Asymmetric Impact of Real Effective Exchange Rate Shocks on Economic Growth in Africa: Evidence From Symmetric and Asymmetric Panel ARDL-PMG Model

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This paper examines the effects of the real effective exchange rate on economic growth in 11 African countries from 1990 to 2022 using linear and nonlinear panel ARDL estimators. The linear panel ARDL-PMG results indicate that broad money supply and general government consumption positively impact economic growth in the short and long term, while the real effective exchange rate has an insignificant effect. The negative and statistically significant error correction term (ECTt-1) suggests a long-term relationship between the variables. Similarly, the nonlinear panel ARDL-PMG results show that broad money supply and general government consumption have positive and significant effects on economic growth in both the short and long term. Negative shocks in the real effective exchange rate hinder economic growth in the short and long term, while positive shocks do not significantly affect economic growth. The paper discusses the policy implications of these findings.

Keywords: asymmetric, ARDL-PMG, economic growth, monetary policy, broad money supply

INTRODUCTION

Monetary authorities of different countries, especially those in Africa, face challenges resulting from real effective exchange rate fluctuations. These challenges are not only unique to the African economies but can be viewed as a global phenomenon. However, its prevalence is more profound in the African continent and context. Also, while several empirical economic studies on real effective exchange rate fluctuations have focused on advanced economies, few have been devoted to developing economies, including most African countries. These observations have therefore prompted this study and selection of these African countries- Benin, Botswana, Burkina Faso, Kenya, Madagascar, Mali, Niger, Rwanda, Senegal, South Africa, Togo, and Uganda for that purpose. Faced with serious challenges resulting from real effective exchange rate fluctuations, the International Monetary Funds (IMF) has continued to advise these African countries to devalue their currencies to boost export competitiveness and increase economic growth. Their contention and advice are informed by several economic literature stating that currency depreciation promotes an increase in domestic aggregate demand and economic growth.

Furthermore, they argue that currency devaluation makes domestically produced goods cheaper than imported ones. Consequently, exports increase, and imports in turn decline. Increases in exports boost aggregate demand and domestic output. In this case, currency depreciations are said to be expansionary and can help boost economic growth.

However, the expansionary view of currency devaluation is not generally accepted in the extent literature. Following the seminal work of Alexander (1952), a number of researchers have sought to show that currency devaluation has instead a contractionary effect on economic growth. The contractionary view popularized advanced by Alexander (1952) posits that currency devaluation is inflationary and thus negates aggregate supply due to increased imported inputs' prices. As the cost of production surges due to increases in input prices, domestic goods and services prices will rise, leading to redistribution of income from the workers to the producers. Given that the producers tend to have lower marginal propensity to consume than the workers, it then follows that the redistribution of income will negate total consumption, leading to decreases in aggregate demand and, hence domestic output declines.

Several empirical studies have also concluded that currency devaluation is contractionary rather than expansionary. These studies further show that a currency depreciation will have a negative or positive economic growth contrary to the previous expansionary conclusion. This is to say that the response of domestic output to a change in the exchange rate could be symmetric or asymmetric. The relationship between the real effective exchange rate and domestic output is symmetric if a 1 percent depreciation in the local currency causes the domestic output to expand by precisely 1 percent. Similarly, a 1 percent appreciation in the local currency will decrease domestic output by exactly 1 percentage point. Conversely, these scenarios may not necessarily hold in most cases as recent empirical studies have shown that the relationship between the real effective exchange rate and domestic output is asymmetric. Asymmetries refer to circumstances where domestic output will respond differently to positive and negative real effective exchange rate changes. It then follows that currency appreciation can lead to either domestic output expansion or contraction. Alternatively, currency depreciation can lead to either domestic output contraction or expansion. The argument is that real effective exchange rate fluctuations certainly affect a country's export and import prices. The degree of the exchange rate pass-through, which is the responsiveness of import or export prices to a one percent change in the exchange rate of the importing nation's currency, could be empirically determined accurately depending on the econometrics models utilized.

