CAUSES OF FOREIGN EXCHANGE RATES MOVEMENTS – A REVISITATION

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ABSTRACT

The theoretical basis for this research is rooted in the platform of financial economics where knowledge of factors responsible for movements of a set of financial assets in terms of restrictive variances and covariances is an essential condition for inventive managing of financial portfolios. Hence, the research examined determinants of exchange rate movements in 18 emerging countries using Bayesian VAR and nonlinear ARDL. Both Litterman and Wishart priors of Bayesian VAR demonstrate that the response of real effective exchange rate (ER) to its causal variables is not a one-stage determination, the response is positive at some stages and negative at some other stages. The findings show that changes in inflation produce an asymmetric impact on real ER. We found non-linear effects of price-based determinants of the real ER for all countries. A percentage decrease in the inflation rate causes real ER to appreciate by 0.12% and 0.57% whereas it caused 0.26% and 0.74% devaluation of real ER at short and long-term periods respectively. We found 1.052% and 1.215% devaluation effects of negative tot at both periods of analysis. Relatively, the paper obtains 0.94% and 1% devaluation of rising foreign debt levels at short and long-term periods respectively.

Keywords: currency devaluation, currency appreciation, foreign debt, inflation, terms of trade, asymmetric impact
JEL classification: F31, G32, D50

1. Introduction

The foreign exchange rate between local and foreign currencies is generally represented as the quantity of local currency that will exchange for one unit of foreign currency. Exchange rates in most African countries are characterized by declining values over time. As a result, African economies experience alterations that may be significant or insignificant over some time. The alterations are most likely to occur in the value of imports which rise in terms of local currencies and exports that might be cheaper if they are completely locally produced. Apart from exchange rates, African countries like many other countries of the world depend on fossil fuels as a source of energy for consumption. Countries in this regard can be grouped into oil-producing and exporting countries and oil-importing countries.

Emerging countries are major exporters of commodities in the world and their share of the total trade is quite insignificant. The government export earnings are somewhat insufficient in meeting the development needs of these countries. Often, these countries have resorted to borrowing to cover the fiscal gap. The export earnings are major sources of foreign reserves which are essential for exchange rate management in these. A major challenge faced by the African economies emanates from the increasing volatility of international prices for these commodities. Currency values have been incredibly unstable in both rich and developing countries since the Bretton Woods system collapsed in 1973. The majority of emerging countries have maintained nominal exchange rate declines even after accounting for their real exchange rates. This exemplifies how difficult it is to ascertain the real exchange rate. Before the 2007 financial crisis which originated in the United States, the global prices of major commodities tended to be increasing steadily. The post-crisis period witnessed significant price fluctuations. This poses a significant impact on the export earnings in these African countries and thus creates uncertainty on exchange rate movement. Therefore, the overarching goal of the present paper is to investigate the factors that influence the determination of real ER in Africa. In particular, this study examines how real ER responds to the consumer price index, terms of trade (tot), and external debts (debt) in Africa. The theoretical basis for this research is rooted in the platform of financial economics where knowledge of factors responsible for movements and dynamics of a set of financial assets in terms of restrictive variances and covariances is an essential condition for inventive managing of financial portfolios (Joshi et al. 2020, Agbonrha-Oghoye et al. 2022, Kudakwashe & Oliver, 2022).

The methodological contribution of this study rests on the utilization of Bayesian VAR in estimating the relationship. We attempted to fill a methodology gap in this research by using the Bayesian VAR modeling technique. BVAR model parameters are treated as random variables, with prior probabilities. In addition to its capacity to model large data sets, the unique empirical advantage of the BVAR model

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estimation is that it utilizes informative priors (author) to narrow the unrestricted model into a parsimonious operational model, thereby reducing parameter nuisance and improving forecast accuracy. In effect, the over-parameterization problem vis a vis limited information on variables (data) is eliminated because as the ratio of variables to observations increases, prior probabilities become increasingly applicable. The informativeness of the prior can be set by treating it as an additional parameter. In particular, each variable follows a random walk process, with drift, and hence, includes a normal prior on a set of coefficients with a constant covariance matrix. The matrix was estimated using a univariate AR matrix. The significance of this paper is rooted in the fact that exchange rate movements have implications for demand, tradable, and non-tradable goods and services. Hence, a non-linear evaluation of the pattern of the influence of the aforementioned predictors on real ER and its dynamic response becomes imperative. The next section is a review of the most recent literature on the determinant of real ER, while section 3 presents materials and methods. Results and discussion are contained in section 4. Accordingly, section 5 is the conclusion.

2. Literature review

2.1. Theories of exchange rate determination

In terms of theoretical foundations, five theories provided explanations for the determination of exchange rate movements. These include traditional theories, monetary theory approach, portfolio balance theoretic approach, purchasing power parity theoretic approach, and elasticity theory respectively (Ojo & Temitayo, 2018, Umoru 2013d). In the traditional theoretic model of Stockman (1980), exchange rates are strongly determined by forces of demand and supply of foreign exchange reserves. In effect, the inflows and outflows of foreign capital are the key factors in funding/regulating current account deficit/surplus. Due to Frenkel (1976), the monetary theoretic model upheld money balances or growth rate of money in circulation, domestic inflation, and local output as the strongest determinants of units of local currencies exchanged for a unit of foreign currencies. Under the regime of the flexible exchange rate, the monetary theoretic exchange rate model can be explained as asset market theory which advocated that exchange rates are intensely determined by variations in money supply, and expected rates of return on assets (Ojo & Temitayo, 2018). The portfolio balance theory advanced by Dornbusch (1975) and Branson (1983) upheld that the overall equilibrium in the local bond market, local money market, and the international bond market determines exchange rate movements. According to Black (2013), portfolio adjustments between local and foreign assets forces fresh demand for foreign exchange. Theoretically, investors' portfolio is made up of money, and bonds (local and foreign) (Fama & Farber 1979).

According to Phylaktis & Ravazzolo (2005), the portfolio balance theory recounts that exchange rates are decided by activities in the capital account. According to the theory, an increase in stock prices invites foreign investors and hence, boots entry of capital inflows. The supply and demand for money in the relevant countries can fluctuate over time, and this can be used to explain the rate of exchange fluctuations between two currencies, according to a variety of different monetary theories. The premise of this strategy is that money is a crucial trading medium. When the two nations' present money inventories are maintained, according to Frankel (1978), this model of setting the exchange rate reaches equilibrium. Both the monetary approach and the asset market approach, which falls under the category of flexible exchange rates, place emphasis on the significance of using money and other assets to ascertain exchange rates. The monetary approach mainly ties changes in exchange rates to anticipated rates of return, income, and other factors that influence the supply and demand of money. According to Kudakwashe & Oliver (2022), advances in exchange rate movements impact the happenings of the stock market.

