan supply (Kashyap and Stein, 2000). With currency mismatches, depreciation raises the naira value of FX liabilities relative to naira income, lowering net worth (Calvo, 1998; Krugman, 1999). The financial accelerator makes the response strongest when net worth is falling and constraints bind (Bernanke, Gertler and Gilchrist, 1999). The exchange rate is also a monetary-transmission channel (Mishkin, 1996), so policy responses can reinforce or dampen the direct credit effects; interest rate and money supply are therefore controls.

Why direction should matter. The theories jointly predict that (i) the adverse balance-sheet, credit-risk and pass-through effects of depreciation are immediate and large; (ii) the beneficial effects of appreciation require balance-sheet repair and relaxed lending standards, so are slower and smaller; and (iii) appreciations are fewer and smaller in Nigeria, so the data contain less information about them. These imply $\theta^+ < 0$ and $|\theta^+| > |\theta^-|$ (long run), with a possibly different short-run pattern. Because nominal credit includes FX-loan valuation effects, the sign of the net depreciation effect on nominal credit is itself an empirical question.

Conceptual framework. Figure 1 shows cumulative depreciation (ER^+) and cumulative appreciation (ER^-) entering credit through separate coefficients; $\theta^+ \neq \theta^-$ (long run) and $\Sigma\pi^+ \neq \Sigma\pi^-$ (short run) signal asymmetry. Five controls carry theoretical roles: the policy rate (negative: higher borrowing cost), inflation (negative: loan-loss risk), broad money (positive: deposit base), real GDP (positive: demand and collateral) and foreign reserves (positive: capacity to cushion depreciation). Financial development is not entered separately because credit is itself its principal indicator; fiscal and oil variables are left to future work to preserve degrees of freedom.

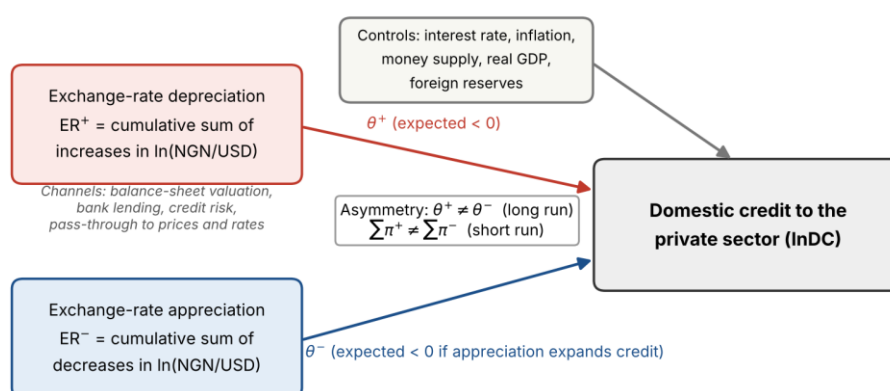


Figure 1. Conceptual framework: asymmetric exchange-rate effects on domestic credit.

4.1 Research hypotheses

Hypothesis development

Overall effect (H0₁). Under the balance-sheet and bank-lending channels of Section 3.1, exchange-rate movements should change credit in at least one direction and horizon. Evidence of effects on

firm leverage and investment (Aguilar, 2005; Serena and Sousa, 2017; Kalemli-Özcan, Liu and Shim, 2021) and on loan performance (Niepmann and Schmidt-Eisenlohr, 2022) supports a non-zero joint effect, whereas Bleakley and Cowan (2008) show that offsetting competitiveness gains can mask it. The joint test therefore has substantive content: failure to reject would favour the offsetting-gains view for aggregate credit.

Short-run effects ($H0_2$, $H0_3$). Depreciation should have an immediate effect through revaluation of FX balances and repricing of credit risk (Niepmann and Schmidt-Eisenlohr, 2022), so $\Sigma\pi^+ < 0$ is expected. Appreciation should have a smaller or delayed effect, because relaxing credit standards and rebuilding net worth take time (Kalemli-Özcan, Liu and Shim, 2021), so $|\Sigma\pi^-|$ is expected to be smaller. Yusuf *et al.* (2025) report the opposite ordering for long-run credit, which is why both are tested separately.

Long-run effects ($H0_4$, $H0_5$) and symmetry ($H0_6$, $H0_7$). In the long run, sustained depreciation lowers net worth and collateral values, giving $\theta^+ < 0$ (Calvo, 1998; Krugman, 1999). Models with occasionally binding constraints imply a weaker response to appreciation (Aghion, Bacchetta and Banerjee, 2001; Mendoza, 2010), and the empirical pass-through literature finds depreciation effects larger than appreciation effects (Delatte and López-Villavicencio, 2012; Kemoe *et al.*, 2024). The alternative, that appreciation matters more, is the finding of Yusuf *et al.* (2025) and may arise if appreciation eases FX funding and trade finance. The symmetry hypotheses $H0_6$ and $H0_7$ are two-sided for that reason.

Parameters are defined in Section 5.3: θ^+ and θ^- are long-run coefficients on cumulative depreciation and appreciation; π_1^+ and π_1^- are short-run coefficients; γ^+ and γ^- are the level coefficients in the error-correction model. The null hypotheses are:

H01: Exchange-rate fluctuations have no effect on credit: $\gamma^+ = \gamma^- = 0$ and $\pi_1^+ = \pi_1^- = 0$ for all l (joint Wald test).

H02: Short-run appreciation has no effect: $\Sigma\pi_1^- = 0$. **H03:** Short-run depreciation has no effect: $\Sigma\pi_1^+ = 0$.

H04: Long-run appreciation has no effect: $\theta^- = 0$. **H05:** Long-run depreciation has no effect: $\theta^+ = 0$.

H06: Short-run symmetry: $\Sigma\pi_1^+ = \Sigma\pi_1^-$. **H07:** Long-run symmetry: $\theta^+ = \theta^-$.

5. Data and Methodology

5.1 Design and data

Table 2. Variable definitions, measurement and expected signs

Variable	Symbol	Definition and measurement	Expected sign	Source
Domestic credit	lnDC	Log of domestic credit to the private sector (end of quarter)	—	CBN; IMF IFS
Exchange rate	lnER	Log of nominal NGN per USD; increase = depreciation	—	CBN; IMF IFS
Cumulative depreciation	ER ⁺	Partial sum of positive changes in lnER (Eq. 2)	$\theta^+ < 0$	Constructed
Cumulative appreciation	ER ⁻	Partial sum of negative changes in lnER (Eq. 3)	$\theta^- < 0$	Constructed
Interest rate	INT	Monetary policy rate, % p.a.	—	CBN

Inflation	INF	Year-on-year change in consumer prices, %	–	NBS
Money supply	lnM2	Log of broad money (M2)	+	CBN
Real GDP	lnGDP	Log of real GDP index	+	NBS
Foreign reserves	lnRES	Log of gross external reserves	+	CBN

Notes. Because ER is naira per dollar, $\theta^- < 0$ means that an appreciation (a fall in ER–, which is non-positive) raises credit. Z denotes the vector of controls (INT, INF, lnM2, lnGDP, lnRES).

5.2 Symmetric ARDL

The baseline is the unrestricted error-correction form of the ARDL of Pesaran, Shin and Smith (2001), where $y_t = \ln DC_t$ and x_t contains the log exchange rate and controls:

$$\Delta y_t = c + \rho y_{t-1} + \sum_{i=1}^k \gamma_i x_{i,t-1} + \sum_{j=1}^{p-1} \varphi_j \Delta y_{t-j} + \sum_{i=1}^k \sum_{l=0}^{q-1} \pi_{i,l} \Delta x_{i,t-l} + \varepsilon_t \quad (1)$$

The long-run coefficient on regressor i is $\theta_i = -\gamma_i/\rho$, with $\rho < 0$ the speed of adjustment. Cointegration is tested with the bounds F-test of $\rho = \gamma_1 = \dots = \gamma_k = 0$ and the t-test on ρ .

