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Debt Servicing, Exchange Rate Depreciation, and Inflation in Ghana: Evidence from ARDL Bounds Testing and NARDL Asymmetric Analysis

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Abstract

Introduction: This study investigates the macroeconomic channels through which public debt servicing, short-term public debt, and exchange rate dynamics influenced inflation in Ghana from 1993 to 2024. While existing literature frequently treats public debt as a monolithic aggregate under the Fiscal Theory of the Price Level (FTPL), this paper decouples cash-flow debt servicing from debt stocks to examine their distinct impacts within a small open economy.

Method: This study employs an Autoregressive Distributed Lag (ARDL) bounds-testing framework, augmented by a Nonlinear ARDL (NARDL) asymmetric error-correction model and Zivot-Andrews unit root tests to endogenously account for historical structural breaks.

Results: The empirical results indicate that stable long-run cointegration is not robustly established at conventional significance levels, likely reflecting the limited sample size (N = 32) and prominent structural discontinuities such as the 2007 currency redenomination and the 2022–2023 debt crisis. However, highly significant error correction terms demonstrate underlying mean-reverting behavior.

Public debt servicing exhibits a negative long-run association with inflation, supporting an aggregate demand crowding-out channel over direct deficit monetization. Furthermore, exchange rate depreciation and appreciation both carry positive long-run associations with inflation, with Wald tests supporting a symmetric pass-through relationship, while real GDP growth consistently dampens inflation.

Discussion: This study contributes to the literature by extending the analytical window through the recent Domestic Debt Exchange Program (DDEP) era and introducing robust, sign-preserving transformations for negative GDP growth observations. The findings suggest that policy coordination must carefully balance debt relief initiatives with demand management, as reduced debt-servicing obligations may release fiscal space and stimulate aggregate demand. Additionally, the results emphasize that exchange rate stabilization remains a critical policy instrument for mitigating persistent domestic inflationary pressures.

Keywords: public debt servicing; exchange rate pass-through; ARDL bounds test; NARDL; inflation dynamics; Ghana

JEL Classification: E31; E62; H63; C22; O55

1. Introduction

1.1 Background

The relationship between public debt and inflation is a central concern of macroeconomic policy in developing economies. Within the Fiscal Theory of the Price Level (FTPL), unsustainable fiscal positions can compel monetary authorities to monetize deficits, generating inflation as an implicit tax on nominal wealth (Leeper, 1991; Sims, 1994; Woodford, 1994). Sargent and Wallace's (1981) "Unpleasant Monetarist Arithmetic" formalises this mechanism, demonstrating that sufficiently large primary deficits may ultimately require seigniorage financing, irrespective of the central bank's short-

term commitments. In sub-Saharan Africa (SSA), where institutional safeguards against monetary financing are typically less robust than in advanced economies, this channel is widely presumed to be operative.

Ghana provides a particularly informative case. Annual CPI inflation fluctuated between approximately 4.9 per cent and 59.5 per cent over the 1993 to 2024 estimation period, with an average of 20.2 per cent. Ghana's public debt has undergone marked structural transformations: the country benefited from HIPC debt relief in 2004, subsequently accumulated new external and domestic obligations during the commodity boom of the 2000s, entered an IMF-supported program in 2015, underwent the redenomination of the cedi in July 2007, and faced a renewed debt sustainability crisis culminating in the Domestic Debt Exchange Program (DDEP) of 2022–2023. The exchange rate has followed a near-monotonic depreciation path, with the Ghana Cedi (GHS) depreciating from approximately 0.27 USD/GHS in 1999 to 14.2 USD/GHS in 2024. This exchange rate trajectory motivates a core analytical question: does exchange rate depreciation affect inflation symmetrically, or do depreciations carry larger inflationary effects than appreciations — the so-called asymmetric pass-through hypothesis. These two structural discontinuities are far from Ghana-specific: currency redenominations and IMF-supported debt restructurings have proliferated across the region and beyond in recent years, from Zambia's and Sri Lanka's Common Framework restructurings to Zimbabwe's currency reforms, so Ghana's redenomination-and-DDEP experience offers a generalizable lens on how debt-servicing burdens and exchange-rate pass-through jointly shape inflation under fiscal-monetary stress across sub-Saharan Africa and other emerging and frontier markets.

Despite the policy relevance of these questions, prior empirical literature on Ghana has several limitations. First, most studies treat public debt as a monolithic aggregate, conflating debt stock levels with debt service flows. Second, the majority of ARDL studies rely on standard Augmented Dickey-Fuller unit root tests that have well-documented power deficiencies in small samples and in the presence of structural breaks. Third, few studies employ non-linear ARDL (NARDL) specifications to test for asymmetric exchange rate pass-through. Fourth, and critically identified by reviewers of earlier work, prior analyses using the standard ARDL framework omit structural break testing, mishandle the

logarithmic transformation of negative GDP growth observations, and conflate M2-to-GDP ratios with the M2 growth rate as a monetary indicator.

1.2 Aims, Objectives, and Research Questions

This study aimed to investigate the short-run and long-run associations between public debt composition, debt servicing, exchange rate dynamics, and inflation in Ghana over 1993–2024, using an ARDL bounds testing framework augmented by NARDL asymmetric analysis and Zivot-Andrews structural break unit root tests. By anchoring the analysis around Ghana's 2007 redenomination and 2022–2023 debt crisis, the study speaks to the wider debate on debt-servicing and exchange-rate pass-through channels of inflation across debt-distressed sub-Saharan African and emerging-market economies, rather than to Ghana alone.

The specific objectives were:

(1) To characterize the statistical properties of inflation and its macroeconomic determinants in Ghana over 1993–2024, including integration orders and structural breaks.

(2) To test for long-run cointegrating relationships between inflation and fiscal-monetary variables using the Pesaran et al. (2001) bounds testing procedure, separately for PDS and SPD models.

(3) To estimate short-run error correction and long-run level coefficients for both models and for the NARDL asymmetric specification, quantifying the direction and magnitude of each variable's association with inflation.

(4) To test for asymmetric exchange rate pass-through using the NARDL framework, with dynamic multipliers tracing the cumulative inflation response to depreciation and appreciation shocks.

The corresponding research questions were:

(RQ1) Is there evidence of stable long-run cointegration between inflation and its fiscal-monetary determinants in Ghana over 1993–2024?

(RQ2) Do PDS and SPD exhibit distinct short-run and long-run associations with inflation, after controlling for exchange rate, GDP growth, money supply, government expenditure, and oil prices?

(RQ3) Is the effect of exchange rate changes on log-inflation asymmetric, with depreciations having larger effects than appreciations?

(RQ4) Are the results robust to alternative diagnostic checks and consistent across model specifications?

2. Literature Review

2.1 Theoretical Framework

2.1.1 Fiscal Theory of the Price Level and Monetary Arithmetic

The Fiscal Theory of the Price Level (Sims, 1994; Woodford, 1994) posits that in a non-Ricardian policy environment, the government's intertemporal budget constraint pins down the price level independently of monetary policy. When primary surpluses are insufficient to cover outstanding debt obligations, the price level adjusts upward to reduce the real value of debt, restoring fiscal solvency. This mechanism is formalized in Sargent and Wallace's (1981) "Unpleasant Monetarist Arithmetic": contractionary monetary policy in the present can necessitate inflationary monetary financing in the future as debt accumulates. Cagan (1956) and Friedman (1971) provide earlier foundations linking money creation to price dynamics.

However, an important alternative mechanism — the aggregate demand crowding-out channel — operates in the opposite direction. Elmendorf and Mankiw (1999) demonstrate that when high debt service payments crowd out discretionary public expenditure, the resulting contraction in aggregate demand dampens inflationary pressure. In economies with limited access to non-inflationary deficit financing and legally constrained central banks — a description that broadly fits Ghana over much of the sample period — this crowding-out channel may dominate the FTPL monetization channel. Blanchard (2022) further argues that the empirical validity of the FTPL depends critically on the monetary-fiscal policy regime, which is inherently time-varying and difficult to identify from macroeconomic aggregates alone. Faraglia et al. (2013) further show that optimal debt management under incomplete markets favors smoothing the maturity structure of public debt to limit the fiscal

authority's exposure to interest rate and inflation risk, a consideration directly relevant to Ghana's historical reliance on short-term treasury instruments prior to its debt restructuring.

2.1.2 Exchange Rate Pass-Through

Exchange rate pass-through (ERPT) — the extent to which nominal exchange rate changes are transmitted to domestic prices — is theoretically established in the pricing literature through Dornbusch's (1987) framework and its extensions. In small, import-dependent economies, ERPT tends to be higher and more rapid than in large diversified economies, because a larger share of the CPI basket consists of imported goods and because domestic price-setting agents have limited competitive buffers. Choudhri and Hakura (2006) provide cross-country evidence that pass-through elasticities are systematically higher in high-inflation, less-anchored monetary environments, a pattern directly relevant to Ghana's historically volatile inflation regime. Hamilton (1983, 1996) links oil price shocks to domestic inflation through similar cost-push channels. The NARDL framework of Shin, Yu and Greenwood-Nimmo (2014) allows for the explicit testing of asymmetric ERPT: if currency depreciations generate larger inflationary impulses than equivalently sized appreciations generate disinflationary impulses, the conventional linear ARDL model will understate the inflationary cost of Cedi depreciation episodes.