Propounded by Cassel (1916, 1918), the PPP theory is driven by the law of one price states exchange rate movements determined by price differentials. Accordingly, the ratio of trade between two forms of currency under the non-convertible notes agreement is controlled by the overall purchasing power of the two forms of currency in separate countries. There are two variants of PPP, the absolute variant PPP and the relative version respectively. Absolute PPP hypothesizes that the speed of a transaction is determined by the ratio of the strength of internal purchases of outstanding cash to the strength of internal purchases of domestic funds. Relative PPP requires equality of inflation rates and exchange rates of two trading countries at the same time. In effect, movements in exchange rates adjust to compensate for variations in price between local and foreign countries (Rogoff 1999, and Hoontrakul, 2000).

The elasticity theory on exchange rate determination posits that, if the balance of payments is accurately in equilibrium, the exchange rate devalues and this benefits the BoP of the devaluing nation. Devaluation must, to the greatest extent feasible, boost the demand for imports both domestically and internationally. Under the ideal conditions defined as the Marshall-Lerner (ML) condition, a country's currency devaluation frequently tends to improve the balance of payments. It looked at how responsive the variables were to shifts in relative prices brought on by devaluation in the trade and services account, which comprises imports and exports of goods and services. The ML condition forms the basis of the elasticity approach (Oladipupo & Onotaniyohuwo, 2011). The country can go through the revaluation process, which will improve its trade balance if the overall elasticities are less than unity. In effect, exports are sources of trade. In the works of Bostan & Firtescu (2019) OLS regression technique was utilized to establish the significant relevance of the exchange rate as a determining factor of export competitiveness for the Romanian economy. Accordingly, the growth effect of foreign trade can be explained from viewpoint of exportation. The rationale for a devaluation policy is to make exports cheaper. Exports bring foreign reserves, needed, most importantly, to maintain a favorable balance of payments of nations while paying for imports and foreign debts. Productivity growth in the export sector leads to economic expansion by earning foreign exchange that could be deployed to facilitate development. In other words, with large capacity utilization, the surplus output is produced for the foreign market. Without production for exports, resources would be underutilized, and this negatively impacts economic growth.

2.2. Empirical review

Numerous empirical research on the variables influencing exchange rates has been conducted since the Bretton Woods agreement fell apart in 1973. Nevertheless, it suffices to report here that recently, a bidirectional relationship was found between the real exchange rate and exchange rate volatility (Dabor et al., 2023), a non-linear association between exchange rate movements and the volume of reserves in emerging countries was established (Umoru et al., 2023b), a non-linear association between movements in exchange rates, oil prices, and foreign reserve holdings was similarly documented (Umoru et al. 2023c). furthermore, an asymmetric association between exchange rate devaluation and industrial output was found to exist in emerging countries of Africa (Umoru et al., 2023a). In addition, an asymmetric relationship was established between exchange rate fluctuations and money demand (Umoru et al., 2023d). Umoru et. al (2023) in their study, assessed the factors that can determine the rate of exchange volatility in 7 African countries; Niger, Sudan, Cameron, Equatorial Guinea, Tunisia, Congo, and Cote D'Ivoire for the period of 1990- 2023. They used the Autoregressive Distributive Lag (ARDL) bounds testing for cointegration and the error correction model was estimated. Also, ARCH and GARCH models were used to assess the extent of oscillations of the time series. The outcome showed that the oscillations in the rate of exchange of the countries in the study were not accidental occurrences. The adjustment speed of the oscillations for the countries were 39% in Sudan, 50% in Niger, 52% in Cameroon, 55% in Tunisia, 32% in Congo, 58% in Equatorial Guinea and 45% in Côte D'Ivoire. The study by Carissa & Khoirudin (2020) reported that import volume, interest rate, and domestic money in circulation contributed positively to the determination of the rupiah exchange rate. Rashid & Basit (2022) reported the significance of the negative influence of foreign-reserve in the determination of ERV in Bangladesh, China, and Malaysia. Government spending negatively determined ERV in India but positively determined ERV in India, Bangladesh, Malaysia, and China.

To Nguyen & Vo Hong D. (2021), changes in exchange rate movements are influenced by macroeconomic determinants namely, trade openness, interest rates, and inflation volatility, but this varies considerably across New Zealand, Australia, Korea, and Japan. On their part, Vo The et al. (2021), interest rates contributed insignificantly in explaining the exchange rate behavior and inflation rate in Indonesia, Malaysia, the Philippines, Singapore, and Thailand. Muhammad et al. (2019) reported that macroeconomic factors namely, GDP, inflation, government debt, trade liberalization, interest rates, government spending, and inflation, are significant determinants of exchange rates with particular emphasis on improvements in domestic economic and political systems. According to Odoom (2019), interest rate, current account balance, and money supply are significant but negative determinants of exchange rate volatility while the rate of domestic inflation is a positive determinant of exchange rate volatility in Ghana. Khan et al. (2019) found long-run significance and positive impact of GDP growth and trade openness in the determination of the china/US exchange rate while significance and negative impact of inflation and domestic rate of interest was observed in USD/CYN determination. To Rabeya (2021), the level of income, the Rohingya crisis, government measures, inflation, natural disasters, and covid-19 pandemic all contributed extensively to the determination of exchange rates. The author found that real interest rate and foreign reserves cause the exchange rate of Thai baht to the UDS to appreciate, per capita income causes the exchange rate of Thai baht to the USD to devalue, and external debt devalues the Thai baht/USD exchange rate.

According to Salim & Shi (2019), trade balance, variation between local and foreign output, variation between local and foreign interest rates, variation between local and foreign money supply, and variation between local and foreign inflation rates are considerable determinants of exchange rates in Indonesia based on linear and non-linear ARDL methods. Kilicarslan (2018) established a significant positive impact of local investment, trade openness, and money supply on the real ER and a significant negative relationship between the real ER, public expenditure, income per head, and FDI. To Sreelakshmi & Manogna (2022), the GBP/USD exchange rate is negatively determined by the volume of reserves in the United Kingdom (U. K.), the interest rate in the U.K., the GDP of the U.K., and the inflation rate in the United Kingdom. According to Shaikh & Roushanara (2023), interest rate played no considerable role in the determination of the ER. Rather, the results obtained demonstrated that foreign exchange reserves, remittances, and GDP growth rate are significant factors responsible for the determination of the exchange rate.