5.3 Nonlinear ARDL

Following Shin, Yu and Greenwood-Nimmo (2014), the log exchange rate is decomposed into partial sums of positive and negative changes:

$$ER_t^+ = \sum_{j=1}^t \max(\Delta ER_j, 0) \quad (2)$$

$$ER_t^- = \sum_{j=1}^t \min(\Delta ER_j, 0) \quad (3)$$

ER^+ is non-decreasing and starts at zero; ER^- is non-increasing and non-positive; $ER_t = ER_0 + ER_t^+ + ER_t^-$. The long-run relationship and the estimated error-correction form are

$$y_t = \theta^+ ER_t^+ + \theta^- ER_t^- + \theta_z' Z_t + u_t \quad (4)$$

$$\begin{aligned} \Delta y_t = c + \rho y_{t-1} + \gamma^+ ER_{t-1}^+ + \gamma^- ER_{t-1}^- + \gamma_z' Z_{t-1} + \sum_{j=1}^{p-1} \varphi_j \Delta y_{t-j} \\ + \sum_{l=0}^{q-1} (\pi_l^+ \Delta ER_{t-l}^+ + \pi_l^- \Delta ER_{t-l}^-) + \sum_{l=0}^{q-1} \delta_l' \Delta Z_{t-l} + \varepsilon_t \end{aligned} \quad (5)$$

Long-run multipliers and cumulative dynamic multipliers are

$$\theta^+ = -\frac{\gamma^+}{\rho}, \quad \theta^- = -\frac{\gamma^-}{\rho} \quad (6)$$

$$m_h^+ = \sum_{j=0}^h \frac{\partial y_{t+j}}{\partial ER_t^+}, \quad m_h^- = \sum_{j=0}^h \frac{\partial y_{t+j}}{\partial ER_t^-}, \quad m_h^\pm \rightarrow \theta^\pm (h \rightarrow \infty) \quad (7)$$

Lag orders p and q count the lags of the dependent variable and the number of short-run terms (lags 0 to $q-1$) respectively. They are chosen over $p, q \in \{1, 2, 3\}$ on the common sample by the Schwarz criterion (SBC), which penalises over-parameterisation more heavily and is commonly preferred in small samples (Pesaran and Shin, 1999); the Akaike criterion (AIC) is reported as a robustness check. The SBC selects $(p, q) = (2, 1)$; the AIC selects $(3, 3)$.

5.4 Hypothesis tests and inference

H_{01} – H_{07} map onto restrictions in Eq. (5). H_{01} is a joint Wald (F) test; H_{02} and H_{03} test sums of short-run coefficients; H_{04} and H_{05} test $\theta^- = 0$ and $\theta^+ = 0$ using delta-method standard errors; H_{06} tests $\Sigma\pi^+ = \Sigma\pi^-$; and H_{07} tests $\theta^+ = \theta^-$, equivalent to $\gamma^+ = \gamma^-$ because both are scaled by the same ρ . Level restrictions are interpreted conditional on cointegration, as is usual in the NARDL literature.

Further analysis. (i) A multiple-threshold decomposition (Pal and Mitra, 2016) splits depreciations into small and large (threshold $\tau = 0.05$ log points per quarter):

$$ER_t^L = \sum_{j \leq t} \Delta ER_j \mathbb{1}(\Delta ER_j > \tau), \quad ER_t^S = \sum_{j \leq t} \Delta ER_j \mathbb{1}(0 < \Delta ER_j \leq \tau), \quad ER_t^A = \sum_{j \leq t} \min(\Delta ER_j, 0)$$

(ii) Dynamic OLS (DOLS; Stock and Watson, 1993) with one lead and lag and Newey–West (1987) standard errors cross-check the long-run coefficients. (iii) Recursive estimation tracks parameter stability. (iv) Supplementary analyses (Section 6.10) re-estimate the model without the price and policy variables (mediation), test Granger causality with the Toda–Yamamoto (1995) procedure and compare expanding-window forecasts with the Diebold–Mariano (1995) test.

Pre- and post-estimation tests. Unit roots: ADF (Dickey and Fuller, 1979), Phillips–Perron (Phillips and Perron, 1988) and Zivot–Andrews (1992); the ADF test on second differences confirms that no variable is $I(2)$. Diagnostics: Breusch–Godfrey (Breusch, 1978; Godfrey, 1978), Breusch–Pagan (Breusch and Pagan, 1979), ARCH (Engle, 1982), RESET (Ramsey, 1969), Jarque–Bera (Jarque and Bera, 1980), and CUSUM and CUSUM-of-squares (Brown, Durbin and Evans, 1975). Computations use Python (statsmodels, arch).

5.5 Identification and exogeneity

The ARDL framework delivers consistent long-run estimates when the regressors are weakly exogenous with respect to the long-run parameters and the residuals are serially uncorrelated; sufficient lags, selected as above, absorb residual correlation. Three threats deserve explicit mention. First, the exchange rate may respond to credit conditions, for example if credit expansion raises import demand and depreciation pressure; the inclusion of broad money, reserves and the policy rate mitigate, but cannot eliminate, this reverse-causality channel. Second, the partial-sum construction treats every non-zero quarterly change as a depreciation or appreciation, so measurement error in the rate (for example from multiple official and parallel rates) can misclassify small movements; the threshold analysis in Section 6.9 probes this. Third, the sign of the short-run asymmetry depends on contemporaneous co-movement of the exchange rate and credit, which is not causal evidence. The paper therefore interprets the estimates as conditional long-run associations consistent with, not proof of, the balance-sheet mechanism.

6. Results

6.1 Descriptive statistics

Table 3 reports descriptive statistics and Table 4 correlations; Figure 2 plots the series and the decomposition. Quarterly changes in the log exchange rate are highly skewed and fat-tailed (skewness 3.73, kurtosis 21.9), reflecting a few large discrete adjustments. Depreciations dominate: 88 of 103 quarterly changes are depreciations (mean 0.030 log points) and only 15 are appreciations (mean -0.021); cumulative depreciation is 2.68 against cumulative appreciation of -0.32 . This imbalance matters for inference: the data contain far less information about appreciation.

Table 3. Descriptive statistics, 2000Q1–2025Q4

Variable	N	Mean	Median	Std. dev.	Min	Max	Skew.	Kurt.	JB p
lnDC	104	7.516	7.597	0.471	6.696	8.228	-0.20	1.78	0.028
lnER	104	5.605	5.514	0.724	4.571	6.987	0.24	1.8	0.027
INT	104	12.67	12.457	1.169	10.78	15.36	0.37	2.02	0.037
INF	104	10.5	10.751	1.953	5.33	13.99	-0.61	2.88	0.04
lnM2	104	8.703	8.753	1.006	6.975	10.34	-0.13	1.84	0.046
lnGDP	104	5.308	5.297	0.45	4.62	6.024	0.05	1.62	0.016
lnRES	104	4.302	4.25	0.317	3.602	4.932	0.26	2.65	0.424
Δ lnER	103	0.023	0.013	0.047	-0.058	0.33	3.73	21.9	<0.001

Table 4. Correlation matrix of variables in levels

	lnDC	lnER	INT	INF	lnM2	lnGDP	lnRES
lnDC	1	0.97	0.8	0.4	1	0.99	0.9
lnER	0.97	1	0.8	0.4	0.98	0.99	0.9
INT	0.77	0.83	1	0.3	0.79	0.82	0.73
INF	0.38	0.38	0.3	1	0.41	0.37	0.41
lnM2	1	0.98	0.8	0.4	1	0.99	0.91
lnGDP	0.99	0.99	0.8	0.4	0.99	1	0.9
lnRES	0.9	0.9	0.7	0.4	0.91	0.9	1

Notes. Pearson correlations of levels. High correlations among trending series reflect common trends, not causation; the ARDL framework accommodates trending series if they are cointegrated.