Previous studies on the relation of the real effective exchange rate to economic growth focused mainly on OECD and Asian countries. However, studies on African countries in this context are sparse. Most of the earlier studies used models that assumed the relationship between the real effective exchange rate and economic growth is linear. However, recent studies, including Iqbal, et al. (2022), Bahmani-Oskooee and Arize (2020), and Eroğlu and Olayiwola (2023) have shown that the relationship between the real effective exchange rate and national output is better modeled in a nonlinear fashion. The present study contributes to the debate on the impact of the real effective exchange rate on economic growth by employing the nonlinear panel ARDL-PMG estimator proposed by Shin et al (2014). The model is attractive because it accounts for both asymmetry and heterogeneity that might be present in the panel. Nonlinearity or asymmetry in this study is established by decomposing the real effective exchange rate into positive changes (appreciation) and negative changes (depreciation). The diverse nature of the sample countries justifies the application of the nonlinear panel ARDL-PMG estimator. For instance, the sample countries are not at the same stage of economic development. As such, the macroeconomic dynamics that govern the relationship between the two variables will be unarguably different. It is therefore, imperative to adopt an econometric model that can account for both asymmetry and heterogeneity.

The findings of this study provide evidence of an asymmetric relationship between the real effective exchange rate and economic growth. Specifically, the study establishes that deprecation in the real effective exchange rate has a contractionary impact on economic growth in both the short- and long-run. However, appreciation in the real effective exchange rate has a statistically insignificant impact on economic growth in both the short and long run. The control variables namely broad money supply and general government consumption, exert positive and statistical impact on economic growth in both the short- and long-run.

The paper is organized as follows. Following the presentation, section 2 provides the literature review. Section 3 discusses the methodology. Section 4 presents the data and the description. Section 5 discusses the empirical results. Section 6 offers the summary and the policy implications of the study.

LITERATURE REVIEW

Studies on the relationship between the real effective exchange and output have produced mixed results in the extent of literature. For instance, Christopoulos (2004) studied the impact of changes in the real effective exchange rates for 11 Asian economies. He finds that currency depreciations have an expansionary effect on output for Indonesia, Myanmar, and the Philippines. However, for India, South Korea, Nepal, Pakistan, and Singapore he finds that currency depreciations have contractionary impact on output. Miteza (2006) using panel data approach explored the effect of changes in real effective exchange rates for Poland, Hungary, the Czech Republic, Slovakia, and Romania. He finds for these countries that currency depreciations are contractionary. Kalyoncu, et al. (2008) investigated the effect of currency depreciations on output for 23 OECD countries. They find that currency devaluation significantly negatively affects output for Australia, Hungary, Poland, Portugal, Switzerland, and Turkey. For Finland, Germany, and Sweden they find that currency depreciation has a significantly positive influence on output.

Bahmani-Oskooee and Arize (2020), using the NARDL model, examined the asymmetric influence of real effective exchange rate changes on domestic production for 13 African countries. They find that movements in the exchange rate have short-run and long-run asymmetric impact on domestic production in most sample countries. In some sample countries, they find that depreciation is expansionary while appreciation does not affect domestic production. They further find that appreciation negates domestic production for some of the sample countries while a depreciation exerts no impact. Iqbal, *et al*. (2022) using the nonlinear ARDL model and data from 1980 to 2019 for South Asian countries, explored the impact of exchange rate changes on domestic production. They decomposed the exchange rate into depreciation and appreciation to introduce nonlinearity into the adjustment process. They find that exchange rate changes significantly impact domestic production for the South Asian economies under study. In short, they find depreciation boosts economic growth while appreciation on the other hand negates economic growth for the majority of the sample countries.

Eroğlu and Olayiwola (2023) examined the effect of the exchange rate on Nigeria's economic growth using the nonlinear ARDL model. They decomposed the effect of the exchange rate on economic growth into positive and negative components. They find that depreciation in the naira exchange rate hampers economic growth in the short run. However, exchange rate appreciation promotes economic growth. They further find that in the long run, appreciation of the naira boosts economic growth while depreciation of the naira is detrimental to economic growth in Nigeria. These effects work in the opposite direction. Based on the results from their study, they concluded that the relationship between exchange rate and economic growth in Nigeria should be modeled asymmetrically. Tharakan (1999) investigates the relationship between exchange uncertainty and economic growth for 21 OECD countries using panel regressions. He finds that exchange rate uncertainty significantly negatively affects long-term growth. Thi Pham, *et al*. (2020) explore the effect of an effective multilateral exchange rate on the economic growth rate of 5 ASEAN countries, namely Vietnam, Indonesia, Singapore, Philippines, and Malaysia, from 1989 to 2018. Specifically, they used the Prais-Winsten (PCSE) estimator to mitigate the problems of heteroskedasticity and autocorrelation present in the panel. They find that an appreciation in the effective exchange rate promotes economic growth for the five sample countries.