Chávez (2020), reported the positive influence of past values of the real exchange rate on the current values of the real exchange rate between 1980 to 2019, the negative influence of TOT and broad money supply on the real exchange rate was reported between 1980- to 2019 basing empirical findings on system GMM that controlled for the endogeneity of panel variables while first difference GMM estimation method based on forward orthogonal deviations was used to eliminate unobserved effects that are invariant with time. According to Thevakumar & Jayathilaka (2022), inflation, and foreign trade balance are significant factors responsible for influencing a short-run impact on exchange rate-lagged values. To Ariyasinghe & Cooray (2021), the exchange rate is strongly determined by the volume of international reserves holdings, and inflation in Sri Lanka. Perera & Rathnayaka (2019) reported that remittance, Colombo share market movements, and tourist arrivals were amongst the most valuable factors for forecasting exchange rate volatility in Sri Lanka. Based on ARIMA (1, 0, 0)-GARCH (1, 0) models. Dutta & Sengupta (2018) and Essayyad et al. (2018) also found remittances as one of the factors driving real effective exchange rate movements in India and South Asia respectively.

Stancik (2007) investigated the factors that contributed to currency rate fluctuations among the six newest EU members between 1999 and 2004. A method for analysis employed in the study was the threshold autoregressive conditional heteroskedasticity (TARCH) model. The results showed that ERV was positively and statistically significantly influenced by economic openness, information, and flexible exchange rate regimes. In the study of Josifidis et al. (2013), how the real ER affects the real economy, and the use of foreign exchange intervention to control and protect exchange rates were all examined. The examination of six new EU members was carried out in the middle of the financial crisis. To Kersan-Škabić, & Benazić (2016), a significant portion of what determines Croatia's nominal exchange rate comes from outside forces that affect the country's economy. It was suggested, however, that to keep the exchange rate steady, policymakers utilize the research to guide their monetary policy decisions. Insah & Chiaraah (2013) indicated a favorable link between government spending and exchange rate volatility. The research concludes that if persistent trends in currency rates are to be controlled, then government spending should be decreased.

The findings of Nawaz et al. (2014) for the Pakistani economy indicated that the most significant determinant of a real exchange rate movement is public debt, followed by current account deficit, thereafter, the difference in interest rates, and lastly, the difference in inflation rates. Orji (2015) using the ECM method, indicated that the interest rate gap and oil income were the main factors influencing Nigeria's real exchange rate, whereas the productivity gap had little bearing on the real exchange rate. The research recommends policymakers efficiently manage the actual exchange rate. Additionally, it recommended diversifying the economy away from the oil industry to decrease the impact of any shocks to that industry. Nigeria's actual exchange rate volatility between 1981 and 2008 was the subject of Ajao's (2015) investigation. Government expenditure and changes in interest rates were among the other key factors that significantly impacted real exchange rates throughout time, according to empirical research. Nwude (2012) used 52 years of annualized data from 1960 to 2011 to explore the variables thought to be predictors of foreign exchange rate movement in Nigeria. It was analyzed using the least squares approach. The inflation rate, deposit rate, lending rate, foreign reserves, GDP, BOP, and all other variables were studied. Based on the level of oil revenue and the macroeconomic environment, it was reported that the exchange rate in Nigeria might be either overvalued or undervalued. According to the paper, solid and effective monetary policy should be promoted while fiscal dominance should be lessened. This is true even though different conclusions have been drawn from the results of the many studies under discussion. External reserves and CPI are macroeconomic indicators that, according to Eze & Okpala (2014), do not substantially affect changes in the value of a currency. There is no one exchange rate policy that is always the best for all countries. Despite how crucial exchange rates are to economic growth, the study referenced above has shown that they cannot be decided independently of other macroeconomic factors. The relationship between these macroeconomic factors and the foreign exchange rate needs to be unraveled to enhance the literature. This becomes the gap we attempted to resolve.

3. Methodology

The quantile regression (QR), generalized Method of Moments (GMM), vector error correction modeling (VECM) technique, the generalized autoregressive conditional heteroskedasticity (GARCH), etc are all methods for investigating the factors responsible for the determination of exchange rate movements. Nonetheless, the study estimates the Bayesian VAR (BAVR) model to analyze rapid shifts in dynamic responses of the exchange rate to the factors responsible for its determination. Also, we choose the BVAR to analyze the rapid shift in the factors responsible for exchange rate movements. Bayesian VAR (BVAR) estimation needs prior information. The priors created by Doan et al. (1984) and Litterman (1986), commonly referred to as Minnesota prior are adopted in this study. Specifically, the paper adopts Bayesian VAR models with 3 priors, namely the independent Normal-Wishart prior, Minnesota prior, and stochastic search variable selection (SSVS). The Markov chain Monte Carlo (MCMC) simulation procedure was deployed to fit Bayesian models. The Marginal likelihood (ML) is computed using the Laplace-Metropolis approximation. Gibbs sampling for simulation. The BVAR's extensive adoption in applied research is largely due to its success in forecasting economic variables (Koop & Korobilis, 2010; Kilian & Lütkepohl, 2017). We obtained the BVAR model specification from the following general VAR (p) specification given in equation (1):

$$Z_t' = \rho' + \sum_{i=1}^{p} z_{t-i}' \varphi_i + e_\tau' \tag{1}$$

The matrix representation of the VAR model is given as follows:

$$Z = Y\phi + e\,,\; Z = (z_1, ..., z_T)' \tag{2}$$

Where, $Y = (y_1, ..., y_T)'$, $\phi = (\rho', \varphi_1', ..., \varphi_p')'$,

and $y_t = (1, y_{t-1}', ..., y_{t-p}')'$ $e = (e_1, ..., e_T)'$

where Z is a $T \times n$ matrix, Y is a $T \times (1+np)$ matrix, y_t is the $(1+np)\times 1$ vector, ϕ is $(1+np)\times n$, e is a $(T \times n)$ matrix. With the Normal-Wishart prior, the VAR equation can be specified as:

$$vec(\phi) \sim MN(vec(\phi_0), \Gamma_0) \tag{3}$$

$$\sum \sim IW(\sum\nolimits_0, \omega_0) \tag{4}$$

where MN is defined as multivariate normal with mean vec(ϕ_0), Γ_0 is the covariance-variance matrix, IW is an inverted Wishart distribution with parameters Σ_0 and df, ω_0. The conditional posterior densities of $vec(\phi)$ and Σ are derived as follows:

$$\begin{aligned} &vec(\phi)\big|\sum, Z \sim MN(vec(\phi_@), \left[\Gamma_0^{-1} + \sum \otimes (Y'Y)\right]^{-1}) \\ &\sum\big|\Phi, Z \sim IW\left[(Z - Y\phi)'(Z - Y\phi) + \sum\nolimits_0, T + \omega_0\right] \\ &vec(\beta_@) = \Gamma_@\left[\Gamma_0^{-1} vec(\phi_0) + (\sum \otimes I_k)^{-1} vec(Y'Z)\right] \end{aligned} \tag{5}$$