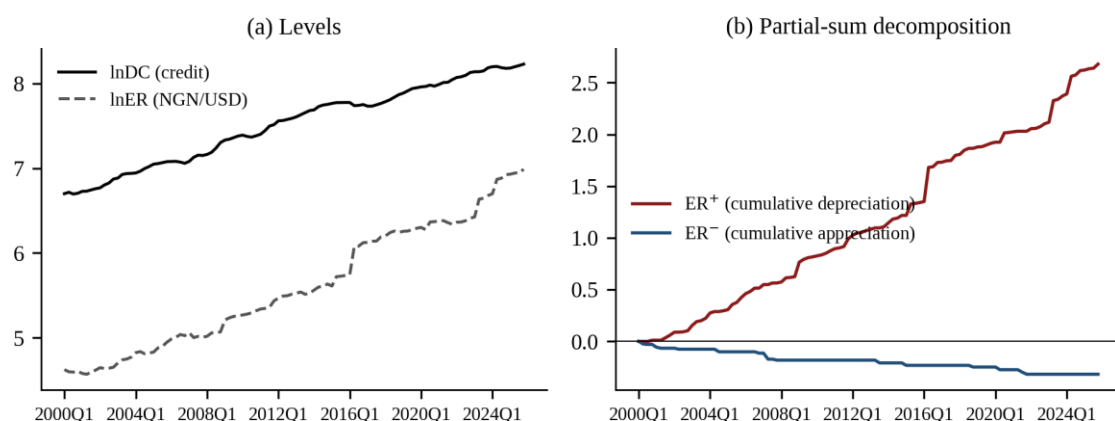


Figure 2. Log credit, log exchange rate and the partial-sum decomposition.

6.2 Unit-root and structural-break tests

Table 5 shows that, at the 5% level, $\ln DC$, $\ln ER$, ER^+ , INF , $\ln M2$, $\ln GDP$, $\ln RES$ are non-stationary in levels under both the ADF and PP tests and stationary after first differencing. The ADF and PP tests disagree at 5% for ER^- , INT , which are treated as borderline $I(0)/I(1)$; this mixture is permissible for bounds testing, which requires only that no variable is $I(2)$. The ADF test on second differences rejects a unit root for all series, so **no variable is $I(2)$** and the NARDL bounds approach is valid. The partial sums are $I(1)$ by construction when both directions occur regularly, and the borderline result for ER^- reflects its long flat stretches. Zivot–Andrews tests with one endogenous break do not reject the unit-root null for $\ln DC$ (statistic -4.62 , 5% critical value -5.07 , break 2015Q4) or $\ln ER$ (-4.96 , break 2016Q1), so their non-stationarity is not an artefact of a single break.

Table 5. Unit-root tests

Variable	ADF level (c,t)	ADF Δ (c)	ADF Δ^2 (c)	PP level (c,t)	PP Δ (c)	Order
$\ln DC$	-2.01	-6.75***	-5.65***	-1.41	-6.37***	$I(1)$
$\ln ER$	-2.75	-10.80***	-11.69***	-2.71	-10.84***	$I(1)$
ER^+	-2.72	-11.01***	-12.06***	-2.66	-11.11***	$I(1)$
ER^-	-3.28*	-10.42***	-8.34***	-3.44**	-10.57***	$I(0)/I(1)^\dagger$
INT	-3.43**	-6.48***	-7.35***	-3.26*	-11.51***	$I(0)/I(1)^\dagger$
INF	-2.52	-8.53***	-8.17***	-2.51	-11.25***	$I(1)$
$\ln M2$	-1.89	-7.04***	-5.77***	-1.16	-6.45***	$I(1)$
$\ln GDP$	-2.68	-3.36**	-5.16***	-2.20	-6.20***	$I(1)$
$\ln RES$	-1.91	-8.69***	-10.25***	-2.08	-9.14***	$I(1)$

Notes. Entries are test statistics; *, **, *** denote rejection of the unit-root null at 10%, 5%, 1%. ADF lag length by AIC (maximum 8); PP automatic bandwidth. Levels include constant and trend; differences a constant. † ADF and PP disagree at 5% (ER^- and INT). The ADF test on Δ^2 rejects for all series, so none is $I(2)$.

6.3 Bounds test for cointegration

Table 6 shows that the bounds F-statistic (5.19) exceeds the upper $I(1)$ bound at the 1% level (4.71), and the t-statistic on the lagged dependent variable (-5.92) is below the $I(1)$ bound at 1% (-5.29). Both tests indicate a long-run relationship between credit, the exchange-rate partial sums and the controls. The speed of adjustment is $\rho = -0.268$: about 27% of any disequilibrium is corrected each quarter, a half-life of 2.2 quarters.

Table 6. NARDL bounds test for cointegration

Test	Statistic	10% $I(0)$	10% $I(1)$	5% $I(0)$	5% $I(1)$	1% $I(0)$	1% $I(1)$
F-test ($k = 7$)	5.185	2.09	3.27	2.436	3.689	3.185	4.71
t-test on $\ln DC_{t-1}$	-5.922	-2.536	-4.141	-2.850	-4.526	-3.516	-5.285

Notes. Critical bounds for $n = 100$, $k = 7$ regressors (two partial sums and five controls), case III. The F-test rejects when the statistic exceeds the $I(1)$ bound; the t-test when it is below the $I(1)$ bound. Decision: cointegration at the 1% level (selected lags $p = 2$, $q = 1$).

6.4 Long-run estimates

Table 7 reports long-run coefficients $\theta = -\gamma/\rho$. **Depreciation** has a large, highly significant negative effect: $\theta^+ = -0.333$ ($p < 0.001$); since the variables are logs, a 10% depreciation lowers credit by

about 3.3% in the long run. **Appreciation** has a coefficient of $\theta^- = 0.313$ (standard error 0.376, $p = 0.405$). Because ER^- falls in an appreciation, a positive θ^- would mean that appreciation *lowers* credit, the opposite of the theoretical expectation, but the estimate is statistically indistinguishable from zero. With only 15 appreciation quarters it should be read as ‘imprecisely estimated’, not as evidence that appreciation hurts credit. Among controls, broad money (0.50) and real GDP (0.58) have positive, significant effects, and the interest rate (-0.024 , $p = 0.005$) and inflation (-0.011 , $p = <0.001$) have the expected negative, significant effects; reserves have no detectable effect ($p = 0.181$).

Economic interpretation. Scale matters for reading these coefficients. The long-run elasticity of credit with respect to broad money is 0.50, so a 10% depreciation (3.3% credit loss) offsets the credit gain from roughly a 7% rise in M2. The credit lost to a depreciation of that size would require a substantial monetary expansion to replace, and monetary expansion is itself inflationary and depreciation-inducing. The elasticity with respect to real GDP (0.58) is of similar size, confirming that credit tracks the real economy and the deposit base in the long run; the exchange rate modifies the credit–activity relationship rather than being its primary driver. The policy rate and inflation matter too: a one-percentage-point rise in the policy rate lowers long-run credit by about 2.4% and a one-point rise in inflation by about 1.1%, so an exchange-rate depreciation that also raises inflation and prompts monetary tightening would act on credit through all three routes. The aggregate estimates cannot separate those routes, which Section 7.6 returns to.

Table 7. Long-run NARDL estimates, dependent variable $\ln DC$

Variable	Coefficient	Std. error	z-statistic	p-value	Expected sign
$ER^+ (\theta^+)$	-0.333^{***}	0.078	-4.26	<0.001	< 0
$ER^- (\theta^-)$	0.313	0.376	0.83	0.405	< 0
INT	-0.024^{***}	0.009	-2.79	0.005	—
INF	-0.011^{***}	0.003	-3.40	<0.001	—
$\ln M2$	0.498^{***}	0.075	6.67	<0.001	+
$\ln GDP$	0.582^{***}	0.21	2.77	0.006	+
$\ln RES$	0.079	0.059	1.34	0.181	+
Constant	0.649	0.851	0.76	0.446	—

Notes. $\theta = -\gamma/\rho$ with delta-method standard errors; p-values from the asymptotic normal distribution. *, **, *** denote significance at 10%, 5%, 1%. INT and INF coefficients are semi-elasticities.

6.5 Short-run dynamics and error correction

Table 8 reports the short-run coefficients of Eq. (5). The error-correction term is negative and significant ($\rho = -0.268$, $t = -5.92$). Depreciation reduces credit within the quarter ($\pi_0^+ = -0.092$, $p = 0.004$): a 10% depreciation lowers credit by about 0.9% on impact. The contemporaneous appreciation coefficient has the expected negative sign (-0.122 , $p = 0.463$) but is statistically indistinguishable from zero. Real GDP growth has a significant positive short-run effect ($p = 0.048$), whereas money growth, which matters in the long run, is not significant in the short run ($p = 0.357$); lagged credit growth is positive and significant, indicating persistence.