Bahmani-Oskooee and Mohammadian (2017) using the nonlinear ARDL technique, examined the asymmetric impact of the real effective exchange rate on Japanese domestic production. They contended that most earlier studies did not find a significant relationship between Japan's real exchange rate and domestic production in the long run because they assumed that the association between the two variables is symmetric. However, after accounting for asymmetry using the nonlinear ARDL approach, they find that changes in exchange rate have statistically significant influence on the Japanese domestic production in both short and long run. Specifically, they found that an appreciation of the exchange rate hampers domestic production in the long run, while depreciation is inconsequential.

Rhodd (1993) explored whether exchange rate changes have an expansionary or contractionary effect on output in Jamaica utilizing a three-market Keynesian model. He finds that in Jamaica, a devaluation of the currency is contractionary in the short run and expansionary in the long run. Bahmani-Oskooee and Kutan (2008) examined the effect of depreciation in the real effective exchange rates on domestic output for seven emerging countries of the European Union including Belarus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Russia, and Slovak Republic. They implemented the bounds testing techniques to cointegration and the error correction framework, allowing them to explore both the short-run and long-run effects of depreciation in real effective exchange rates on domestic production for the sample countries. They find that in the short run, real depreciation is expansionary in Belarus, Latvia, Poland, and Slovak Republic; contractionary in Czech Republic, Estonia, Hungary, and Russia; and has no effect in Lithuania.

Bahmani-Oskooee and Gelan (2013) using the VECM examined the relation of the real effective exchange rate to domestic output for 22 African countries for the period running from 1971 to 2009. They find for Cote d'lvoire, Ethiopia, Gabon, Kenya, Morocco, Niger, Nigeria, and Togo that currency depreciations are expansionary. For these countries, the regression coefficients on the real effective exchange rate are negatively significant at the conventional levels. However, Algeria, Mauritius, Rwanda, Tanzania, and Tunisia find that exchange rate depreciations are contractionary, given that the regression coefficients on the real effective exchange rate are positively significant. For the rest of the countries, they find that the real effective exchange rate has an insignificant effect on domestic output. Bahmani-Oskooee and Mohammadian (2016) examined whether the effect of the real effective exchange rate on domestic production is symmetric or asymmetric using the nonlinear ARDL estimator proposed by Shin, *et al*. (2014). In short, they utilized the concept of partial sum and separated appreciations from depreciations to test whether the effects are symmetric or asymmetric. They find that movements in the real effective exchange rate of the Australian dollar have asymmetric effects on domestic production in both the short and long run. Specifically, they find that both appreciations and depreciations in the real effective exchange rate affect domestic production in Australia. However, only the appreciation of the real effective exchange rate significantly affected Australian domestic production in the long run.

METHODOLOGY

Cross-Sectional Dependence Tests

In implementing a panel data study, it is important to check for cross-sectional dependence. To this effect, the study implements the cross-sectional dependence (CD) test proposed by Pesaran (2004). The CD test is calculated as follows:

$$CD = \sqrt{2T / N(N-1)} \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \left(T\hat{p}_{ij}^{2} - 1\right) \tag{1}$$

The null hypothesis of the various CD procedures discussed in this study is that there is no cross-sectional dependence among the panel members. For robustness, the study will also implement the bias-adjusted LM cross-sectional dependence procedure advanced by Pesaran, *et al*. (2008). The expression for the bias-adjusted LM test given by:

$$LM_{adj} = \sqrt{2 / N(N-1)} \sum_{t=1}^{N-1} \sum_{j=i+1}^{N} (\hat{p}_{ij}) \frac{(T-k-1)\hat{p}_{ij}^{2} - \mu_{Tij}}{v_{Tij}} \tag{2}$$

In equation (2), μ_{Tij} and ν_{Tij} denote the mean and variance of $(T-k-1)\hat{p}_{ij}^2$. The null hypothesis for the bias-adjusted LM test is that there is no cross-sectional dependence among the panel members. The null hypothesis is rejected if the test statistic exceeds the critical value at the conventional levels.