With Minnesota prior, the Bayesian VAR model has decreasing lagged variables (Litterman, 1986) for the prior and this is defined as:

$$\phi \sim N\left[\bar{\phi}_i, Var(\phi_i)\right] \tag{6}$$

and $\bar{\phi}_1 = I_n$

$$\begin{aligned} &\bar{\phi}_2 = ... = \bar{\phi}_p = 0_n \\ &Var(\phi_i) = \frac{\alpha^2}{i^2}\begin{bmatrix} 1 & \delta(\sigma_1^2/\sigma_2^2) & \delta(\sigma_1^2/\sigma_3^2) \\ \delta(\sigma_2^2/\sigma_1^2) & 1 & \delta(\sigma_1^2/\sigma_3^2) \\ \delta(\sigma_3^2/\sigma_1^2) & \delta(\sigma_3^2/\sigma_2^2) & 1 \end{bmatrix} \end{aligned} \tag{7}$$

where $\bar{\phi}_1, \bar{\phi}_2$ are the mathematically expected values of ϕ_i and the variance of ϕ_i is defined by $Var(\phi_i)$. The restrictions on the hyperparameters are given as follows.

$$\begin{aligned} &0 < \delta < 1 \\ &\sum = diag(\sigma_1^2, \sigma_2^2, \sigma_3^2) \end{aligned} \tag{8}$$

Finally, we have the SSVS prior due to George et al. (2008). The SSVS priors restrict the parameters of the BVAR model by ordering the priors on the parameters. The SSVS defines the prior for the VAR coefficient ϕ for each element. Hence, if φ_j are elements in ϕ, then the prior for φ_j becomes an ordered prior given in equation (8).

$$\varphi_j \big| \eta_j \sim (1-\eta_j) N(\kappa_{0,j}^2) + \eta_j N(0, \kappa_{1,j}^2) \tag{8}$$

Where $\kappa_{0,j}^2 < \kappa_{1,j}^2$

$$\begin{cases} if\, \eta_j = 0,\; \varphi_j = 0 \;\; \forall\; \varphi_j \big| \eta_j \sim N(0, \kappa_{0,j}^2) \\ if\, \eta_j = 1,\; \varphi_j = 1 \;\; \forall\; \varphi_j \big| \eta_j \sim N(0, \kappa_{1,j}^2) \end{cases}$$

Accordingly, the zero means of the first-order autoregressive model is assumed to be 0 while the SSVS prior defines classified prior that combines two normal distributions with diverse variances conditional on a dummy variable η_j that takes zero or one. In effect, at one end, the prior is practically zero with a small variance, while at the other, the prior has a huge variance (Sugita, 2022). Methodologically, therefore, the priors obey an independently distributed Bernoulli process whose random variables are given as.

$$\begin{aligned} &p_j = P(\eta_j = 1) \\ &P(\eta_j = 0) = 1 - p_j \end{aligned}$$

In this study, our hyperparameters are set at α = 0.05, δ = 0.1, $\omega = 6$, vec(ϕ_0) = 0, Γ_0 = 100, and $\sum_0 = 0.1$. Also, the nonlinear autoregressive distributed lag model was estimated for detecting asymmetric behavior of the factors answerable for exchange rate movements. We proceed by specifying the long-run asymmetric model specification given by equation (9).

$$y_t = \sigma^+ x_t + \sigma^- x_t + u_t,$$
$$x_t = x_t^+ + x_t^- \quad (9)$$

where x_t^+, x_t^- are partial changes in x_t and x_t is a *k*1* vector of regressors, β^+, β^- are the partial sum parameters Accordingly, the asymmetric modelling using partial sum decompositions becomes.

$$x_t^+ = \sum_{j=1}^{t} \Delta x_t^+ = \sum_{j=1}^{t} max(\Delta x_j, 0)\,,\; x_t^- = \sum_{j=1}^{t} \Delta x_t^- = \sum_{j=1}^{t} min(\Delta x_j, 0)$$

(10!)

The stationary equation of the partial changees is given in equation (10):

$$z_t = \sigma_0^+ y_t^+ + \sigma_0^- y_t^- + \sigma x_t^+ + \sigma_1^- x_t^- \quad (10)$$

If restriction $\sigma_0^- = \sigma_0^+ = \sigma$; equation (9) becomes symmetric, whereas when $\sigma_0^- \neq \sigma_0^+ \neq \sigma_0$, we then have a non-linear *ARDL (p,q)* as advanced by Shin et al. (2014). This is given in equation (11) below.

$$y_t = \sum_{j-1}^{p} \phi_j\, y_{t-j} + \sum_{j=0}^{q} (\sigma_j^{+'} x_{t-j}^+ + \sigma_j^{-'} x_{t-j}^-) + \varepsilon_t \quad (11)$$

Where σ_j^+ and σ_j^+ are the asymmetrically distributed lag parameters. The non-linear error correction term by Pesaran et al. (2001).

$$\Delta y_t = p y_{t-1} + \theta_j^{+'} x_{t-1}^+ + \theta_j^{-'} x_{t-1}^- + \sum_{j=1}^{p=1} \gamma_j\, \Delta y_{t-j} + \sum_{j=1}^{q=1} (\varphi_j^{+'} \Delta x_{t-j}^+ + \varphi_j^{-'} \Delta x_{t-j}^-) \quad (12)$$

$$ecm = p\xi_{t-1} + \sum_{j=1}^{p=1} \gamma_j\, \Delta y_{t-j} + \sum_{j=1}^{q=1} (\varphi_j^{+'} \Delta x_{t-j}^+ + \varphi_j^{-'} \Delta x_{t-j}^-)$$

Substituting study variables into the non-linear model (12), we have equations (13) and (14) respectively.

$$\begin{aligned} lnrealER_t = \sum_{j-1}^{p} \gamma_j\, lnrealER_{t-j} + \tau_j^{+'} lndebt_{t-1}^+ + \tau_j^{-'} lndebt_{t-1}^- \\ + b_j^{+'} lntot_{t-1}^+ + b_j^{-'} lntot_{t-1}^- \\ + a_j^{+'} lnifl_{t-1}^+ + a_j^{-'} lnifl_{t-1}^- \\ + \sum_{j=0}^{q} (d_j^{+'} lndebt_{t-j}^+ + d_j^{-'} lndebt_{t-j}^-) \\ + \sum_{j=0}^{q} (\emptyset_j^{+'} lntot_{t-j}^+ + \emptyset_j^{-'} lntot_{t-j}^-) \\ + \sum_{j=0}^{q} (\epsilon_j^{+'} lnifl_{t-j}^+ + \epsilon_j^{-'} lnifl_{t-j}^-) + \varepsilon_t \end{aligned}$$