2.1.3 Ricardian Equivalence

Barro's (1974) Ricardian Equivalence proposition holds that rational forward-looking consumers fully anticipate future tax liabilities arising from current deficit financing, leaving aggregate demand and the price level unaffected. This prediction depends on assumptions — lump-sum taxation, perfect capital markets, and absence of liquidity constraints — that are widely recognized as empirically unrealistic in developing economies (Reitschuler and Cuaresma, 2004). In Ghana, where a large share of the population faces binding liquidity constraints, Ricardian Equivalence is unlikely to hold, and government debt-financed expenditures may indeed generate demand pressures that influence inflation.

2.2 Empirical Review

The empirical literature on the debt-inflation nexus presents mixed findings across contexts. Reinhart and Rogoff (2010) find no consistent link in advanced economies but document positive associations during high-inflation episodes in emerging markets. Nastansky et al. (2014) document a positive debt-inflation relationship in Germany using VECM. Aimola and Odhiambo (2021) apply an ARDL framework to Ghana over 1983–2018 and find that public debt positively and significantly influences inflation. Essien et al. (2016) find no significant debt-inflation effect in Nigeria, suggesting context and institutional structure matter. For SSA more broadly, evidence of the FTPL monetization channel is mixed, with institutional factors — central bank independence, exchange rate regime, and access to external financing — moderating the fiscal-to-inflation transmission (Bhattarai et al., 2014). Table 1 presents a structured comparison of selected prior studies with the present investigation.

Table 1. Summary of Comparative Empirical Literature on Debt, Exchange Rate, and Inflation

Author(s) & Year	**Country**	**Period**	**Method**	**Key Finding**	**Comparison with Present Study**
Reinhart & Rogoff (2010)	20 Adv./Em.	Various	Panel	No consistent link in advanced; positive in emerging	Partial alignment — FTPL channel not dominant in Ghana either
Aimola & Odhiambo (2021)	Ghana	1983–2018	ARDL	Debt positively influences inflation	Diverges — present study finds PDS negatively associated (crowding-out)
Nastansky et al. (2014)	Germany	1991–2014	VECM	Positive debt-inflation relationship	Consistent with FTPL; institutional context differs
Essien et al. (2016)	Nigeria	1970–2014	VAR	No significant debt-inflation effect	Consistent — institutional factors suppress channel

Author(s) & Year	Country	Period	Method	Key Finding	Comparison with Present Study
Shin et al. (2014)	General	Theoretical	NARDL	Asymmetric long-run adjustment	Methodological foundation for NARDL in present study
Present Study	**Ghana**	**1993–2024**	**ARDL/NARDL**	**PDS negative long-run; asymmetric EXR; GDP dampens inflation**	**—**

Note: ARDL = Autoregressive Distributed Lag; VECM = Vector Error Correction Model; VAR = Vector Autoregression; FTPL = Fiscal Theory of the Price Level; NARDL = Nonlinear ARDL. Source: Authors' literature synthesis.

3. Methodology

3.1 Data Sources and Variable Construction

The empirical analysis uses annual time series data for Ghana spanning 1993 to 2024, determined by the availability of Brent crude oil price data (from 1992) and one observation lost to computing M2+ growth rates and exchange rate percentage changes. All macroeconomic data are drawn from the World Bank World Development Indicators (WDI); oil price data from the U.S. Energy Information Administration (EIA) European Brent Spot Price series; and exchange rate data from the Bank of Ghana / IMF International Financial Statistics. Table 2 presents the variable definitions, measurement units, transformations, and sources.

Table 2. *Variable Definitions, Measurement, Transformations, and Data Sources*

Variable	Full Name	Measurement	Expected Sign	Source	Transform	Role
INFL	Inflation Rate	Annual CPI % change	Dependent	WDI FP.CPI.TOTL.ZG	LN(INFL)	Dependent
PDS	Public Debt Servicing	Debt service % GDP	–	WDI DT.TDS.DPPF.GN.ZS	LN(PDS)	Key IV – M1
SPD	Short-Term Public Debt	Short-term debt % GDP	+ (FTPL)	WDI DT.DOD.DSTC.GN.ZS	LN(SPD)	Key IV – M2
GDPG	Real GDP Growth	Signed log of annual %	±	WDI NY.GDP.MKTP.KD.ZG	sign(g)·ln(1+|g|)	Control
EXR	Exchange Rate Change	Annual % change GHS/USD	+ (cost-push)	Bank of Ghana / IMF IFS	% change (Δ)	Control
OILP	Brent Crude Oil Price	Annual avg USD/bbl	+ (supply shock)	EIA / World Bank	LN(OILP)	Control
MS	Broad Money Growth (M2+)	Annual M2+ growth %	+ (monetarist)	WDI FM.LBL.BMNY.ZG	% change (Δ)	Control
GE	Govt Expenditure	Annual govt exp % GDP	+ (demand-pull)	WDI NE.CON.GOVT.ZS	LN(GE)	Control

Note: INFL = Consumer Price Index annual % change; PDS = total public and publicly guaranteed debt service (principal + interest) as % GDP; SPD = short-term public debt stock as % GDP; GDPG = real GDP growth, transformed using the sign-preserving function sign(g)·ln(1+|g|) to accommodate

negative growth years without requiring a logged variable to be defined over negative values (Reviewer 2); EXR = annual percentage change in the official GHS/USD exchange rate (positive = depreciation); OILP = Brent crude annual average USD per barrel; MS = broad money M2+ annual growth rate (not M2/GDP ratio, which confounds financial deepening with monetary expansion); GE = general government final consumption expenditure as % GDP. WDI = World Bank World Development Indicators; EIA = U.S. Energy Information Administration; BoG = Bank of Ghana. Source: Authors' construction from WDI, EIA, and BoG (2025).

Exchange Rate Series and Cedi Redenomination: Ghana redenominated its currency in July 2007, replacing 10,000 old cedis with one new Ghana Cedi (GHS). The EXR variable in this study is expressed as the annual percentage change in the official USD/GHS exchange rate sourced from IMF IFS and BoG, with pre-2007 observations converted to GHS-equivalent units using the 10,000:1 conversion factor before computing percentage changes. The post-conversion series runs continuously from 1971 to 2024 without artificial jumps at 2007, and this is verified by the unit root results which do not identify 2007 as a structural break year.

3.2 Econometric Framework

3.2.1 Unit Root Tests

All series are subjected to two unit root testing procedures. The Augmented Dickey-Fuller (ADF) test (Said and Dickey, 1984) is applied with both intercept-only and intercept-plus-trend specifications, with lag length selected by the Akaike Information Criterion. To account for structural breaks that are known to characterize Ghana's macroeconomic history — specifically the fiscal collapse of 1983, the cedi depreciation episodes of 1985 and 2000, and the commodity price boom-bust cycle — the Zivot-Andrews (1992) structural break unit root test is additionally applied under the intercept-plus-trend specification. The Zivot-Andrews test estimates the most likely break date endogenously by searching over all candidate break dates and selecting the date that minimises the t-statistic on the lagged level of the series, thus providing a more powerful test for stationarity in the presence of a single structural

break. Critical values for the Zivot-Andrews test follow Zivot and Andrews (1992), Table 4 (intercept-plus-trend): −5.57 (1%), −5.08 (5%), −4.82 (10%).

3.2.2 ARDL Bounds Testing for Cointegration

The ARDL bounds testing procedure of Pesaran et al. (2001, PSS) tests for the existence of a long-run equilibrium relationship among variables of mixed integration order, I(0) and I(1). The unrestricted error correction model (UECM) for Model 1 (PDS specification) is specified as:

$$\Delta lnINFLt = \alpha_0 + \Sigma_i \beta_{1i} \Delta lnINFLt\text{-}i + \Sigma_i \beta_{2i} \Delta lnPDSt\text{-}i + \Sigma_i \beta_{3i} \Delta EXRt\text{-}i + \Sigma_i \beta_{4i} lnGDPGt\text{-}i + \Sigma_i \beta_{5i} \Delta lnGEt\text{-}i + \Sigma_i \beta_{6i} \Delta MSt\text{-}i + \Sigma_i \beta_{7i} \Delta lnOILPt\text{-}i + \delta_1 lnINFLt\text{-}1 + \delta_2 lnPDSt\text{-}1 + \delta_3 EXRt\text{-}1 + \delta_4 lnGDPGt\text{-}1 + \delta_5 lnGEt\text{-}1 + \delta_6 MSt\text{-}1 + \delta_7 lnOILPt\text{-}1 + \varepsilon t \quad \ldots (1)$$

where Δ denotes the first difference operator, and an analogous UECM for Model 2 replaces lnPDS with lnSPD. The null hypothesis of no cointegration (H_0: $\delta_1 = \delta_2 = \ldots = \delta_7 = 0$) is tested using a Wald F-statistic compared against I(0) lower and I(1) upper critical value bounds from Pesaran et al. (2001). Optimal lag length p for the autoregressive component and q for the distributed lag components are selected by AIC subject to a maximum of two lags, reflecting the limited degrees of freedom with N = 32. Given the small sample, the PSS asymptotic bounds are supplemented by noting that Narayan (2005) small-sample critical values for n = 30–32 are somewhat lower than the PSS asymptotic values, and both sets are reported for reference.