Speed and persistence. Adjustment is fast: with $\rho = -0.268$, about 27% of any gap between actual and equilibrium credit closes each quarter, 90% of the gap closes in roughly 7.4 quarters, and the half-life is 2.2 quarters. The positive coefficient on lagged credit growth (0.20) adds persistence in

the short run, so a shock to credit growth takes several quarters to dissipate even though the long-run gap closes steadily. For banks and supervisors this means that the credit effect of a depreciation is front-loaded: much of the adjustment arrives within the first year, when provisioning and funding decisions are being made, and later quarters bring a smaller further decline. The short-run appreciation coefficient has the expected sign but a large standard error, so the data show no measurable immediate gain from appreciation.

Table 8. Short-run NARDL / error-correction estimates, dependent variable $\Delta \ln DC$

Variable	Coefficient	Std. error	t-statistic	p-value
$\Delta \ln DC_{t-1}$	0.199**	0.094	2.11	0.038
$\Delta ER_t^+ (\pi^+_0)$	-0.092***	0.031	-2.98	0.004
$\Delta ER_t^- (\pi^-_0)$	-0.122	0.165	-0.74	0.463
ΔINT_t	-0.001	0.003	-0.31	0.761
ΔINF_t	-0.001	0.002	-0.32	0.747
$\Delta \ln M2_t$	0.067	0.073	0.93	0.357
$\Delta \ln GDP_t$	0.520**	0.258	2.01	0.048
$\Delta \ln RES_t$	-0.072	0.05	-1.45	0.15
Constant	0.174	0.234	0.74	0.459
$ECT_{t-1} (p)$	-0.268***	0.045	-5.92	<0.001

Notes. OLS estimates of Eq. (5), $(p, q) = (2, 1)$; ECT_{t-1} is the coefficient on $\ln DC_{t-1}$. *, **, *** denote significance at 10%, 5%, 1%. $R^2 = 0.518$; adjusted $R^2 = 0.425$; $n = 100$; AIC = -577.4; BIC = -533.2.

6.6 Asymmetry tests and dynamic multipliers

Table 9 reports the Wald tests for $H0_1$ – $H0_7$. The joint null of no exchange-rate effect is decisively rejected ($p < 0.001$). Short-run depreciation ($H0_3$, $p = 0.004$) and long-run depreciation ($H0_5$, $p < 0.001$) reduce credit, while short-run appreciation ($H0_2$, $p = 0.463$) and long-run appreciation ($H0_4$, $p = 0.405$) have no detectable effect. **Long-run symmetry is not rejected** ($H0_7$: $F = 2.41$, $p = 0.124$), and **short-run symmetry is not rejected** ($H0_6$: $F = 0.03$, $p = 0.865$). The estimated long-run gap $\theta^+ - \theta^-$ is -0.65; the point estimate indicates effects of opposite sign, but the difference is not statistically significant, and the long-run test is the closer of the two to rejection.

Table 9. Wald tests for short-run and long-run asymmetry

Hypothesis	Restriction	Test statistic	p-value	Decision (5%/10%)
$H0_1$: no exchange-rate effect	$\gamma^+ = \gamma^- = \pi^+_0 = \pi^-_0 = 0$	$F(4, 83) = 5.78$	<0.001	Reject
$H0_2$: SR appreciation	$\Sigma \pi^- = 0$	$F(1, 83) = 0.54$	0.463	Fail to reject
$H0_3$: SR depreciation	$\Sigma \pi^+ = 0$	$F(1, 83) = 8.90$	0.004	Reject
$H0_4$: LR appreciation	$\theta^- = 0$	$\chi^2(1) = 0.69$	0.405	Fail to reject
$H0_5$: LR depreciation	$\theta^+ = 0$	$\chi^2(1) = 18.15$	<0.001	Reject
$H0_6$: SR symmetry	$\Sigma \pi^+ = \Sigma \pi^-$	$F(1, 83) = 0.03$	0.865	Fail to reject
$H0_7$: LR symmetry	$\theta^+ = \theta^-$	$F(1, 83) = 2.41$	0.124	Fail to reject

Notes. With $q = 1$ there is a single short-run term, so $\Sigma \pi$ equals the contemporaneous coefficient. F-tests are exact linear restrictions on Eq. (5); $H0_4$ and $H0_5$ use delta-method statistics ($\chi^2 = z^2$).

Figure 3 plots the dynamic multipliers (Eq. 7) for a 10% depreciation and a 10% appreciation. The response to depreciation builds quickly, reaching 90% of its long-run level within about 5 quarters, and settles at -3.3%. The response to appreciation settles at -3.1% but is imprecisely estimated (long-run $p = 0.405$). Panel (b) plots the sum of the two responses, which equals zero if the effects

are symmetric; its long-run level is -6.5% , and the long-run symmetry test does not reject ($p = 0.124$).

Three points of interpretation follow. First, the asymmetry measure in Figure 3(b) is negative because the point estimate of the appreciation response is itself negative, so both a depreciation and an appreciation are associated with lower credit; that pattern would fit an exchange-rate uncertainty effect better than a pure balance-sheet effect, but because the symmetry test does not reject ($p = 0.124$) it is a possibility to examine with better data, not a finding. Second, the asymptotic F-test ($p = 0.124$) does not reject long-run symmetry, while the HAC-based test in Table 12 gives $p = 0.063$, which is rejected at 10% only; the conclusion is therefore sensitive to the covariance estimator at the 10% level. Third, the short-run test is far from rejection ($p = 0.865$) because the short-run depreciation and appreciation coefficients are similar in sign and magnitude, with the appreciation coefficient imprecise.

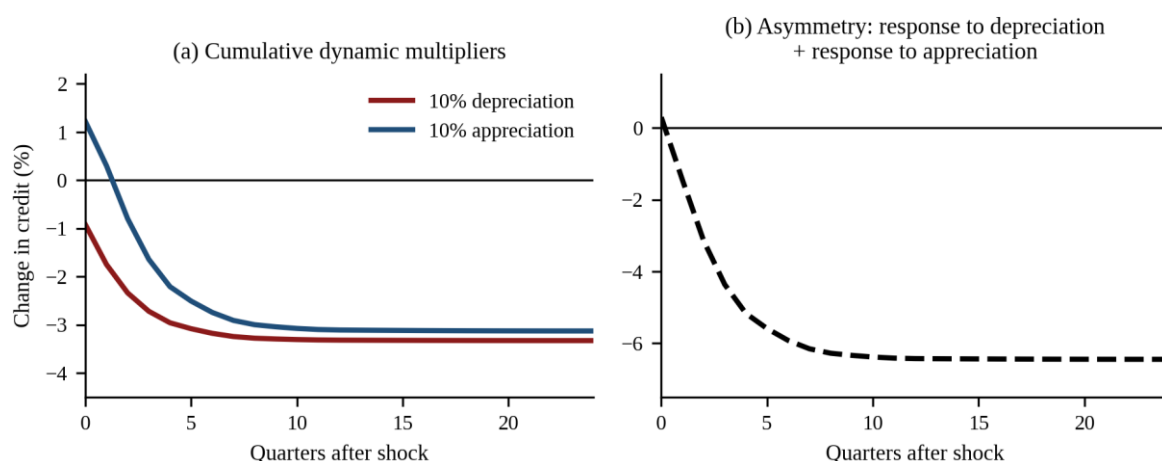


Figure 3. *Dynamic multipliers: response of credit to a 10% depreciation and a 10% appreciation.*

6.7 Diagnostic and stability tests

Table 10 shows that the residuals pass all diagnostic tests: no serial correlation (Breusch–Godfrey $p = 0.287$ at four lags), no heteroskedasticity or ARCH effects ($p = 0.355$ and 0.642), no functional-form misspecification (RESET $p = 0.169$) and normal errors (Jarque–Bera $p = 0.873$). The CUSUM statistic stays within its 5% bounds (maximum at 41% of the bound) and the CUSUM-of-squares deviation (0.175) is below the approximate band (0.212) (Table 11, Figure 4). The impulse dummy for 2016Q2, the largest depreciation, is significant ($p = 0.009$), the 2023Q2 dummy is significant at 10% ($p = 0.093$) and the post-2016 step dummy is insignificant ($p = 0.805$). Including them leaves the long-run depreciation coefficient essentially unchanged (-0.331 against -0.333), so the break sensitivity concerns the short-run credit response to the largest depreciation, not the long-run coefficient.