(13)

$$\begin{aligned} \Delta lnrealERi_t = \Phi + \tau_j^{+'} lndebt_{t-1}^+ + \tau_j^{-'} lndebt_{t-1}^- + b_j^{+'} lntot_{t-1}^+ \\ + b_j^{-'} lntot_{t-1}^- + a_j^{+'} lnifl_{t-1}^+ + a_j^{-'} lnifl_{t-1}^- \\ + \sum_{j=1}^{p=1} \gamma_j\, \Delta lnrealER_{t-j} \\ + \sum_{j=1}^{q=1} (d_j^{+'} \Delta lndebt_{t-j}^+ + d_j^{-'} \Delta lndebt_{t-j}^-) \\ + \sum_{j=1}^{q=1} (\emptyset_j^{+'} \Delta lntot_{t-j}^+ + \emptyset_j^{-'} \Delta lntot_{t-j}^-) \\ + \sum_{j=1}^{q=1} (\epsilon_j^{+'} \Delta lnifl_{t-j}^+ + \epsilon_j^{-'} \Delta lnifl_{t-j}^-) \end{aligned}$$

(14)

Where, $\tau, b, a, d, \emptyset, \in$ is the asymmetrically distributed lag parameters, where ifl_t is inflation, γ_j is the autoregressive lag of ifl_t, $real\ ER_t$ is a real effective exchange rate, τ_j is the autoregressive lag of the dependent variable, τ^+ and τ^-, b^+ and b^-, a^+ and a^-, are the long-run coefficients of the positive and negative changes in foreign debt, terms of trade balance, and inflation while d^+ and d^-, $\emptyset^+$ and $\emptyset^-$, $\in^+$ and $\in^-$ are the short-run coefficients of the positive and negative changes in foreign debt, terms of trade balance, and inflation respectively.

Table 1: Variables description

Code	Definition	Source
real ER	Real effective exchange rate index	World Development Indicator
ifl	Inflation rate measured by a consumer price index	World Bank's commodity pricing database
tot	Net terms of trade index	World Development Indicator
debt	External debt stocks (% of GDP)	World Development Indicator

The real ER, inflation, tot, and foreign debt are all used in estimation. The variables are altered during the log difference calculation so that they stay constant. The same formula is used to convert the exchange rates of the mentioned nations. The World Bank's commodity pricing database provided information on commodity prices (also known as the pink sheet). The countries in our sample for analysis are enlisted in table 2 below.

Table 2: Sample of countries used in the study

countries	
Burundi	Malawi
Cameroon	Nigeria
Lesotho	South Africa
Congo, Dem. Rep.	Togo
Cote d'Ivoire	Uganda
Gabon	Zambia
Gambia, The	Algeria
Ghana	Morocco
Central African Republic	Tunisia

4. Results and discussions

Summary statistics for the variables are presented in Table 3. Mean values of the real exchange rate, inflation rate, external debt, and tot are 105.97, 97.24, 56.83, and 122.08 with standard deviations of 35.57, 55.53, 45.07, and 39.53 respectively.

Table 3: Descriptive statistics

statistics	real ER	ifl	debt	tot
Mean	105.97	97.24	56.83	122.08
Median	99.88	89.66	43.54	112.42
Maximum	511.06	454.43	283.91	290.93
Minimum	49.18	0.01	2.55	21.4
Std. Dev.	35.57	55.53	45.07	39.53
Skewness	5.16	2.06	1.64	1.02
Kurtosis	46.87	11.51	6.46	4.68
Jarque-Bera	39602.22	1743.48	442.97	136.03
Probability	0	0	0	0
Sum	49594.91	45509.03	26596.81	57134.3
Sum Sq. Dev.	590962.9	1440292	948691.3	729818.5
Observations	468	468	468	468

The panel unit root tests for the variables are also presented in Table 4. The real ER is stationary at level. Including the trend in the data generating process, the real effxrt became stationary at first difference. The Breitung test also indicates stationarity at first difference. The cpi index is also stationary at the level and first difference. On the contrary, the Breitung test indicates the variable is non-stationary. Only at first differenced is the external debt stationary when assume to have intercept and trend in the data generating process. The Breitung test is also stationary at first difference. The term of trade was non-stationary at level but stationary when differenced. The Pedroni, and Kao residuals co-integration tests as well as the Johansen Fisher panel co-integration test were conducted to assess the co-integrating relationship between real ER, external debt, inflation rate, and terms of trade.

Table 4: Panel unit root results

variable	intercept/trend	method	level		difference	
			statistic	prob.**	statistic	prob.**
real ER	intercept	LLC t*	-5.78	0.00	-15.43	0.00
	intercept & trend	LLLC t*	-0.12	0.45	-13.75	0.00
	intercept & trend	B t-stat	0.11	0.54	-6.60	0.00
lnifl	intercept	LLC t*	-1.32	0.09	-10.69	0.00
	intercept & trend	LLC t*	-2 .74	0.00	-9.35	0.00
	intercept & trend	B t-stat	1.62	0.95	-0.99	0.16
lndebt	intercept	LLC t*	-1.34	0.09	-12.03	0.00
	intercept & trend	LL Ct*	3.27	1.00	-10.43	0.00
	intercept & trend	B t-stat	2.81	1.00	-8.76	0.00
lntot	intercept	LLC t*	-2.44	0.01	-13.36	0.00
	intercept & trend	LLC t*	-0.63	0.27	-10.69	0.00
	intercept & trend	B t-stat	-0.33	0.37	-8.05	0.00

From table 5 the condition for co-integration exists for panel v statistic, and adf statistic at 0.05 significance level. In addition, the pp statistic is significant at a 0.10 significance level. This points to the possible co-integrating link between the variables.

Table 5: Pedroni panel co-integration results

Measures	Statistic	Prob.	Weighted	
			Statistic	Prob.
Panel v-statistic	0.42	0.34	0.59	0.28
rho-Statistic	1.23	0.89	0.29	0.61
pp-Statistic	-0.46	0.32	-1.46	0.07
adf-Statistic	-1.35	0.09	-2.12	0.02

The Kao residual test results shown in table 6 also indicate rejection of no co-integrating association.

Table 6: Kao panel co-integration results

Measure	t-Statistic	Prob.
ADF	-4.73	0
Residual variance	0.01	-
HAC variance	0.01	-

The Bayesian vector autoregression results are reported in table 7 below. The BVAR regression coefficients were implemented under the assignment of a Minnesota prior (MP), while the error covariance was assigned an inverse Wishart prior. As earlier elucidated,MP helped to shrink all the BVAR coefficients toward zeros or ones for the first own-lag coefficients while preserving the causal time-dependent interactions in the data. We had a total of 3,000 burn-in iterations and 14,000 for the Markov Chain Monte Carlo (MCMC) simulation sample size. The MCMC results are strongly efficient given the presence of Gibbs sampling for simulation the efficiency is reported by a minimum value of 0.92756 which is approximately equal to 1. Also, the MCMC converged appropriately. The Monte Carlo Standard Errors (MCSE) are small to guarantee reliability on sample estimations.