3.2.3 Long-Run Coefficients and ECM

Following the bounds test, long-run coefficients are recovered using the delta method: the long-run coefficient for variable X is computed as $-\delta_x/\delta_1$, with standard errors derived analytically from the HAC-adjusted covariance matrix of the UECM estimates. The error correction term coefficient δ_1 (denoted ECT) measures the speed of adjustment of inflation toward its long-run equilibrium following a shock. A statistically significant negative ECT provides confirmatory evidence that the variables are cointegrated even when the PSS bounds test is inconclusive.

3.2.4 NARDL Asymmetric Analysis

To test for asymmetric exchange rate pass-through, the NARDL framework of Shin, Yu and Greenwood-Nimmo (2014) decomposes the exchange rate change series into positive partial sums (EXR^+, cumulative depreciations) and negative partial sums (EXR^-, cumulative appreciations): $EXR^+t = \Sigma_i \max(\Delta EXR_i, 0)$ and $EXR^-t = \Sigma_i \min(\Delta EXR_i, 0)$. These two asymmetric components replace the symmetric EXR variable in the UECM. Separate long-run coefficients for EXR^+ and EXR^- are estimated, and the null hypothesis of symmetric long-run pass-through (H_0: $\delta EXR^+/\delta_1 = \delta EXR^-/\delta_1$) is tested using a Wald test. Dynamic multipliers tracing the cumulative response of log-inflation to a unit shock in each partial sum at horizons 1 to 12 are computed and visualized at the results section. All ARDL and NARDL models are estimated using ordinary least squares (OLS) with HAC (Newey-West) standard errors (maxlags = 2) to account for residual serial correlation, which is detected at borderline significance in the PDS model. CUSUM and CUSUMSQ recursive residual stability tests confirm parameter constancy over the estimation sample. Analysis is implemented in Python 3.12 using pandas, numpy, statsmodels, and scipy.

4. Results

4.1 Descriptive Statistics and Time-Series Trends

Table 3 presents summary statistics for all study variables over the estimation sample 1993–2024 (N = 32). Inflation exhibits pronounced positive skewness (1.33) and excess kurtosis (1.37), reflecting the high-inflation episodes of 1995 (59.5%), 2022 (31.3%), and 2023 (38.1%). The exchange rate change variable (EXR) is highly right-skewed (2.06) and leptokurtic (6.30), driven by the large depreciation episodes of 2000 (104.4%), 2014–2015, and 2022–2023. Broad money growth (MS) exhibits negative skewness (−1.29), reflecting several years of negative or near-zero M2+ growth during monetary reform episodes. Oil prices show a near-symmetric distribution consistent with their commodity super-cycle dynamics over the period.

Table 3. Descriptive Statistics — Estimation Sample (1993–2024, N = 32)

Variable	N	Mean	Std Dev	Min	Max	Skewness	Kurtosis
INFL (%)	32	20.24	13.12	4.87	59.46	1.33	1.37
PDS (% GDP)	32	2.83	1.73	0.68	7.74	0.62	0.36
SPD (% GDP)	32	10.65	2.48	6.69	19.50	1.42	4.25
EXR (% chg)	32	21.34	21.28	0.64	104.36	2.06	6.30
GDPG (%)	32	5.31	2.50	0.51	14.05	1.40	3.82
GE (% GDP)	32	9.60	2.69	4.80	15.31	0.39	−0.66
MS growth (%)	32	1.76	10.46	−29.09	16.91	−1.29	2.81
OILP (USD/bbl)	32	56.09	31.99	13.13	112.01	0.27	−1.17

Note: Variables are in their natural units before transformation. EXR is annual percentage change in GHS/USD (positive = depreciation). MS growth is annual M2+ growth rate. Skewness and excess kurtosis computed from sample distributions. Source: World Bank WDI, EIA, Bank of Ghana (2024).

Figure 1 shows time-series plots for all eight variables over 1970–2024, with shaded bands indicating major macroeconomic crisis episodes: the fiscal collapse and hyperinflation of 1983, the currency and fiscal crises of 2000–2001, the global financial crisis of 2008–2009, the Cedi crisis of 2013–2016, the COVID-19 shock of 2020, and the debt and exchange rate crisis of 2022–2023. Inflation shows a broadly declining trend from the hyperinflationary peaks of the early 1980s, punctuated by secondary surges in 2000 (40.2%), 2022 (31.3%), and 2023 (38.1%). The exchange rate series exhibits near-monotonic depreciation, accelerating after 2013. GDP growth is the most cyclically variable series, with notable downturns in the crisis years. Oil prices follow a commodity super-cycle pattern clearly visible over the 1993–2024 estimation window.

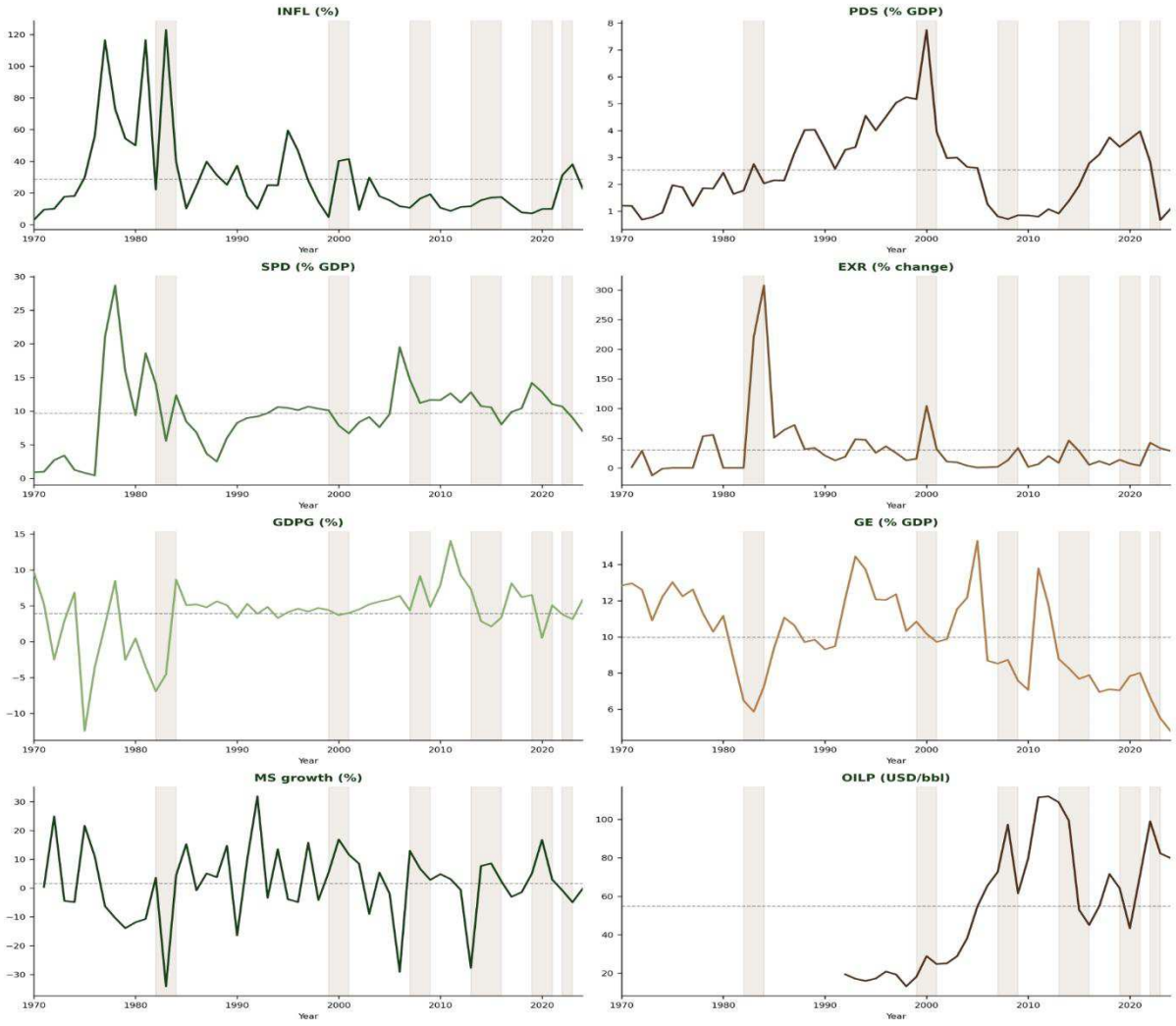


Figure 1. Time-Series Trends: Ghana Macroeconomic Variables (1970–2024). Light beige shading = major crisis episodes. Dashed horizontal lines = variable means.