Table 10. Diagnostic tests of the baseline NARDL model

Test	Null hypothesis	Statistic	p-value	Decision
Breusch–Godfrey (1 lag)	No serial correlation	$F = 1.582$	0.212	Pass
Breusch–Godfrey (4 lags)	No serial correlation	$F = 1.274$	0.287	Pass
Breusch–Pagan	Homoskedasticity	$F = 1.116$	0.355	Pass
ARCH (4 lags)	No ARCH effects	$F = 0.630$	0.642	Pass

Ramsey RESET	Correct functional form	F = 1.928	0.169	Pass
Jarque–Bera	Normal residuals	JB = 0.272	0.873	Pass
Durbin–Watson	No first-order autocorrelation	DW = 2.115	—	Pass

Notes. Tests applied to the residuals of Eq. (5) with $(p, q) = (2, 1)$. Residual standard error = 0.0125. ‘Pass’ indicates the null is not rejected at 5%.

Table 11. Model stability and structural-break tests

Test	Statistic	5% bound / critical value	Decision
CUSUM (recursive from 2005Q2)	max $ W $ / bound = 0.410	1	Stable
CUSUM of squares	max deviation = 0.175	0.212 (approx.)	Stable
Zivot–Andrews, lnDC (break 2015Q4)	−4.617	−5.073	Unit root not rejected
Zivot–Andrews, lnER (break 2016Q1)	−4.960	−5.073	Unit root not rejected
Impulse dummy 2016Q2	p = 0.009	0.05	Significant
Impulse dummy 2023Q2	p = 0.093	0.05	Significant at 10%
Step dummy post-2016Q2	p = 0.805	0.05	Not significant

Notes. Recursive residuals (83) follow Brown, Durbin and Evans (1975); the CUSUM-of-squares band is the large-sample approximation $\pm 1.358/\sqrt{(m-1)/2}$, so that result is indicative. Zivot–Andrews: break in intercept and trend, AIC lags. Dummy p-values are from the NARDL re-estimated with the dummies.

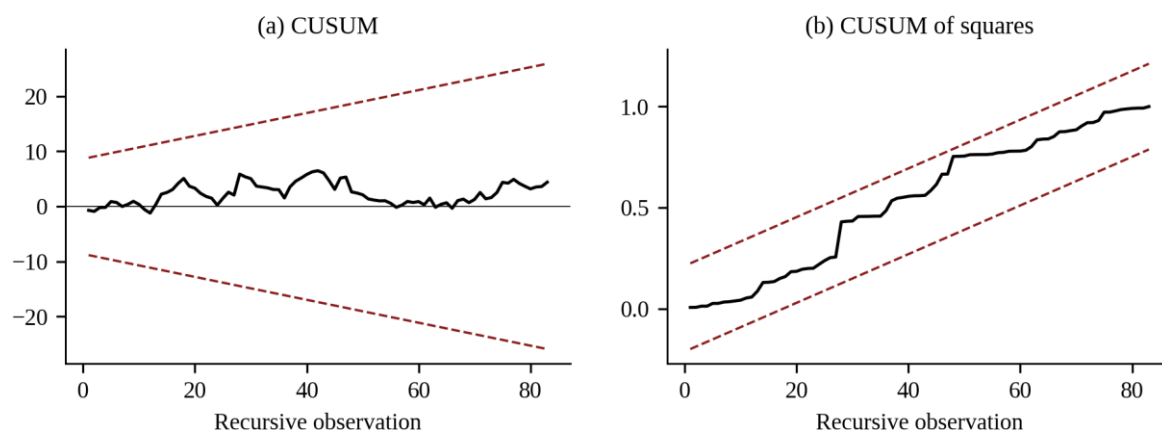


Figure 4. *CUSUM and CUSUM-of-squares plots for the baseline NARDL model. Dashed lines are 5% bounds.*

6.8 Robustness analysis

Table 12 summarises 9 alternative specifications. The depreciation coefficient is negative in every specification and significant at 5% in all of them, ranging from -0.320 to -0.482 . Evidence of a long-run relationship is weaker in Real credit (deflated by CPI) (only the F-test supports cointegration); those rows should be read with caution. The appreciation coefficient is positive in every specification and is significant at 5% only in Real credit (deflated by CPI). Among the 8 NARDL specifications supported by both bounds tests, long-run symmetry is rejected at 5% in 1 (Credit-to-GDP ratio (log)) and at 10% only in 3 (Sample 2000Q1–2022Q4, Sample 2005Q1–

2025Q4, HAC (Newey–West) inference), while short-run symmetry is not rejected at 10% in any specification. Newey–West standard errors change the appreciation standard error from 0.376 to 0.330. The symmetric ARDL gives a single exchange-rate coefficient of -0.275 , between the NARDL depreciation and appreciation coefficients and closer to the former because depreciation quarters dominate. Its AIC (-577.9) is close to the NARDL's (-577.4) and its BIC is lower (-538.9 against -533.2), so the criteria do not favour the extra parameters of the NARDL; its case rests on hypothesis tests that are mixed here.

Summary. The depreciation effect is robust in sign and significance across specifications. The appreciation coefficient is wrong-signed in every specification and imprecise, so the evidence on its sign and size is inconclusive. Long-run asymmetry is not significant in the baseline but is significant or borderline in several alternative specifications, and short-run symmetry is never rejected.

Table 12. Robustness tests

Specification	N	F	t	Coint.	θ^+ (SE)	θ^- (SE)	LR sym. p	SR sym. p
Baseline NARDL	100	5.2	-5.92	Yes	-0.333^{***} (0.078)	0.313 (0.376)	0.124	0.865
Symmetric ARDL	100	5.5	-5.70	Yes	-0.275^{***} (0.070)	—	—	—
Real credit (deflated by CPI)	100	4.1	-4.45	F only	-0.482^{***} (0.125)	1.382** (0.600)	0.014	0.5
Credit-to-GDP ratio (log)	100	6.9	-6.05	Yes	-0.426^{***} (0.061)	0.570 (0.397)	0.026	0.928
Real exchange-rate proxy	100	4.7	-5.60	Yes	-0.320^{***} (0.082)	0.070 (0.197)	0.119	0.197
AIC-selected lags (3,3)	100	6.5	-6.69	Yes	-0.345^{***} (0.054)	0.117 (0.260)	0.123	0.739
Sample 2000Q1-2022Q4	88	4.3	-5.33	Yes	-0.429^{***} (0.128)	0.384 (0.376)	0.08	0.921
Sample 2005Q1-2025Q4	80	3.9	-5.02	Yes	-0.432^{***} (0.119)	0.773 (0.643)	0.087	0.797
Break dummies (2016Q2, 2023Q2)	100	5.9	-5.35	Yes	-0.331^{***} (0.081)	0.156 (0.356)	0.219	0.142
HAC (Newey–West) inference	100	5.2	-5.92	Yes	-0.333^{***} (0.052)	0.313 (0.330)	0.063	0.813

Notes. θ^+ , θ^- : long-run coefficients (for the symmetric ARDL, the single exchange-rate coefficient is shown under θ^+); standard errors in parentheses; *, **, *** denote significance at 10%, 5%, 1%. ‘Coint.’ uses bounds for each model: ‘Yes’ if both F and t exceed the I(1) bound at 5%; ‘F only’ if only the F-test does; ‘No’ otherwise. Lags (p, q) = baseline unless stated. The credit-to-GDP row omits lnGDP from the controls. HAC row: Newey–West, four lags, for standard errors and Wald tests.

6.9 Further analysis

Size of depreciation. Splitting depreciations at $\tau = 0.05$ log points per quarter (11 large and 77 small depreciation quarters) gives long-run coefficients of -0.330 (large), -0.406 (small) and 0.161 (appreciation) (Table 13). Equality of large and small depreciation effects is not rejected ($F = 0.12$, $p = 0.729$), so the data show no evidence of size nonlinearity within depreciations, unlike the pass-through evidence of Kemoe *et al.* (2024). **Alternative estimator.** DOLS gives $\theta^+ = -0.328$ (SE

0.038) and $\theta^- = 0.301$ (SE 0.256), and its test of symmetry is rejected ($p = 0.019$). The depreciation coefficient is close to the NARDL estimate, but the DOLS test is more decisive than the NARDL test ($p = 0.124$) because the DOLS standard errors are smaller (for θ^- , 0.256 against 0.376). Static cointegrating regressions with serially correlated errors tend to understate uncertainty in samples of this size, so the disagreement is itself a reason not to treat asymmetry as established. **Recursive estimates.** Figure 5 shows that θ^+ remains negative throughout and its bands narrow as the sample grows, whereas θ^- is positive with bands that include zero; the recursive symmetry test falls below 5% in 1 of 45 windows (2016Q2).