Table 7. Bayesian vector autoregression results

Variables		Mean	Std. dev.	MCSE	Median	95% credible band	
real ER	real ER(-1)	1.20389	0.0684	0.000234	1.2378	0.37690	0.39455
	lnifl(-1)	-0.18927	0.0146	0.000123	0.3486	0.56230	0.65431
	lndebt(-1)	-0.46264	0.00356	0.000293	0.0923	0.12784	0.34560
	lntot(-1)	1.03743	0.0278	0.000457	1.2038	0.29275	0.29937
	cons	0.34682	0.00135	0.000112	0.00251	0.13854	0.15609
lndebt	real ER	0.02835	0.04790	0.000376	0.0274	0.47394	0.56423
	lnifl(-1)	-0.78459	0.00245	0.000681	1.4789	0.37625	0.8945
	lndebt(-1)	-1.03981	0.09489	0.000325	0.0042	0.68310	0.69572
	lntot(-1)	0.13542	0.00389	0.000347	0.00048	0.34782	0.38329
	cons	3.10290	0.00178	0.000913	1.2570	0.78473	0.99851
lntot	real ER	0.03795	0.4613	0.000521	0.3586	0.25632	0.25681
	lnifl(-1)	-0.38636	0.00378	0.000468	0.00476	0.33482	0.34791
	lndebt(-1)	0.02762	0.03871	0.000560	0.0291	0.27845	0.2976
	lntot(-1)	1.27031	0.02784	0.000715	0.0018	0.19478	0.34570
	cons	0.3681	0.00257	0.000430	0.00386	0.56739	0.57910
lnifl	real ER	0.01398	-0.8453	0.000521	0.1976	0.17826	0.17830
	lnifl(-1)	-1.3569	0.00378	0.000234	0.00476	0.02945	0.47850
	lndebt(-1)	-0.0546	-0.13489	0.0007	0.0115	0.21389	0.0237
	lntot(-1)	1.10127	0.23891	0.000358	0.00192	0.12570	0.01481
	cons	2.3458	0.18923	0.000127	1.00030	0.12478	0.10923
Sigma	Sigma_1_1	046824	0.00134	0.000291	0.1234	-0.24783	-0.4478
	Sigma_2_1	0.5782	0.00124	0.000211	0.5468	0.57823	0.13457
	Sigma_3_1	0.57933	0.05745	0.000310	0.8720	0.17826	0.25986
	Sigma_4_1	0.21756	0.06236	0.000960	0.14371	0.59756	0.58705
	Sigma_2_2	0.94475	0.03467	0.000524	0.76542	0.78642	0.79381
	Sigma_2_3	0.63256	0.01256	0.000212	0.65784	0.59851	0.9483
	Sigma_2_4	0.77386	0.04637	0.000141	0.93743	0.56733	0.46892
	Sigma_3_3	0.68931	0.09281	0.000897	0.01523	0.49723	0.39783
	Sigma_4_4	0.78942	0.03569	0.000900	0.49267	0.72809	0.45896
MCMC iterations			14,000	Sample:		1990Q1- 2022Q4	
Burn-in			3,000	Acceptance rate		1	
MCMC sample size			11,000	Efficiency:		Minimum	0.92756
Log marginal-likelihood			921.463			Average	0.99452
Number of observations			2,304			Maximum	1

With our Bayesian analysis, the appropriate lag was selected by estimating the model posterior probability. The results are reported in table 8 below. The model with one lag had 0.79510 probability and this is the maximum posterior probability of the four models considered in the paper.

Table 8. Bayesian VAR model selection

lag	log(ML)	P(M)	P(M/y)
lag1	921.463	0.2222	0.79510
lag2	911.204	0.2222	0.00462
lag3	900.389	0.2222	0.03471
lag4	896.468	0.2222	0.15829
ML = Marginal likelihood			

To assess the sensitivity of our Bayesian inference to change in the priors method, the Normal Wishart prior was adopted and the impulse response is displayed in Figures 1 and 2. The impact of shocks on the real ER slightly depends on the prior specification. Besides the response of real ER to shockwave in cpi, we find a slight variation in the responses of the real ER to shocks in external debt and tot. As for the external debt shockwave, the exchange rate response fluctuates around the positive and negative bands. Nevertheless, the impact is very low and perhaps insignificant. As for the litterman Minnesota prior, the response is negative whose magnitude is stronger than the observed negative response for the Normal-Wishart prior. Between negative and positive changes in inflation, the negative change had a major impact on real ER. By implication, a decrease in the domestic price level is key in the determination of a country's level of competitiveness in the global market. Both external debt and tot contributed significantly in explaining Africa’s level of competitiveness in international trade. In the short run, positive changes to cpi and tot are major factors that have a momentous influence on explaining the appreciation or depreciation of the real ER in Africa.

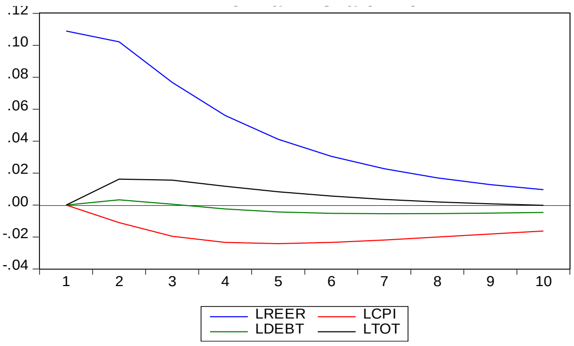


Figure 1: Normal-Wishart prior impulse response

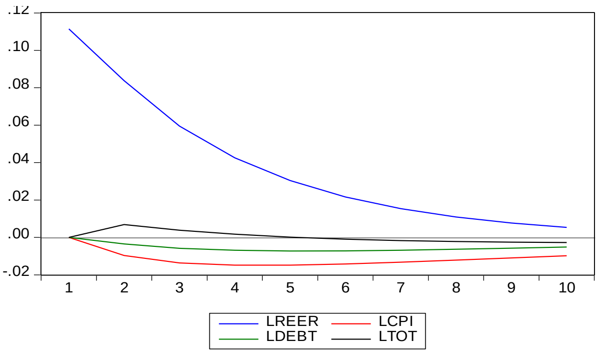


Figure 2: Normal-Wishart prior impulse response

Figures 3 and 4 show the Bayesian impulse responses of variables. The results indicate for the response of real effective exchange rate to shock to cpi, the response is quite similar to the ones obtained using litterman/Minnesota prior thus indicating robustness to prior methods. A positive shock to the cpi has a positive impact on real ER. The shockwave impact is persistent up to the 6th period and partially declines. The positive shock to external debt adversely impacted the real ER. Though the effect is marginally weak and wears out as time passes. This finding is corroborated by Nambie & Donkor (2022) who found a significant association between external debt and exchange rates in Africa using the GMM estimation technique. As for the positive shockwave to tot, there is no instantaneous impact, rather, the impact builds up positively and quickly wears out. The second phase of the shockwave impact indicates a negative decline in the real ER but a very low response upon impact shock.