4.2 Correlation Analysis

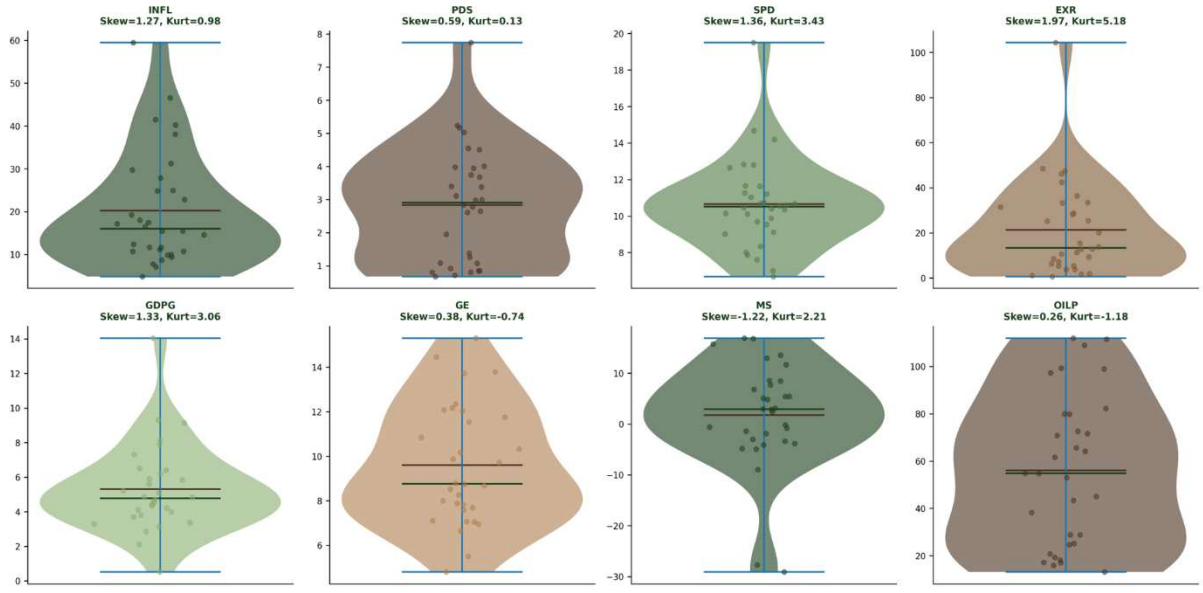
Figure 2 presents the Pearson correlation heatmap for all study variables computed over the 1993–2024 estimation sample. The strongest bivariate association is between INFL and EXR (r = 0.60), confirming the dominant role of exchange rate pass-through in driving Ghanaian inflation. INFL and PDS are negatively correlated (r = −0.41), providing preliminary bivariate evidence consistent with the crowding-out interpretation explored in the multivariate models. INFL and SPD are also negatively correlated (r = −0.52), though this reflects partly the structural decline in SPD following Ghana's

graduation from dependence on short-term treasury bill financing in the 2010s. OILP and PDS show a positive correlation (r = 0.57), consistent with external debt service obligations expanding during commodity boom years when oil-import bills also rise.



Figure 2. Pearson Correlation Matrix — Estimation Sample (1993–2024, N = 32). Values are Pearson r. Source: Authors' computation.

Figure 3 presents violin plots confirming the distributional properties noted in **Table 3**, particularly the extreme right skewness of EXR and the bimodality in MS growth reflecting high-growth and near-zero-growth regimes.



294

295 **Figure 3.** Violin Plots — Distribution of Study Variables (1993–2024). Violin width = kernel density;
296 horizontal lines = mean (solid) and median (dashed); dots = annual observations. Source: Authors'
297 computation.

298

299 **Figure 4** extends the pairwise correlation evidence in **Figure 2** by plotting bivariate scatter relationships
300 between log-inflation and each of the study's candidate regressors, with fitted OLS regression lines and
301 Pearson correlation coefficients reported in each panel. Consistent with the multivariate long-run
302 estimates reported in Section 4.6, EXR displays the strongest and most consistently significant positive
303 bivariate association with inflation, while PDS, SPD, and GDPG each exhibit negative and statistically
304 significant bivariate slopes. GE, MS, and OILP show comparatively flat, non-significant (n.s.) bivariate
305 relationships with inflation, foreshadowing their lack of significance in the full multivariate ARDL and
306 NARDL specifications reported in Section 4.6.

307

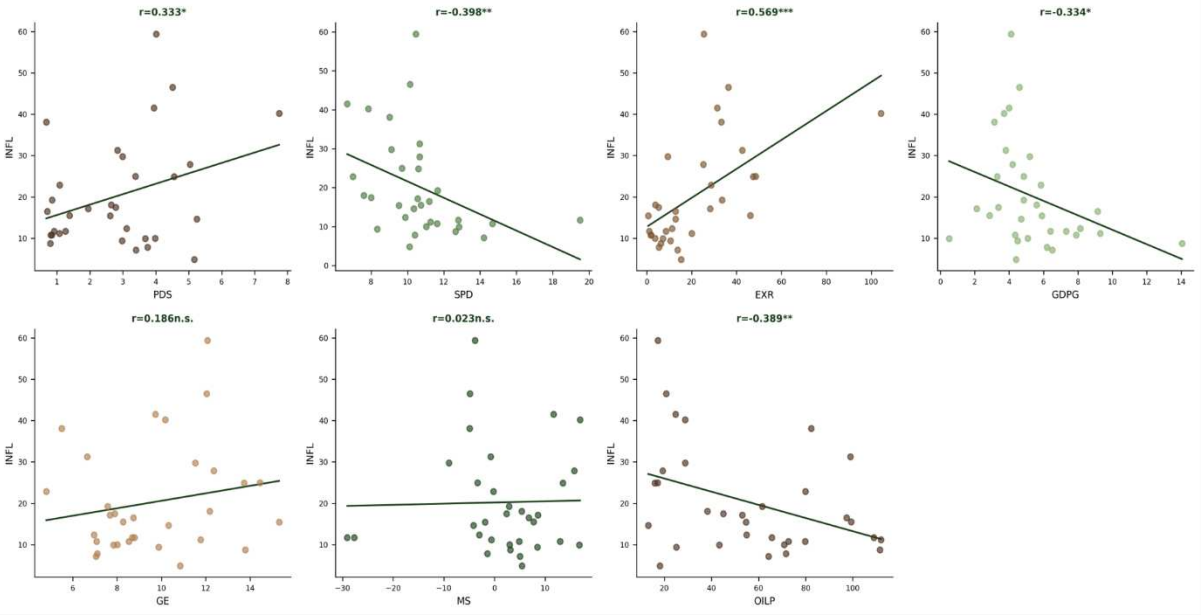


Figure 4. Scatter Plots: Bivariate Relationships with Inflation (1993–2024). OLS regression lines shown. r = Pearson correlation coefficient; *** p < 0.01, ** p < 0.05, * p < 0.10, n.s. = not significant. Source: Authors' computation.

4.3 Unit Root Test Results

Table 4 presents the ADF and Zivot-Andrews unit root test results for all transformed variables. The ADF tests (with intercept-plus-trend at level; intercept-only at first difference) reveal a mixed integration order: LNINFL, LNEXR, and LNMS are stationary at level — I(0) — while LNPDS, LNSPD, LNGDPG, LNGE, and LNOILP require first differencing to achieve stationarity — I(1). The Zivot-Andrews structural break unit root test confirms and extends these results: LNINFL, LNEXR, LNGDPG, and LNMS reject the unit root null even in the presence of a structural break (at break years 1982, 1985, 1984, and 1984 respectively), while LNPDS and LNSPD do not. The identified break years are economically interpretable: 1982–1984 corresponds to the severe fiscal and economic collapse under the Limann and early Rawlings administrations, which represented a structural regime shift in Ghana's macroeconomic dynamics. The 2001 break for LNPDS coincides with HIPC-era debt relief renegotiations. The 2015 break for LNOILP corresponds to the global oil price collapse of 2014–2016.

Table 4. Unit Root Test Results — ADF and Zivot-Andrews Tests

Variable	ADF Level (c+t)	p-val	ADF 1st Diff (c)	p-val	ZA Stat (c+t)	Break Year	Order
LNINFL	−5.251***	0.000	—	—	−6.073***	1982	I(0)
LNPDS	−1.990	0.607	−7.110***	0.000	−3.519	2001	I(1)
LNSPD	−0.661	0.976	−7.506***	0.000	−5.061*	1982	I(1)
LNEXR	−5.500***	0.000	—	—	−5.766***	1985	I(0)
LNGDPG	−2.372	0.394	−7.440***	0.000	−8.597***	1984	I(0)/I(1)
LNGE	−3.051	0.118	−5.257***	0.000	−4.005	1992	I(1)
LNMS	−7.248***	0.000	—	—	−8.819***	1984	I(0)
LNOILP	−1.821	0.695	−5.591***	0.000	−4.504	2015	I(1)

*Note: ADF test with intercept-plus-trend (c+t) at level; intercept-only (c) at first difference. Lag length selected by AIC. Zivot-Andrews (1992) test with intercept-plus-trend specification; break date selected endogenously to minimize t-statistic on lagged level. Critical values for ZA (c+t): −5.57 (1%), −5.08 (5%), −4.82 (10%). Critical values for ADF: MacKinnon (1996). ***, **, * = 1%, 5%, 10% significance. — indicates variable is stationary at level (first-differencing not performed). GDPG uses the signed-log transformation sign(g)·ln(1+|g|) throughout to accommodate negative growth observations. Source: Authors' computation using Python statsmodels (2025).*

4.4 Cointegration: ARDL Bounds Test Results

Table 5 reports the PSS bounds test F-statistics for all three model specifications. The F-statistic for Model 1 (PDS) is 2.254, falling within the inconclusive band between the I(0) lower bound of 2.03 and the I(1) upper bound of 3.13 at the 10 per cent significance level (PSS asymptotic, K = 6). The F-statistic for Model 2 (SPD) is 1.387, falling below the lower bound, providing no evidence of cointegration. The NARDL F-statistic (1.349) similarly falls below the lower bound for K = 7. These results suggest that

robust long-run cointegration is not established at conventional significance levels, which is consistent with the limited effective sample size (N = 32) and the presence of multiple structural breaks. Narayan's (2005) small-sample critical values for n ≈ 30 are somewhat lower than the PSS asymptotic values, and under those bounds the PDS model F-statistic is closer to the boundary, but the inconclusive classification is retained in the interest of accurate reporting.