Table 13. Advanced analysis: size decomposition and dynamic OLS

Specification	Large dep.	Small dep.	Appreciation	Test
NARDL, three partial sums ($\tau = 0.05$)	-0.330*** (0.074)	-0.406* (0.230)	0.161 (0.368)	Large = small: $p = 0.729$
DOLS (HAC standard errors)	Dep. (ER+): -0.328*** (0.038)	—	0.301 (0.256)	$\theta^+ = \theta^-$: $p = 0.019$

Notes. Long-run coefficients with standard errors in parentheses; *, **, *** denote significance at 10%, 5%, 1%. Bounds for the three-partial-sum model: $F = 4.94$, $t = -6.19$ (cointegration: Yes). DOLS uses one lead and lag of the differenced regressors ($n = 101$).

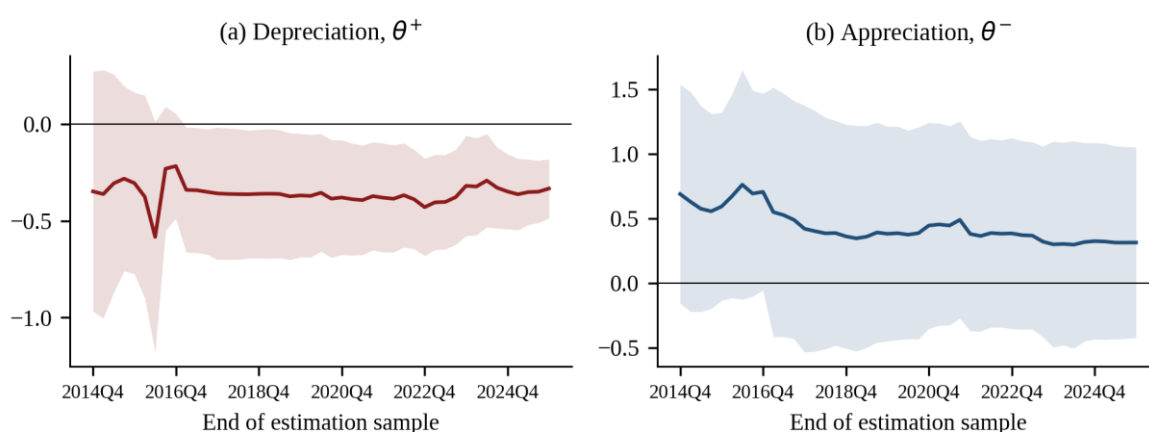


Figure 5. Recursive estimates of the long-run coefficients on depreciation (a) and appreciation (b), with 95% bands

6.10 Mediation, causality and forecast evidence

Mediation through prices and policy. Inflation and the policy rate respond to exchange-rate movements and also affect credit, so part of the depreciation effect may be transmitted through them. Table 14 re-estimates the NARDL while excluding these variables. Excluding inflation raises the long-run depreciation coefficient in magnitude from -0.333 to -0.421 ; excluding the policy rate gives -0.352 ; excluding both gives -0.459 , although that specification does not pass the bounds test and is indicative only. On that comparison, about 27% of the total long-run depreciation effect is absorbed by inflation and the policy rate and about 73% remains as a direct effect.

Specification	θ^+ (SE)	θ^- (SE)	ρ	F	t	Coint.
Full controls (baseline)	-0.333*** (0.078)	0.313 (0.376)	-0.268	5.2	-5.92	Yes
Excluding inflation	-0.421*** (0.098)	0.465 (0.481)	-0.214	4.1	-4.84	Yes

Excluding policy rate	-0.352*** (0.092)	0.232 (0.440)	-0.235	4.5	-5.19	Yes
Excluding policy rate and inflation	-0.459*** (0.118)	0.412 (0.571)	-0.184	3.4	-4.20	No

Notes. Baseline lags (p, q). *, **, *** denote significance at 10%, 5%, 1%. ‘Coint.’ applies 5% bounds for each model’s number of regressors: ‘Yes’ if both the F and t statistics pass, ‘F only’ if only F does, ‘No’ otherwise.

Causality and exogeneity. Section 5.5 noted that the exchange rate might respond to credit conditions. Table 15 reports Toda–Yamamoto (1995) Granger-causality tests in a levels VAR of $\ln DC$, ER^+ , ER^- and $\ln M2$, with lag length $k = 2$ chosen by AIC and one additional lag to allow for integration. Credit does not Granger-cause the depreciation partial sum ($p = 0.611$) or the appreciation partial sum ($p = 0.109$), so the data give no sign that credit conditions drive the exchange rate, which supports the weak-exogeneity assumption. The tests also find no incremental predictive content of ER^+ ($p = 0.638$), ER^- ($p = 0.538$) or the two jointly ($p = 0.696$) for credit. That result does not contradict the NARDL: Granger tests measure short-horizon predictive content with a few lags, whereas the depreciation effect in the NARDL is a long-run error-correction relationship, and Wald tests in a VAR of this size have limited power. The result should be read as support for exogeneity, not as confirmation of the depreciation effect.

Null hypothesis	χ^2 statistic	df	p-value	Decision (5%)
ER^+ does not Granger-cause $\ln DC$	0.9	2	0.638	Fail to reject
ER^- does not Granger-cause $\ln DC$	1.24	2	0.538	Fail to reject
ER^+ and ER^- jointly do not cause $\ln DC$	2.21	4	0.696	Fail to reject
$\ln DC$ does not Granger-cause ER^+	0.99	2	0.611	Fail to reject
$\ln DC$ does not Granger-cause ER^-	4.44	2	0.109	Fail to reject

Notes. Levels VAR in $\ln DC$, ER^+ , ER^- , $\ln M2$ with $k = 2$ lags selected by AIC plus $d_{\max} = 1$ additional lag; Wald χ^2 test on the first k lags of the causing variable.

Out-of-sample forecasting. A model can be significant in sample and still not improve forecasts. Table 16 compares conditional one-step-ahead forecasts of credit growth from an expanding-window estimation of three models: the NARDL, the symmetric ARDL and a version with no exchange-rate terms. There are 39 forecasts, from 2016Q2 to 2025Q4. The root mean squared errors are 0.0175 (NARDL), 0.0153 (symmetric ARDL) and 0.0168 (no exchange rate), so the symmetric ARDL has the lowest error. Diebold–Mariano (1995) tests find no significant difference between the NARDL and the symmetric model ($p = 0.167$), between the symmetric model and the model without the exchange rate ($p = 0.373$), or between the NARDL and the model without the exchange rate ($p = 0.778$). The significant long-run depreciation effect therefore does not translate into a measurable forecasting gain, and the additional parameters of the NARDL do not pay for themselves out of sample, which is consistent with the information-criterion comparison in Section 6.8. Because the forecasts condition on the realised exchange-rate path, the test asks whether the model structure helps explain credit growth given the exchange rate, not whether the exchange rate can be forecast.

Model	RMSE	MAE	DM test versus NARDL (p)
NARDL	0.018	0.012	—
Symmetric ARDL	0.015	0.011	0.167
No exchange-rate terms	0.017	0.012	0.778

Notes. Expanding-window, conditional one-step-ahead forecasts of $\Delta \ln DC$, 39 forecasts (2016Q2–2025Q4); first estimation window of 56 observations. Diebold–Mariano test on squared-error differences, two-sided p-values from the normal distribution.

6.11 Summary of hypothesis outcomes

Table 17 maps each hypothesis to the research objectives and states the result and its robustness, so that the conclusions can be traced from the tests to the claims made in Sections 7–10.