The reaction of real ER to shockwave in external debt is slightly similar except in the initial shockwave stage when the impact is positive. This denotes the absence of sensitivity in response to external debt shocks. As for the reaction of real ER to shockwave in tot, the shockwave is sensitive to prior adopted. For the Normal-Wishart prior, the tot shockwave impact is not in two stages, rather, the shockwave has a direct positive impact on real ER. However, this impact wears out. Similarly, for the shock to terms of trade, the response of real ER is in two stages. The initial stage shows real ER response is positive and the later stage shows a decline in real ER. However, for the Normal-Wishart prior, the response is straight and positive pointing to the lack of robustness in the response of real ER to tot.

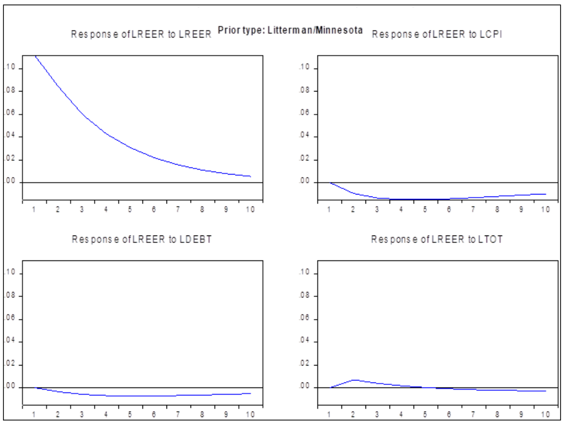


Figure 3: Bayesian VAR impulse response

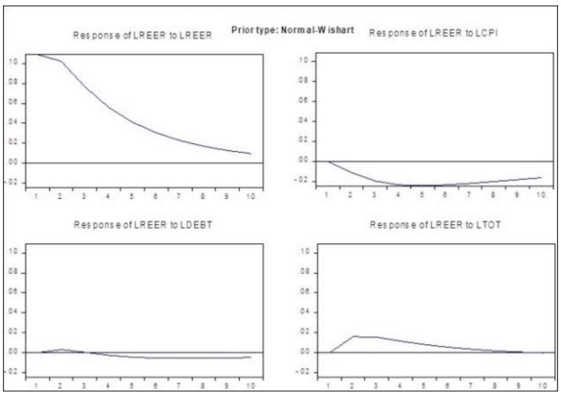


Figure 4: Bayesian VAR impulse response

Checking parameter stability with the BVAR model estimation for reliable inference, we computed the Bayesian Eigenvalue stability condition. The results are shown in table 9 below. According to the results, the 95% credible intervals neither have values that are equal to one or exceed one for individual eigenvalue moduli. This demonstrates the stability of estimated BVAR coefficients. Also, the posterior probabilities that all eigenvalues are within the unit circle are close to one. This demonstrates absence of instability in the model.

Table 9. Bayesian stability condition.

Eigenvalue modulus	Mean	Std. dev.	MCSE	Median	95% credible band	
1	0.99378	0.18885	0.00056	0.96178	0.91456	0.97347
2	0.82971	0.09378	0.00043	0.80235	0.94782	0.95712
3	0.27853	0.06891	0.00028	0.25910	0.72234	0.82503
4	0.16789	0.00230	0.000112	0.16239	0.06744	0.35761
Companion matrix size		4	MCMC sample size		11,000	
Pr(eigenvalues lie inside the unit circle) = 0.9999						

The non-linear ARDL model results are presented in Table 10. From Table 10 the long-run positive effect of an increase in inflation on the real ER is positive. A percentage rise in the price index leads to a lesser effect on the real ER. Though this impact is statistically insignificant which implied the impact of price increase might not be a key factor influencing the appreciation or depreciation of real ER in Africa. The negative change in the cpi has a significant impact on real ER. More specifically, a percentage decrease in the domestic price index leads to a decrease in real ER by 0.11 percentage points.

Tot and debt are significant determinants of movement in real ER. A percentage increase in tot leads to a lesser impact on real ER. Precisely, the real ER decreased by 0.04 percent. This is only significant at the 0.10 level. Debt negatively impacted the real effective exchange rate. A percentage increase in external debts led to a 0.02 percent decrease in real ER. In the short run, positive changes in cpi have a significant impact on real ER in Africa. An increase in the inflation rate led to a 0.26 increase in real ER. However, the previous positive increase in the price index negatively influenced the real effective exchange rate. The second lag of the negative change in inflation negatively impacted real ER.

Table 10: Nonlinear ARDL model

Dependent variable: D(lnreal ER)			
Long-run effect			
Variable	Coefficient	t-Statistic	Prob.*
C	1.342	7.423	0.000
lnifl_pos(-1)	0.739	3.195	0.010
lnifl_neg(-1)	-0.572	-2.369	0.020
lntot_pos(-1)	-0.145	-4.867	0.000
lntot_neg(-1)	1.052	3.292	0.010
lndebt_pos(-1)	0.939	2.435	0.020
lndebt_neg(-1)	-0.132	-19.246	0.000
Short-run effect			
Variable	Coefficient	t-Statistic	Prob.*
dlnifl_pos	0.263	4.540	0.000
dlnifl_pos(-1)	0.191	3.402	0.000
dlnifl_neg(-1)	-0.117	-11.890	0.000
dlntot_pos(-1)	-0.136	-2.927	0.000
dlntot_neg(-1)	1.215	5.869	0.000
dlndebt_pos(-1)	1.019	2.773	0.010
dlndebt_neg(-1)	-0.394	-23.654	0.000
F-statistic	13.327		
Prob(F-statistic)	0.000		
Durbin-Watson stat	2.056		
ARCH Test:			
F-stat	11.97	Prob. F(2,375)	0.00
Obs*R-squared	5.84	Prob. Chi-Square(2)	0.00
BGSC LM Test:			
F-stat	0.29	Prob. F(2,401)	0.569
Obs*R-sq	1.68	Prob. Chi-Square(2)	4.10

Regarding the diagnostic results of table 11, we accept the hypothesis of no serial correlation at a 0.05 significance level. However, the heteroscedasticity test indicates the rejection of the null hypothesis of no ARCH term in the estimated model residuals. Tables 8 and 9 report asymmetric test results for determinants of real effective exchange rate based on the Wald test statistic. Where Table 8 contains Wald test results for the long-run estimates, table 10 contains the results for short-run coefficients. With significant chi-square values of 12.345, 19.053, and 30.124, a positive and negative shock to terms of trade produces asymmetric responses of the inflation rate, terms of trade, and foreign debt on real ER is validated in the study. Similar results were found for the short-run test for asymmetry. These asymmetric results further corroborate the nonlinear ARDL estimates of table 10. More precisely, positive changes in the inflation rate led to 0.26% and 0.74% devaluation of real ER in SR and LR separately. Nevertheless, the negative shock in the inflation-induced a 0.12% and 0.57% appreciation impact on the current real ER respectively. Our finding contradicts the findings of Carissa & Khoirudin (2020) where it was documented that inflation contributed insignificantly in exchange rate of the Indonesian currency. Going forward, a country with a lower inflation rate is faced with currency appreciation while those with a high rate of domestic inflation experience currency depreciation compared to the currencies of other trading countries.