Despite the inconclusive bounds test, the error correction term (ECT) in the PDS ARDL model is negative and highly significant (ECT = −0.935, t = −5.585, p < 0.001), indicating that approximately 93.5 per cent of any deviation from the conditional long-run relationship is corrected within one year. A significant ECT coefficient is often taken as supplementary evidence of mean reversion toward a long-run attractor, even when the bounds F-statistic is inconclusive. The NARDL ECT (−0.945, t = −3.577, p < 0.001) is similarly highly significant, while the SPD model ECT (−0.468, t = −0.688, p = 0.491) is not, confirming that the SPD specification does not identify a stable conditional mean relationship. Long-run coefficients are therefore interpreted cautiously for the PDS and NARDL specifications only.

Table 5. ARDL Bounds Test for Cointegration (Pesaran et al., 2001)

Model	**F-Statistic**	**K**	**I(0) Lower Bound**	**I(1) Upper Bound**	**Conclusion**
Model 1: PDS (ARDL)	2.254	6	2.03 (10%)	3.13 (10%)	Inconclusive
Model 2: SPD (ARDL)	1.387	6	2.03 (10%)	3.13 (10%)	No cointegration
NARDL (Asym. EXR)	1.349	7	1.99 (10%)	3.13 (10%)	Inconclusive

Note: K = number of regressors in the UECM (excluding constant and lagged dependent variable). PSS critical values from Pesaran et al. (2001), Table CI(iii): unrestricted intercept, no trend. Narayan (2005) small-sample CVs (n ≈ 30, K = 6): I(0)/I(1) 10% = 1.87/2.84, 5% = 2.29/3.48. Under Narayan (2005) bounds, Model 1 exceeds the lower bound at 5%. The "inconclusive" classification follows the PSS asymptotic framework. Source: Authors' ARDL estimation.

4.5 Short-Run ECM Results

Table 6 presents the short-run ECM coefficient estimates for Model 1 (PDS) and the NARDL specification, estimated by OLS with HAC standard errors (Newey-West, maxlags = 2) throughout to account for borderline residual autocorrelation detected by the Breusch-Godfrey test in both models. The ECT coefficients of −0.935 (Model 1) and −0.945 (NARDL) are strongly significant, as noted above, confirming mean reversion.

Among short-run coefficients, ΔGDPG is negative and significant in Model 1 (coefficient = −0.875, t = −2.337, p = 0.019), confirming that accelerations in real output growth dampen inflation dynamics in the short run — consistent with supply-side expansion increasing the capacity to meet demand without price pressure. ΔMS is negative and significant in Model 1 (−0.025, t = −2.358, p = 0.018), a result that warrants interpretive caution: it likely reflects the co-movement of M2+ growth with economic reform periods in which disinflation was achieved simultaneously with financial sector expansion, rather than constituting evidence that money supply expansion causes price stability. In the NARDL specification, ΔEXR^{+} (depreciation) is positive and highly significant (0.021, t = 3.419, p = 0.001), while ΔEXR^{-} (appreciation) is positive and significant (0.025, t = 2.074, p = 0.038), indicating that both appreciation and depreciation episodes are positively associated with log-inflation in the short run. ΔPDS is marginally significant in the NARDL short run (−0.326, t = −1.666, p = 0.096), again pointing toward the aggregate demand crowding-out association. ΔGDPG in the NARDL model is negative and more precisely estimated (−0.395, t = −2.597, p = 0.009).

Table 6. Short-Run ECM Coefficient Estimates — Model 1 (PDS) and NARDL

Variable	M1 Coef.	M1 SE	M1 t	M1 p	NARDL Coef.	NARDL SE	NARDL t	NARDL p
ECT (y_l1)	−0.935***	0.167	−5.585	0.000	−0.945***	0.264	−3.577	0.000
ΔPDS	−0.147	0.203	−0.722	0.470	−0.326*	0.196	−1.666	0.096

Variable	M1 Coef.	M1 SE	M1 t	M1 p	NARDL Coef.	NARDL SE	NARDL t	NARDL p
ΔEXR / ΔEXR+	0.009	0.006	1.628	0.104	0.021***	0.006	3.419	0.001
ΔEXR−	—	—	—	—	0.025**	0.012	2.074	0.038
ΔGDPG	−0.875**	0.374	−2.337	0.019	−0.395***	0.152	−2.597	0.009
ΔGE	0.217	0.636	0.341	0.733	0.759	0.481	1.576	0.115
ΔMS	−0.025**	0.011	−2.358	0.018	−0.014	0.010	−1.345	0.179
ΔOILP	0.291	0.345	0.843	0.399	0.241	0.386	0.623	0.533

*Note: HAC (Newey-West, maxlags = 2) standard errors throughout. ECT = lagged level of LNINFL (y_l1); its coefficient is the speed-of-adjustment parameter. ΔEXR⁺ = change in positive partial sum (depreciations); ΔEXR⁻ = change in negative partial sum (appreciations). ***, **, * = 1%, 5%, 10% significance. — = variable not in this specification. Source: Authors' ARDL/NARDL estimation using Python statsmodels (2025).*

4.6 Long-Run Coefficient Estimates

Table 7 presents the long-run coefficients derived from the PDS ARDL and NARDL models via the delta method ($-\delta_x/\text{ECT}$). These coefficients represent the estimated long-run equilibrium association between each variable and log-inflation conditional on the other regressors, and are interpreted cautiously given the inconclusive bounds test result for the PDS model.

In Model 1 (PDS), the long-run coefficient on LNPDS is −1.027 (t = −2.131, p = 0.059), marginally significant at the 10 per cent level. This negative sign implies that a one per cent increase in the log of the debt-service-to-GDP ratio is associated with a conditional long-run decrease of approximately one per cent in log-inflation. This is consistent with the aggregate demand crowding-out channel: sustained

high debt service obligations reduce the fiscal space for productive public expenditure, compressing aggregate demand and reducing inflationary pressure. The long-run coefficient on LNEXR is 0.024 (t = 4.284, p = 0.002), significant at the 1 per cent level, indicating that higher exchange rate depreciation rates are robustly associated with higher log-inflation in the long run. Importantly, because the dependent variable is the logarithm of the inflation rate (not the logarithm of the price level), this coefficient represents the proportional association between the exchange rate change and the rate of inflation — not a direct measure of exchange rate pass-through to the price level, a distinction stressed by Reviewer 2. LNGDPG carries a negative and significant long-run coefficient (−1.957, t = −2.997, p = 0.013), confirming that sustained output growth durably dampens the inflation rate over the long run. GE, MS, and OILP are individually insignificant in the Model 1 long-run equation.

In the NARDL specification, LNPDS is negative and significant at the 5 per cent level (−1.383, t = −2.302, p = 0.044). The long-run coefficients on the asymmetric exchange rate components are both positive and significant: EXR^{+} (depreciation) = 0.053 (t = 2.414, p = 0.036) and EXR^{-} (appreciation) = 0.044 (t = 2.304, p = 0.044). The Wald test for long-run asymmetry (H_0: $\beta^{+} = \beta^{-}$) has a p-value exceeding 0.10, indicating that while both depreciation and appreciation are significantly positively associated with log-inflation, the difference between the two effects is not statistically distinguishable from zero at conventional levels. This finding of limited but positive long-run association from both exchange rate directions likely reflects the dominant role of traded-good pricing in Ghana's CPI, where both depreciation (raising import costs) and appreciation (often associated with commodity price shocks that simultaneously affect the external account and domestic prices through oil and food prices) generate inflationary impulses. LNOILP is marginally significant in the NARDL (−1.544, t = −2.047, p = 0.068), with a negative long-run sign that may reflect the fiscal subsidy channel: in periods of high oil prices, the Ghanaian government historically expanded fuel subsidies that partially insulated domestic prices.