Hypothesis	Objective	Result (baseline)	Robustness
H0 ₁ : no exchange-rate effect	Objective 1	Rejected (p < 0.001)	Joint test in the baseline; depreciation terms significant in every specification
H0 ₂ : SR appreciation = 0	Objective 3	Not rejected (p = 0.463)	Expected sign but imprecise
H0 ₃ : SR depreciation = 0	Objective 3	Rejected (p = 0.004)	Significant in the baseline; short-run terms are not tabulated in Table 12
H0 ₄ : LR appreciation = 0	Objective 3	Not rejected (p = 0.405)	Imprecise; wrong-signed in every specification
H0 ₅ : LR depreciation = 0	Objective 3	Rejected (p < 0.001)	Robust in every specification
H0 ₆ : SR symmetry	Objective 4	Not rejected (p = 0.865)	Not rejected in any specification
H0 ₇ : LR symmetry	Objective 4	Not rejected (p = 0.124)	Rejected at 10% or better in 4 of 8 cointegrated specifications; DOLS p = 0.019

Notes. Objective 2 (whether appreciation and depreciation differ) is addressed jointly by H0₆ and H0₇; Objective 5 (robustness) by Tables 12–13.

6.12 Implied credit effects of depreciation scenarios

Depreciation	Impact (quarter 0)	After 4 quarters	Long run
5% (0.05 log points)	–0.5%	–1.5%	–1.7%
10% (0.10 log points)	–0.9%	–3.0%	–3.3%
20% (0.20 log points)	–1.8%	–5.9%	–6.7%
30% (0.30 log points)	–2.8%	–8.9%	–10.0%

7. Discussion of Findings

7.1 Statistical versus economic significance

The depreciation effect is both statistically and economically significant: a 10% depreciation lowers credit by about 3.3% in the long run and 0.9% within the quarter. The appreciation coefficient is positive, implying that a 10% appreciation would lower credit by 3.1%, but the coefficient is imprecisely estimated (p = 0.405), so the estimate supports neither the claim that appreciation lowers credit nor that it raises it. The Wald tests do not reject symmetry in the baseline (long-run p = 0.124; short-run p = 0.865), but with only 15 appreciation quarters the test has little power, the DOLS cross-check does reject (p = 0.019) and several robustness specifications reject at 10%. The evidence on asymmetry is therefore suggestive but not established, and the economically meaningful conclusion is the size of the depreciation effect.

7.2 Short-run versus long-run effects

Credit adjusts at about 27% per quarter (half-life 2.2 quarters), so most of the response to depreciation is complete within a year (Figure 3). Neither short-run nor long-run symmetry is rejected in the baseline (p = 0.865 and 0.124); the short-run depreciation effect is significant,

whereas the short-run appreciation coefficient has the expected sign but is indistinguishable from zero ($\pi^-_0 = -0.122$, $p = 0.463$). A plausible reading is that the immediate effect of depreciation operates through revaluation of FX balances and risk perceptions, whereas appreciation has no immediate effect because lending standards relax only gradually; this reading is conjectural and untestable with these data.

7.3 Symmetric versus asymmetric models

The symmetric model reports one exchange-rate effect (-0.275), interpreted as depreciation lowering and appreciation raising credit by the same proportion. The NARDL shows that these average mixes a precisely estimated depreciation effect (-0.333) with an appreciation effect that is imprecise and, in the point estimate, of the opposite sign (0.313). Because the information criteria do not favour the additional parameters of the NARDL, the choice between the models rests on the symmetry tests, which are mixed. For policy, the symmetric model would suggest that an appreciation can undo the credit loss from a depreciation; the asymmetric estimates give no support for that assumption.

7.4 Comparison with previous studies

7.5 Mechanisms and interpretation

The pattern is consistent with sudden depreciation episodes damaging borrower balance sheets and raising credit risk, but it cannot identify the mechanism. Two caveats apply. First, the model is estimated for nominal credit, which includes valuation effects of FX loans; the real-credit and credit-to-GDP checks do not isolate valuation from new lending. Second, with 15 appreciation quarters identification of the appreciation effect is inherently weak.

7.6 Linking the results to the transmission channels

The estimated pattern is compared below with what each channel in Section 3.1 would predict, and with what would count against it. The aim is to show which parts of the interpretation the aggregate evidence can support and which require different data.

Borrower balance-sheet channel. This channel predicts a negative and significant θ^+ , a smaller or insignificant θ^- , and an effect concentrated in sectors with FX debt (Aguiar, 2005; Kalemli-Özcan, Liu and Shim, 2021). The significant negative θ^+ and the insignificant θ^- fit the first two predictions, although the data have too little information about appreciation to confirm that the second holds; the third cannot be examined with aggregate data. The evidence is therefore compatible with, but does not establish, the borrower channel. A finding that would count against it is a depreciation effect that is equally large for sectors with no FX borrowing.

Bank credit-risk channel. This channel predicts that depreciation raises loan losses and tightens supply (Niepmann and Schmidt-Eisenlohr, 2022). The immediate negative response to depreciation ($\pi^+_0 < 0$) and the fast error correction fit supply-side tightening, but a demand-side explanation, in which depreciation raises uncertainty and defers borrowing, fits equally well. Distinguishing the two requires bank-level data on provisions, non-performing loans and lending standards, which is the first item for further research.

Global-funding channel. This channel predicts that credit responds to dollar movements with the sign and persistence set by global bank leverage (Bruno and Shin, 2015; Avdjiev *et al.*, 2019). Because Nigerian credit is mainly domestically funded, a direct effect is unlikely; an indirect effect

through trade finance and FX liquidity is possible. The appreciation coefficient, which is imprecise and wrong-signed, offers no support for a funding-side channel, but the data lack the power to rule one out.

8. Contribution to Knowledge

The study advances the literature in five ways, without claiming priority over earlier work on asymmetric exchange-rate effects in Nigeria (Yusuf *et al.*, 2025):

It replaces the assumption of a single exchange-rate effect (Adeleke and Awodumi, 2018) with a model that lets appreciation and depreciation differ and compares the two (Table 12). Short- and long-run symmetry are tested separately, with Wald tests (Table 9). The sample, institutional discussion and break checks are built around the 2016 and 2023–2024 FX changes. A mediation analysis, Toda–Yamamoto causality tests and a Diebold–Mariano forecast comparison (Section 6.10) test whether the depreciation effect operates through prices and policy, whether credit drives the exchange rate, and whether the asymmetric model improves forecasts. The bounds critical values matched to each model, an alternative estimator (DOLS), a multiple-threshold decomposition, recursive estimation and full reporting of which conclusions fail robustness checks.

9. Implications and Recommendations

9.1 Theoretical and academic implications

For balance-sheet theory. The precisely estimated depreciation effect (-0.333) is consistent with models in which depreciation tightens credit through borrower net worth and bank risk (Céspedes, Chang and Velasco, 2004; Mendoza, 2010). The appreciation effect is statistically indistinguishable from zero, so the stronger prediction of those models, a muted response in appreciations, is neither confirmed nor refuted. The likely reason is limited information: depreciations outnumber appreciations by 88 to 15, so the test of asymmetry has little power. Theory that predicts asymmetry should therefore be tested on samples, or at levels of aggregation (firms, banks, sectors), with enough appreciation episodes to give the test power.

For the econometrics of asymmetric effects. Reporting a Wald test of symmetry without noting its limited power invites a false conclusion of symmetry, particularly in economies whose exchange rates move mostly in one direction. Small-sample bounds critical values are a further low-cost safeguard. The results also illustrate that the NARDL's main advantage, separating the two directions, is paid for in precision.

For the Nigerian literature. Published Nigerian asymmetric studies report stronger effects of appreciation on credit (Yusuf *et al.*, 2025) or of positive exchange-rate shocks on investment (Yola, Iliyasu and Mustapha, 2025). They resemble the second but not the first. Resolving the difference requires attention to estimation precision and to the construction of the exchange-rate series, not only to the sign of coefficients.

9.2 Policy and practical recommendations

Table 19 sets out the recommendations by stakeholder, the result on which each rests, and an indicator by which progress can be monitored. The discussion that follows explains the reasoning and the trade-offs.