Positive and negative shocks to terms of trade produce 0.15% and 1.05% appreciation and devaluation in the real ER in the long-term period. Accordingly, in the short-term, positive and negative shocks to terms of trade stimulate about 0.14% appreciation and 1.2% devaluation in the real ER respectively. In sum, the terms-of-trade depreciation effect is an indication of more supplies of domestic currency than foreign person demand for domestic goods. This results in a trade deficit in the current account which could imply that most of the emerging countries are borrowing capital from foreign sources or the country is spending more on foreign trade than it is receiving. The superfluous demand for foreign currency lowers the exchange rate of the domestic currency pending when foreign assets become costly to cause sales for domestic interests. The results are in support of the findings obtained for Bangladesh by Shaikh & Roushanara (2023) where it was documented that trade balance contributed significantly and positively to the determination of exchange rate movement. Also, a positive change in foreign debt brings about 0.94% devaluation and 1% devaluation of real ER in the short and long-term periods respectively. A negative shock to the external debt level induced 0.13% and 0.39% appreciation in real ER respectively in both long and short-term periods. The findings of this paper are supported by the findings obtained by Nwanne & Eze (2015) Kim et al. (2020), Kumar et al. (2019), Taghizadeh-Hesary et al. (2021), and Marwa (2021). Kim et al. (2020) established a negative impact of foreign debt on the exchange rate for Multinational enterprises vs. exporting firms. Nwanne & Eze (2015) reported a positive and considerable effect of debt on the real exchange rate of Nigeria vis-vis the US dollar. Kumar et al. (2019) also obtained a positive effect of debt on the exchange rate in Pakistan. To Taghizadeh-Hesary et al. (2021), the accumulation of foreign debt was the major factor responsible for the misalignments in real ER of countries in Africa. Marwa (2021) noted the significant role played by foreign debt in the build-up of reserves in Indonesia. In sum, a shock to inflation, terms o trade, and foreign debt produces both long-run and short-run asymmetric responses on real ER.

Table 11: Long-run results of the asymmetric effect

LR results for lnifl			
Test	Value	df	Prob.
F-sta	10.101	(2, 403)	0.000
Chi-sq (Wald)	12.345	1.00	0.000
LR results for lntot			
Test	Value	df	Prob.
F-sta	9.208	(2, 403)	0.000
Chi-sq (Wald)	19.053	1.00	0.000
LR results for lndebt			
Test	Value	df	Prob.
F-sta	18.021	(2, 403)	0.000
Chi-sq (Wald)	30.124	1.00	0.000

Table 12: Short-run results of the asymmetric effect

SR results for lnifl			
Test	Value	df	Prob.
F-sta	17.65	(2, 403)	0.000
Chi-sq (Wald)	25.65	1.00	0.000
SR results for lntot			
Test	Value	df	Prob.
F-sta	24.16	(2, 403)	0.000
Chi-sq (Wald)	48.25	1.00	0.000
SR results for lndebt			
Test	Value	df	Prob.
F-sta	16.57	(2, 403)	0.000
Chi-sq (Wald)	29.85	1.00	0.000

The CUSUM and CUSUM of squares charts reveal that coefficients were stable within the 95% confidence interval.

Figure 5A. Stability plots

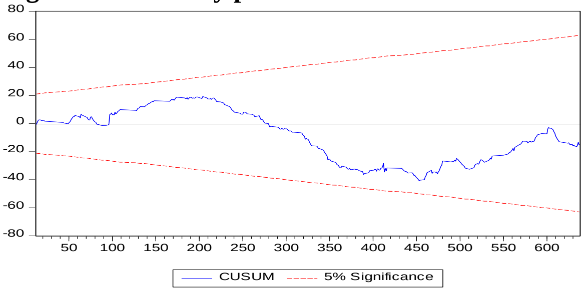
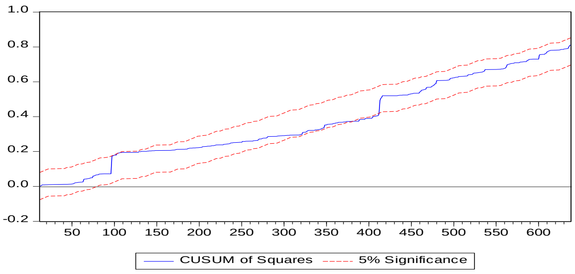


Figure 5B. Stability plots



5. Conclusion

The paper investigates the factors answerable for the movements in the real effective exchange rates in Africa using the Bayesian VAR and non-linear ARDL techniques. Positive consumer price shock causes a real effective exchange rate to depreciate while a negative shockwave to inflation engenders an appreciation of the real ER in Africa. The initial response of real ER is sensitive to the type of prior adopted. Similarly, a positive shockwave to external debt had a positive impact on real ER throughout the horizon. This indicates persistent depreciation of real ER. No wonder it has been reported that most governments of emerging countries are more and more resorting to domestic and non-concessional foreign debt, which attracted huge interest rates (Owusu-Nantwi & Owusu-Nantwi, 2021, Rothenberg, Chappe, & Feldman, 2021, Ndulu & O'Connell, 2021). Kavila (2022) and Depetris-Chauvin (2022) noted that some countries especially in Africa are overwhelmed with liquidity constraints and debt overhang and liquidity.

On the contrary, a decreasing shockwave to foreign debt leads to an appreciation of the real rate. Positive and negative shocks to terms of trade produce asymmetric responses of real ER appreciation and devaluation respectively. Quantitatively, we found 1.052% and 1.215% devaluation effects of negative tot at both periods of analysis. Relatively, the paper obtains 0.94% and 1% devaluation of rising foreign debt levels at short and long-term periods respectively. The response of real ER is insensitive to the prior method adopted. Going by the findings of this study, unfavorable trade balance and rising foreign debt levels produce a major adverse impact on the real ER in Africa. Such an impact is devaluation. There is a need for the effective execution of inflation targeting as a way to enhance the competitiveness of African countries. This study also recommends proper management of external debt as a way to enhance real improvement in the competitiveness of African countries. The importance of this research lies on the ground that exchange rate dynamics cannot be determined independently of macroeconomic factors. The limitation of the present study is that it investigated the effects of only three macroeconomic factors that could be responsible for exchange rate movements. Further studies should include, other variables, namely, differentials in inflation (rather than the level of inflation), differentials in interest rates, current account deficits (rather than terms of trade balance), and an indicator of economic performance (GDP). These would enhance the findings regarding the causative factors of exchange rate movements.

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