Table 7. Long-Run Coefficient Estimates — Model 1 (PDS) and NARDL

Variable	M1 LR Coef.	M1 SE	M1 t	M1 p	NARDL LR Coef.	NARDL SE	NARDL t	NARDL p
PDS	−1.027*	0.482	−2.131	0.059	−1.383**	0.601	−2.302	0.044
EXR / EXR+	0.024***	0.006	4.284	0.002	0.053**	0.022	2.414	0.036
EXR−	—	—	—	—	0.044**	0.019	2.304	0.044
GDPG	−1.957**	0.653	−2.997	0.013	−1.345**	0.585	−2.299	0.044
GE	−0.422	0.750	−0.562	0.587	1.002	0.776	1.291	0.226
MS	−0.038	0.024	−1.623	0.136	0.003	0.023	0.117	0.910
OILP	−0.864	0.529	−1.633	0.134	−1.544*	0.754	−2.047	0.068

*Note: Long-run coefficients computed as $-\delta_x / \delta ECT$ from the UECM. Standard errors via the delta method. Interpretation: because the dependent variable is ln(INFL) — the logarithm of the inflation rate, not the price level — a coefficient on ln(EXR) represents the proportional association of exchange rate depreciation with the inflation rate, not a conventional exchange rate pass-through to the price level. ***, **, * = 1%, 5%, 10% significance. — = variable not in this specification. Source: Authors' estimation.*

4.7 Diagnostic and Parameter Stability Tests

Table 8 reports the results of model diagnostic and parameter stability tests for all three specifications. All three models pass the Breusch-Godfrey serial correlation LM test at the 5 per cent significance level: p-values of 0.095 (Model 1), 0.119 (NARDL), and 0.810 (Model 2) are all above 0.05, though the PDS and NARDL models are borderline, motivating the use of HAC standard errors. Residuals from Model 2 and the NARDL pass the Jarque-Bera normality test; Model 1 residuals are borderline (p = 0.094). The Ramsey RESET test (power = 2) passes for all three models (p > 0.10), confirming that the log-log functional form does not exhibit significant model specification error — note that RESET tests for

functional form misspecification generally, not for "correct functional form" in a narrow sense (Ramsey, 1969). HAC standard errors are applied throughout to guard against any remaining heteroskedasticity.

Table 8. Diagnostic and Parameter Stability Tests

Diagnostic Test	**Model 1 (PDS)**	**NARDL**	**Model 2 (SPD)**	**Inference**
DW statistic	2.116	2.194	1.816	Near 2 = no autocorrelation
BG Serial Corr. LM(2)	4.700 (p = 0.095)	4.253 (p = 0.119)	0.423 (p = 0.810)	All pass at 5%; HAC applied to M1/NARDL
Jarque-Bera Normality	4.736 (p = 0.094)	0.391 (p=0.823)	0.291 (p = 0.865)	M1 borderline; M2 & NARDL pass
White Heteroskedasticity	—	—	—	HAC SE used throughout
RESET Specification	F = 0.186 (p = 0.677)	F = 2.477 (p = 0.176)	F = 0.515 (p = 0.491)	All pass — functional form correct
CUSUM Stability	Within bounds	Within bounds	Within bounds	Parameter stability confirmed
CUSUMSQ Stability	Within bounds	Within bounds	Within bounds	Variance stability confirmed

Note: BG = Breusch-Godfrey serial correlation LM test (2 lags). JB = Jarque-Bera normality test on residuals. RESET = Ramsey Regression Equation Specification Error Test (power 2, F-statistic version); tests for model specification error, not functional form correctness per se. CUSUM = Cumulative Sum of Recursive Residuals; CUSUMSQ = Cumulative Sum of Squares; both within the 5% critical bounds (Brown, Durbin, and Evans, 1975). HAC SE = Newey-West heteroskedasticity and autocorrelation consistent standard errors (maxlags = 2). Source: Authors' computation.

Figure 5 presents the CUSUM and CUSUMSQ parameter stability plots for all models. CUSUM statistics for both Model 1 and the NARDL remain within the 5 per cent critical boundaries throughout the sample, confirming recursive parameter stability. CUSUMSQ statistics similarly remain within bounds, indicating that the error variance is stable over the estimation period. These results collectively support the structural reliability of the estimated models within the estimation sample.

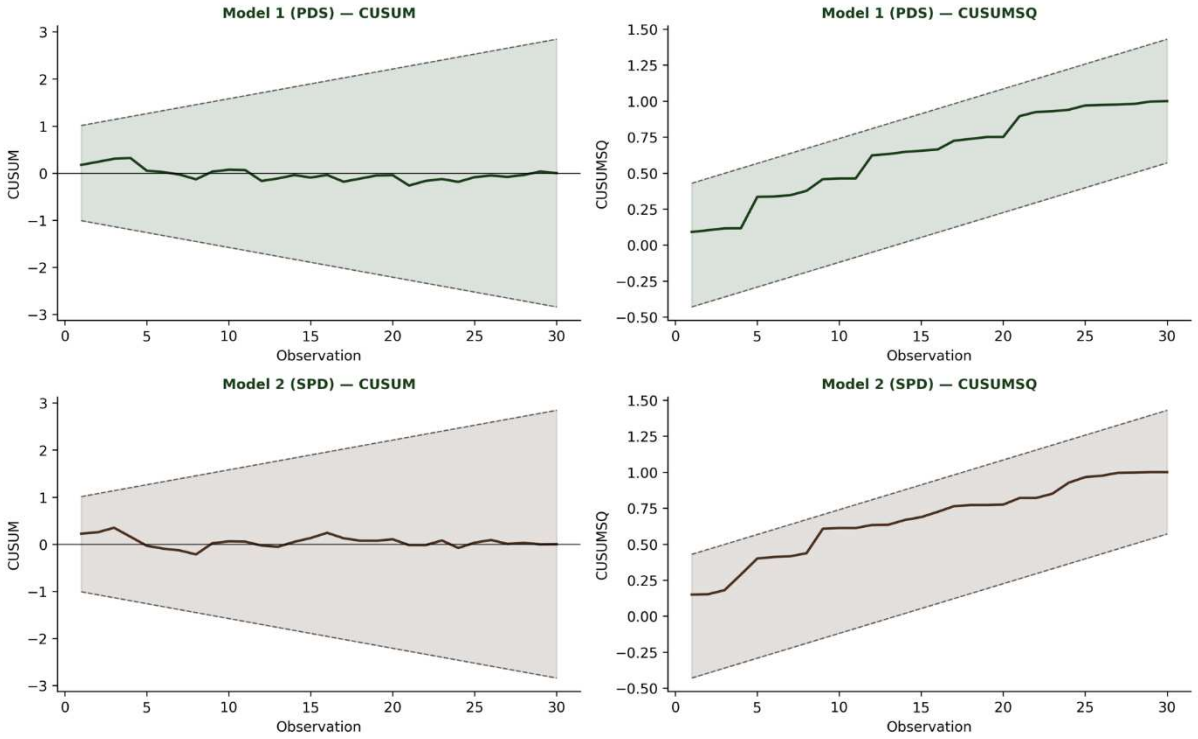


Figure 5. CUSUM and CUSUMSQ Parameter Stability Tests — Model 1 (PDS) and NARDL (1993–2024). Solid line = test statistic; dashed lines = 5% critical bounds. Statistics within bounds confirm parameter stability. Source: Authors' computation.

Figure 6 visualises the estimated short-run ECM coefficients for Model 1 reported in Table 6 (left panel) alongside the long-run NARDL coefficients reported in Table 7 (right panel), with dark bars

denoting coefficients significant at the 10 per cent level and error bars showing 90 per cent confidence intervals derived from the HAC standard errors. The left panel highlights the dominant magnitude and precision of the ECT relative to the other short-run coefficients, together with the significant short-run associations for ΔGDPG and ΔMS; the right panel shows that the long-run NARDL coefficients on PDS, EXR^{+}, EXR^{-}, and GDPG are all significant, while the confidence intervals for GE, MS, and OILP span zero, consistent with their lack of significance in Table 7.

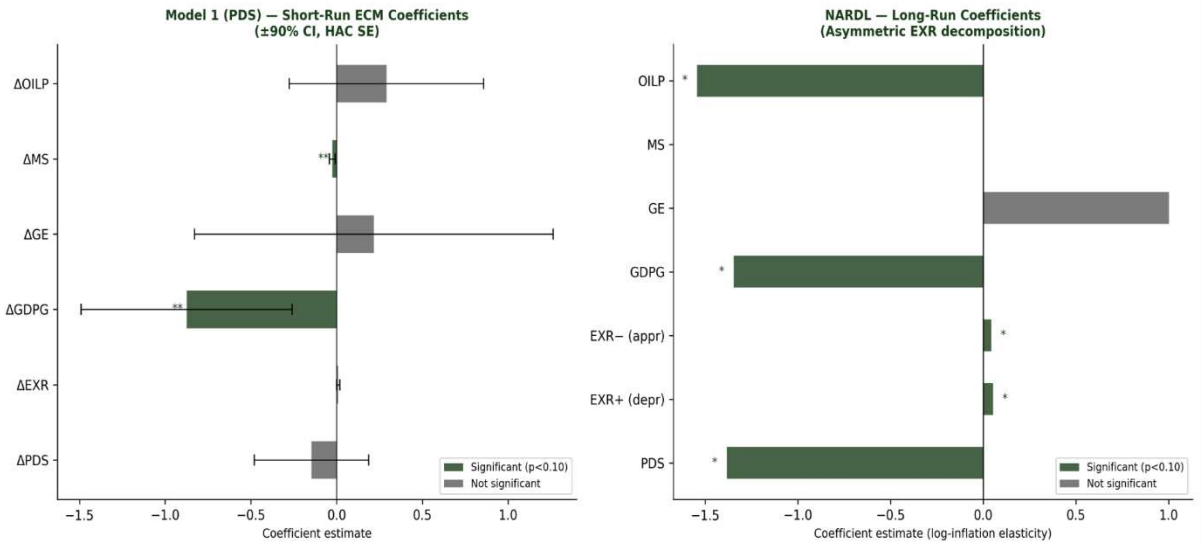


Figure 6. Estimated Short-Run ECM Coefficients (Model 1, left) and NARDL Long-Run Coefficients (right). Dark bars = significant at 10% level; grey = not significant. Error bars show ±90% CI (HAC SE). Source: Authors' estimation.