Table 19. *Recommendations, evidence basis and monitoring indicators*

Stakeholder	Recommendation	Basis in this paper	Indicator to monitor
Central Bank of Nigeria (FX policy)	Prioritise orderly adjustment: smooth large discrete depreciations through transparent FX-market operations and clear communication rather than relying on later appreciation to restore credit.	Depreciation lowers credit by about 3.3% per 10% in the long run, with most of it within a year (Tables 7–8; Figure 3); no reliable offsetting appreciation gain (Table 9).	Quarterly exchange-rate volatility; share of quarters with depreciation above 5%
CBN and NDIC (prudential supervision)	Require banks to report the currency composition of loans and borrowers' unhedged FX exposure; add a depreciation scenario to supervisory stress tests; use countercyclical provisioning in depreciation episodes.	Credit response is fast and concentrated at impact (π^+_0 ; ρ), leaving little time to react; credit-risk channel (Niepmann and Schmidt-Eisenlohr, 2022).	FX-loan share; stress-test capital shortfall under a 20% depreciation
Deposit money banks	Stress-test loan books against 10% and 20% depreciations (Table 18); tighten limits on FX lending to borrowers without FX revenue; build provisions ahead of expected adjustments.	Scenario losses in Table 18; Bleakley and Cowan (2008) show that natural hedges, not FX debt itself, determine exposure.	Non-performing loans of FX borrowers; share of FX loans to non-exporters
Fiscal and trade authorities	Support export earnings and local-currency financing instruments so that more borrowers have natural hedges and fewer rely on FX debt.	The adverse effect is conditional on exposure (Serena and Sousa, 2017); hedging reduces the channel.	Share of private credit in naira to exporters; availability of naira hedging instruments
Firms and borrowers	Match the currency of borrowing to the currency of revenue; hedge residual exposure; avoid short-term FX debt.	Aguiar (2005) and Echeverry *et al.* (2003): exposure drives the effect.	Unhedged FX debt relative to FX revenue
NBS, CBN and researchers	Publish quarterly data on credit by currency and sector and on the official, interbank and parallel exchange rates; support loan-level studies.	The appreciation effect is not identified with aggregate data; the borrower channel cannot be isolated (Sections 6.9 and 7.6).	Availability and timeliness of the series

Central Bank of Nigeria. The evidence of a significant, rapid and large credit loss from depreciation, and the absence of a reliable offsetting appreciation gain, implies that the cost of disorderly depreciation falls on credit and cannot be assumed to reverse. This is consistent with the IMF's (2025) call for a robust foreign-exchange intervention framework focused on containing excess volatility. Interventions that merely postpone a depreciation can raise its eventual size, and Table 18 shows that credit losses scale with the size of the move; the aim should be to avoid large discrete adjustments through transparent rules and communication rather than to hold a particular level. The same logic cautions against reading an appreciation as a signal that credit will recover, since the data do not support a reliable appreciation effect.

Prudential supervision and banks. Because the response is concentrated at impact and completes within about a year, supervisory tools must be in place before the shock. Currency-of-loan reporting is the precondition: without it neither supervisors nor banks can tell which part of the loan book is exposed. Stress tests should include 10% and 20% depreciation scenarios (Table 18), and provisioning rules that build buffers in tranquil periods are better suited to a fast shock than reactive provisioning. The balance-sheet evidence also shows that exposure, not depreciation alone, determines losses, so loan limits and pricing should distinguish borrowers with FX revenue from those without (Bleakley and Cowan, 2008; Serena and Sousa, 2017).

Fiscal, trade and financial-development policy. Policies that increase the share of borrowers with natural hedges, such as export promotion, local-currency financing instruments and deeper hedging markets, address the channel at its source and are less costly than repeated FX intervention. Their effect would be visible in a smaller depreciation coefficient in later samples.

9.3 Trade-offs, sequencing and risks

Three trade-offs deserve attention. First, smoothing depreciation requires reserves and credibility; the insignificant reserves coefficient in Table 7 suggests that holding reserves alone does not offset the effect, so reserve accumulation should not be the only instrument. Second, tighter limits on FX lending could reduce credit to exporters who need it; limits should therefore be calibrated to revenue currency. Third, since the evidence rests on aggregate nominal credit, the recommended data improvements precede any strong policy conclusion: the first step is data collection and supervisory reporting, the second is bank stress testing, and the third is the more structural work on hedging markets and export promotion. Doing the measurement first also allows the asymmetry question to be answered with data that have enough power.

10. Conclusion, Limitations and Further Research

The broader implication of these results is that depreciation is costly for private credit (about 3.3% in the long run for a 10% depreciation, with most of the adjustment within a year) and that the data may be unable to establish whether appreciation recovers that cost. Policy that implicitly relies on symmetry would misjudge depreciation episodes; policy that relies on appreciation to restore credit would rely on an effect the evidence cannot yet confirm. Because the evidence rests on aggregate nominal credit, these implications are conditional associations, not proof of the balance-sheet mechanism, and the first priority is better data on the currency composition of credit.

Quarterly series for real GDP and for the currency composition of credit are difficult to obtain for 2000–2025, rebasing creates breaks, and Nigeria has had multiple official, interbank and parallel rates; the choice of rate changes the timing and size of depreciations. With 100 observations and 7 regressors, power is limited, especially for the appreciation coefficient (15 appreciation quarters). NARDL assumes a zero (or specified) threshold, a common lag order for positive and negative components and weakly exogenous regressors; level restrictions have non-standard distributions without cointegration; inference relies on asymptotic approximations. Omitted variables, oil prices, fiscal crowding-out, cash-reserve requirements, non-performing loans and the FX-loan share may matter.

Further research. (i) use data on the currency composition of bank loans to separate valuation from new lending; (ii) use bank-level or sectoral data to test whether depreciation effects concentrate in non-tradable sectors, as in Kalemli-Özcan, Liu and Shim (2021); (iii) allow regime-switching or

time-varying parameters across FX regimes; and (iv) add oil prices, fiscal variables and non-performing loans.

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Data availability

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Declarations

Ethics approval and consent to participate

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Appendix A. Lag Selection**Table 21.** *Information criteria over (p, q), common sample (n = 100)*

P	q	Parameters	AIC	SBC (BIC)
1	1	16	-574.2	-532.6
1	2	23	-569.3	-509.4
1	3	30	-573.0	-494.9
2	1	17	-577.4	-533.2
2	2	24	-576.0	-513.5
2	3	31	-582.8	-502.1
3	1	18	-576.8	-529.9
3	2	25	-574.7	-509.5
3	3	32	-585.3	-501.9

Notes. Lowest AIC at (p, q) = (3, 3); lowest SBC at (2, 1), which is used for the baseline. The AIC-selected model is reported in Table 12.

Table 22. *upper-bound critical values used in the paper*

(n, k, p, q)	F, 5% I(1)	F, 1% I(1)	t, 5% I(1)	t, 1% I(1)
100, 7, 2, 1	3.69	4.71	-4.53	-5.29
100, 6, 2, 1	3.85	4.85	-4.38	-5.09
100, 7, 3, 3	3.74	4.73	-4.42	-5.17
88, 7, 2, 1	3.78	4.81	-4.52	-5.29
80, 7, 2, 1	3.79	4.87	-4.51	-5.27
100, 8, 2, 1	3.6	4.47	-4.64	-5.33

Notes. Case III; only the upper I (1) bounds are shown.

Appendix B. Dynamic Multipliers at Selected Horizons

Table 23 reports the cumulative response of credit (in per cent) to a 10% depreciation and a 10% appreciation at selected horizons. These are the values plotted in Figure 3.

Horizon (quarters)	10% depreciation	10% appreciation	Sum (asymmetry)
0	-0.92	1.22	0.3
1	-1.75	0.3	-1.45
2	-2.34	-0.80	-3.14
4	-2.96	-2.21	-5.17
8	-3.28	-3.00	-6.28
12	-3.32	-3.11	-6.43
24	-3.33	-3.13	-6.45
40	-3.33	-3.13	-6.45

Notes. Response of $\ln DC$ in per cent to a 10% depreciation (ER^+ up 0.10) and a 10% appreciation (ER^- down 0.10). The sum equals zero under symmetry.

Table 24 lists the eight largest quarterly depreciations. They dominate the identification of θ^+ , which is why robustness to dummies and sub-samples is reported in Table 12.

Quarter	Change in $\ln ER$ (log points)	Equivalent depreciation
2016Q2	0.33	39.10%
2023Q2	0.21	23.40%
2024Q2	0.17	18.50%
2009Q1	0.14	15.00%
2015Q2	0.11	11.60%
2020Q3	0.09	9.40%
2011Q4	0.076	7.90%
2004Q1	0.052	5.40%

Notes. the exchange-rate path contains 88 depreciation quarters, 11 of which exceed 0.05 log points, and 15 appreciation quarters, the largest of which is 0.058 log points.