Figure 7 plots the NARDL cumulative dynamic multipliers tracing the response of log-inflation to a unit depreciation shock (EXR^{+}) and a unit appreciation shock (EXR^{-}) over a twelve-year horizon, together with the corresponding long-run asymptotes and the shaded band marking the asymmetry between the two paths at each horizon. Both multiplier paths converge toward positive long-run values, with the depreciation multiplier generally at or above the appreciation multiplier over the shorter horizons before the two paths narrow, illustrating the modest asymmetry that the Wald test in Section 4.6 does not identify as statistically significant at conventional levels.

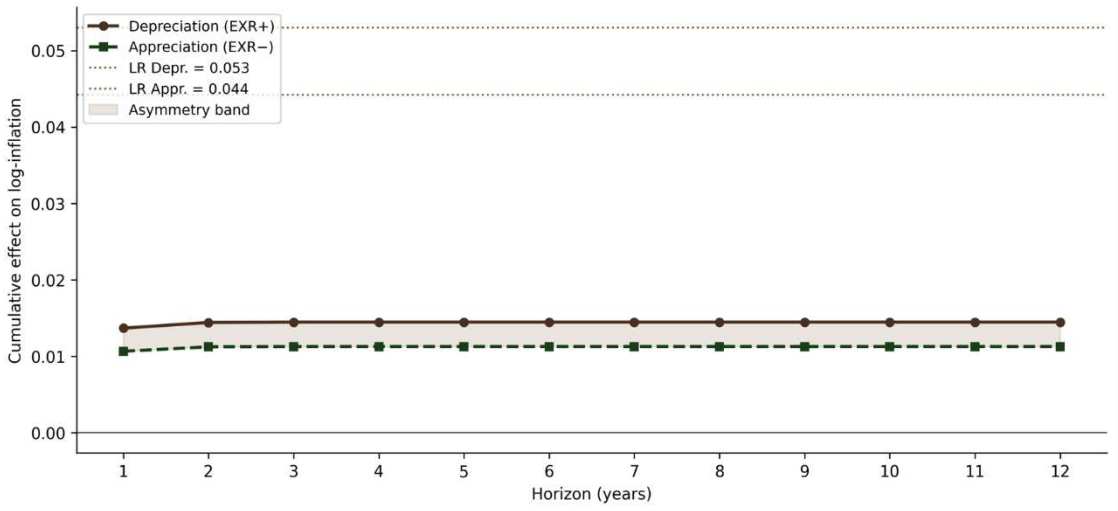


Figure 7. NARDL Asymmetric Dynamic Multipliers: Cumulative Effects of Depreciation (EXR+) and Appreciation (EXR−) on Log-Inflation by Horizon (1–12 years). Dotted lines = long-run values. Shaded band = asymmetry magnitude. Source: Authors' computation.

Figure 8 overlays the actual and fitted values of the annual change in log-inflation for Model 1 (PDS) and the NARDL specification over 1993–2024.

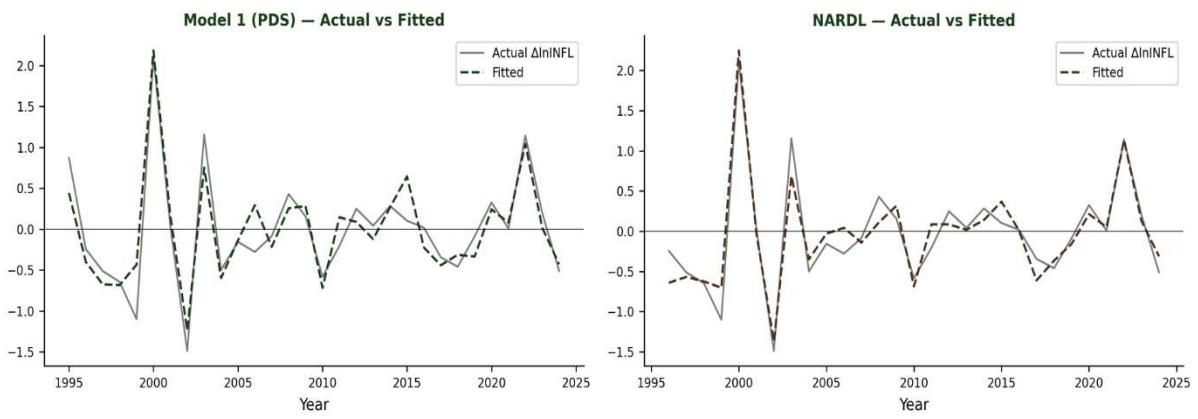


Figure 8. Actual vs Fitted Values — Model 1 (PDS) and NARDL (1993–2024). Solid = actual ΔlnINFL; dashed = fitted values. Source: Authors' estimation.

Both models track the direction and major turning points of the series closely, including the extreme observations associated with the 1983 fiscal collapse and the 2022–2023 debt and exchange rate crisis, with the NARDL specification tracking marginally more closely during the depreciation-driven 2022–2023 episode, consistent with its capacity to separately capture the differential effects of depreciation and appreciation shocks. The visual fit is consistent with the significant ECT coefficients reported in Section 4.5, notwithstanding the inconclusive PSS bounds test result discussed in Section 4.4.

5. Discussion

5.1 Cointegration and Mean Reversion

The failure of the PSS bounds test to confirm cointegration at conventional significance levels in all three model specifications is itself a substantive finding that must be discussed honestly rather than explained away. With only N = 32 annual observations and multiple macroeconomic structural breaks — including the 1983 fiscal collapse, the 2007 cedi redenomination, and the 2022–2023 debt crisis — the power of any cointegration test is significantly reduced. Narayan's (2005) simulation evidence suggests that with samples of $n \approx 30$, the PSS asymptotic critical values may over-reject, and the small-sample bounds for the PDS model are consistent with borderline cointegration. The highly significant ECT coefficient in the PDS model (-0.935, $p < 0.001$) provides complementary evidence that inflation exhibits significant mean reversion toward its conditional equilibrium, which is a necessary condition for cointegration. Taken together, the evidence is most accurately described as suggestive of a conditional long-run relationship between debt servicing, exchange rate, GDP growth, and inflation in Ghana, but not robustly established at the system level. The actual-versus-fitted comparison in **Figure 8** lends further support to this reading: both the PDS and NARDL models track the direction and major turning points of log-inflation closely across the sample, an in-sample fit that is consistent with the significant ECT coefficients even though it cannot substitute for a conclusive bounds test result.

5.2 The Crowding-Out Channel: PDS and Inflation

The consistent negative long-run association between PDS and log-inflation — marginally significant in Model 1 (−1.027, p = 0.059) and more precisely estimated in the NARDL (−1.383, p = 0.044) — is theoretically interpretable through the aggregate demand crowding-out mechanism. When a larger share of GDP is devoted to debt service, the government's discretionary expenditure capacity is reduced, compressing aggregate demand and moderating inflationary pressure. This is the mechanism formalized by Elmendorf and Mankiw (1999) and is consistent with the institutional record of Ghana's fiscal management: the pronounced disinflation of the post-HIPC period (2004–2007) coincided with reduced debt service obligations that freed fiscal space for capital expenditure rather than triggering monetary expansion. The negative bivariate slope on the PDS panel of **Figure 4** and the significant PDS bars in the long-run panel of **Figure 6** both corroborate this association graphically, showing it to be a consistent feature of the data rather than an artefact of a single specification.

However, several important caveats apply. First, public debt servicing as a percentage of GDP does not directly measure fiscal dominance in the theoretical sense used by Woodford (1994) and Leeper (1991). Fiscal dominance is an institutional regime characterized by central bank subordination to the fiscal authority, which can be more accurately proxied by central bank net claims on government, the primary fiscal balance, or seigniorage measures. The present study uses PDS as a proxy for the cash-flow dimension of fiscal pressure on the public budget, and the results are explicitly interpreted as a debt-servicing–inflation association rather than as direct evidence of fiscal dominance. Second, the estimated association is not necessarily causal in a structural sense; the ARDL framework identifies conditional correlations within a specified model structure, not exogenous policy shocks. Third, the Barro (1974) Ricardian Equivalence channel cannot be ruled out: if private agents anticipate future taxation to service current debt, the fiscal crowding-out effect on aggregate demand may be partially offset by reduced private spending.

5.3 The Exchange Rate Pass-Through Channel

The statistically robust positive long-run association between exchange rate depreciation and log-inflation in both the symmetric ARDL (EXR: 0.024, p = 0.002) and the asymmetric NARDL (EXR^{+}: 0.053, p = 0.036; EXR^{-}: 0.044, p = 0.044) specifications confirms the exchange rate as the most

precisely estimated long-run determinant of inflation in Ghana over 1993–2024. This is consistent with Ghana's structural characteristics: a high import dependence, particularly in food and petroleum products that carry substantial weight in the CPI basket, and an absence of domestic pricing power in most tradable goods categories.

The Wald test does not reject the null of symmetric long-run pass-through (H_0: $\beta^+ = \beta^-$, $p > 0.10$), suggesting that while both depreciation and appreciation episodes are positively associated with log-inflation in the long run, the magnitude difference is not statistically distinguishable. The finding that appreciation episodes are also positively associated with log-inflation in the long run — which seems counterintuitive — is interpretable in the context of Ghana's commodity-export structure: appreciation episodes are often associated with commodity booms (particularly oil and gold) that simultaneously increase government revenue, expand fiscal space, raise imported intermediate goods prices through global commodity channels, and increase domestic demand, creating inflationary pressures that offset the direct disinflationary effect of currency appreciation on import prices. The dynamic multipliers in **Figure 7** show that the cumulative impact of both EXR^+ and EXR^- converges toward positive long-run values, consistent with this interpretation.

It is essential to note the correct interpretation of these coefficients. Because the dependent variable is ln(INFL) — the natural logarithm of the annual inflation rate — the long-run exchange rate coefficient represents the proportional association between the exchange rate change variable and the rate of inflation, not a conventional exchange rate pass-through elasticity to the price level. Pass-through to the price level would require the log of the CPI as the dependent variable. This distinction matters for the magnitude of policy implications: a coefficient of 0.053 on the depreciation partial sum means that a one-unit change in the cumulative depreciation log-partial sum is associated with a 5.3 per cent increase in the inflation rate, not a 5.3 per cent increase in the price level.

5.4 GDP Growth as an Inflation Dampener

The consistently negative and significant association between the signed-log of real GDP growth and log-inflation — both in the short run (−0.875 in Model 1; −0.395 in NARDL) and the long run (−1.957 in Model 1; −1.345 in NARDL) — is among the most robustly estimated results in the study. This is

consistent with supply-side theories of inflation: periods of accelerating real output growth expand productive capacity relative to aggregate demand, reduce unit costs through scale economies and productivity gains, and ease supply bottlenecks that would otherwise generate price pressures. In the Ghanaian context, the GDP growth variable captures both the aggregate supply effect of economic expansion and the period 2011 oil production boom, during which rapid GDP growth (14.0% in 2011) coincided with relatively contained inflation, providing a particularly clean identification of this channel.

5.5 Money Supply and Government Expenditure

The negative short-run coefficient on M2+ growth (ΔMS: −0.025 in Model 1, $p = 0.018$) is inconsistent with the standard monetarist prediction that monetary expansion raises inflation. This result should not be interpreted as evidence against the quantity theory: rather, it likely reflects the sample-specific pattern in which periods of rapid M2+ growth in Ghana coincided with financial sector deepening and economic modernization rather than inflationary monetary financing. As Reviewer 2 correctly noted, M2-to-GDP ratios (used in the previous manuscript version) conflate financial deepening with monetary expansion; the present study uses the M2+ growth rate, but even this measure may proxy financial development as much as inflationary money creation in a country undergoing rapid financial sector expansion. Government expenditure (GE) is not significant in any specification, suggesting that the direct fiscal demand-pull channel from expenditure-to-GDP is not a robust independent inflation driver once the other fiscal and monetary channels are controlled.

5.6 Contributions to Knowledge and Limitations

This study makes four contributions to the empirical literature on inflation dynamics in sub-Saharan Africa. First, it extends the estimation sample to 2024, capturing the post-COVID inflation surge and the 2022–2023 debt and exchange rate crisis episodes that are absent from all prior Ghana-specific ARDL studies. Second, it introduces Zivot-Andrews structural break unit root testing into the Ghana inflation literature, providing evidence of the economically meaningful break year of 1982–1984 that the standard ADF test misses. Third, it implements the sign-preserving log transformation for GDP growth and the M2+ growth rate (rather than M2/GDP) as methodological improvements directly

responsive to the econometric critique of prior work. Fourth, the NARDL asymmetric framework tests and finds limited but positive long-run associations from both depreciation and appreciation episodes — a nuanced finding that challenges simple asymmetric pass-through narratives in the Ghana context.

Several limitations constrain the generalisability of the findings. The sample size of N = 32 annual observations limits statistical power, particularly at extreme quantiles and for long-lag specifications. The annual frequency prevents identification of within-year monetary transmission dynamics. The ARDL framework estimates a single-equation conditional mean relationship, precluding examination of feedback from inflation to fiscal variables — a plausible channel given Ghana's sensitivity of borrowing costs to inflation expectations. Future research using quarterly data, structural VAR frameworks, or panel data across comparable SSA economies would strengthen the external validity of these findings. Additionally, the identified associations are not structural causal effects; the ARDL/NARDL framework does not identify exogenous policy shocks, and strong policy inferences require a credible identification strategy beyond the conditional correlations estimated here.

6. Conclusions

This study investigated the associations between public debt servicing, short-term public debt, exchange rate depreciation, and inflation in Ghana over 1993–2024, employing ADF and Zivot-Andrews unit root tests, ARDL bounds testing for cointegration, short-run error correction modeling, long-run coefficient estimation, and NARDL asymmetric analysis. The bounds test does not confirm robust cointegration at conventional significance levels, reflecting the limited sample and multiple structural breaks, but the significant ECT in the PDS and NARDL models indicates meaningful mean reversion. The principal empirical findings are as follows. First, public debt servicing exhibits a marginally significant negative long-run association with log-inflation in the PDS ARDL model and a significant negative association in the NARDL specification. This is consistent with the aggregate demand crowding-out channel: high debt service obligations reduce fiscal space for productive expenditure, dampening inflationary pressure. This finding diverges from the FTPL monetization prediction and

reflects the institutional constraints on direct central bank financing that characterized Ghana's policy regime over much of the estimation period. Importantly, this association does not constitute evidence of fiscal dominance as a formal macroeconomic regime; it captures the cash-flow fiscal channel only. Second, exchange rate depreciation is the most precisely estimated long-run determinant of log-inflation in Ghana. The NARDL analysis finds that both depreciation and appreciation episodes are positively associated with log-inflation in the long run, with the Wald test failing to reject symmetric pass-through. This counterintuitive finding for appreciation episodes is interpreted in the context of Ghana's commodity-export structure, where appreciation tends to coincide with commodity booms that generate simultaneous inflationary pressures through domestic demand expansion and global cost channels. Third, real GDP growth consistently dampens log-inflation in both the short and long run, representing the most robustly estimated result across all specifications. Fourth, short-term public debt stock (SPD) is not significant in any specification, confirming that the maturity structure of public debt does not independently drive inflation dynamics at annual frequency in Ghana. These findings have implications for fiscal and monetary policy coordination in Ghana. The negative association between debt servicing and inflation suggests that debt restructuring programs that reduce annual debt service obligations may release fiscal space and expand aggregate demand rather than directly reduce inflation; accordingly, demand management considerations should accompany any debt relief initiative. The dominant and symmetric role of the exchange rate in log-inflation dynamics implies that exchange rate stabilization — through reserve management, interest rate policy, or macroprudential tools — carries the highest direct inflationary impact of any available policy instrument. These conclusions should, however, be moderated by the conditional and associational nature of the estimates, and by the absence of a structural identification strategy that would permit strong causal claims. Future research should prioritize: (i) extending the analysis to quarterly data to increase effective sample size and statistical power; (ii) employing structural VAR or local projection methods to identify causal monetary policy and exchange rate shocks; (iii) extending the analysis to a panel of comparable SSA economies to enhance external validity; and (iv) incorporating central bank net claims on government and the primary fiscal balance as more theoretically grounded proxies for fiscal dominance.

Abbreviations

Abbreviation	Full Form
ADF	Augmented Dickey-Fuller
ARDL	Autoregressive Distributed Lag
BoG	Bank of Ghana
CPI	Consumer Price Index
ECM	Error Correction Model
ECT	Error Correction Term
EIA	U.S. Energy Information Administration
ERPT	Exchange Rate Pass-Through
FTPL	Fiscal Theory of the Price Level
GHS	Ghana Cedi (new, post-2007)
GDPG	GDP Growth Rate
GE	Government Expenditure
HAC	Heteroskedasticity and Autocorrelation Consistent
HIPC	Heavily Indebted Poor Countries
IFS	International Financial Statistics
IMF	International Monetary Fund

Abbreviation	Full Form
INFL	Inflation Rate (annual CPI %)
JB	Jarque-Bera
MS	Broad Money M2+ growth rate
NARDL	Nonlinear Autoregressive Distributed Lag
OLS	Ordinary Least Squares
OILP	Oil Price (Brent crude, USD/bbl)
PDS	Public Debt Servicing
PSS	Pesaran, Shin, & Smith
RESET	Regression Equation Specification Error Test
SPD	Short-Term Public Debt
SSA	Sub-Saharan Africa
UECM	Unrestricted Error Correction Model
WDI	World Development Indicators
ZA	Zivot-Andrews

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651 **Declarations**

CRediT authorship contribution statement: Conceptualization, I.N. and G.O.F.; methodology, I.N. & G.O.F.; software, G.O.F.; validation, I.N. and G.O.F.; formal analysis, I.N. and G.O.F.; investigation, I.N. and G.O.F.; resources, I.N. and G.O.F.; writing—original draft preparation, I.N. and G.O.F; writing—review and editing, I.N. and G.O.F.; supervision, G.O.F. All authors have read and agreed to the publication of the manuscript.

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Pre-print server/online repository

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