Slope Homogeneity

To check for slope homogeneity in the panel, the study uses the delta ($\tilde{\Delta}$) and delta adjusted ($\tilde{\Delta}$adj) procedures proposed by Pesaran and Yamagata (2008). The slope homogeneity tests are given as follows:

$$\tilde{\Delta}= \sqrt{N}\left(\frac{N^{-1}\tilde{S}-k}{\sqrt{2k}}\right) \tag{3}$$

$$\tilde{\Delta}_{adj}= \sqrt{N}\left(\frac{N^{-1}\tilde{S}-E(\tilde{z}_{it})}{\sqrt{var(\tilde{z}_{it})}}\right) \tag{4}$$

where the mean $E(\tilde{z}_{it})$ = k and the variance $var(\tilde{z}_{it})$ = 2k(T-k-1)/(T+1).

To check for stationarity, the study implements both the cross-sectional ADF (CADF) and the cross-sectional augmented Im-Pesaran-Shin (CIPS) panel unit root tests. The CIPS panel unit root test developed by Pesaran (2007) accounts for panel cross sectional dependence. The CADF procedure is based on the following equation:

$$\Delta y_{i,t} = \emptyset_i + \rho_{i,}y_{i,t-1} + \delta_{0,}\bar{y}_{t-1} + \sum_{j=0}^{p}\delta_{i,j}\,\Delta y_{i,j} + \sum_{j=1}^{p}\Theta_{i,j}\,\Delta y_{i,j} + \varepsilon_{i,t} \tag{5}$$

where Δ is the first difference operator, y denotes the variable of interest. $\emptyset_i$, $\rho_{i,}$, $\delta_{0,}$ $\delta_{i,}$ *and* $\Theta_{i,j}$ represent the slope coefficients obtained from the ADF test for country i, $\bar{y}_{t-1}$ denotes the mean, and $\varepsilon_{i,t}$ stand for the error terms. The CIPS test statistic is computed from equation (5) as follows:

$$CIPS = \frac{1}{N}\sum_{i=1}^{N} CADF \tag{6}$$

To avoid bias inferences that could arise in cases where T might not be large enough, Pesaran (2007) suggested applying the truncated version of the CIPS test. The calculation of the truncated CIPS is given by:

$$TR - CIPS = \frac{1}{N}\sum_{i=1}^{N} CADF_I^* \tag{7}$$

Both the CIPS and the truncated CIPS are attractive because they account for cross-sectional dependence that might be present in panels.

The Symmetric Panel ARDL

This study's empirical analysis commences with applying the symmetric panel ARDL approach following Pesaran, *et at* (1996, 2001). The symmetric framework is based on the following equation:

$$\Delta EG_{(i,t)} = \beta_{0i} + \beta_1 EG_{it} + \beta_2 GCG_{it} + \beta_3 M2G_{i,t} + \beta_4 LRER_{i,t} + \sum_{j=1}^{N1}\Delta EG_{i,t-j} + \sum_{j=1}^{N2}\Delta GCG_{i,t-j} + \sum_{j=1}^{N3}\Delta M2G_{i,t-j} + \sum_{j=1}^{N4}\Delta LRER_{i,t-j} + \delta_t + \varepsilon_{i,t} \tag{8}$$

where, Δ is the first difference operator, EG represents economic growth rate, GCG depicts growth of final government consumption, M2G stands for growth rate of broad money supply, LRER is the natural logarithm of real effective exchange rate, δ_t denotes the group-specific effect, and $\varepsilon_{i,t}$ portrays the error term. The Akaike Information Criterion (AIC) determines the appropriate lag lengths.

Pesaran, *et al* (1996, 2001) panel ARDL approach allows for long run relationship between variables in the model to be examined without the requirement of cointegration between the variables in the model. Against this backdrop, it is possible under the Pesaran, et al (1996, 2001) panel ARDL approach to explore both the short run and long dynamics between the variables in the model. In short, the panel ARDL approach does not require that the variables have the same order of integration. In order words, the panel ARDL approach can be applied whether the variables have the same or mixed order of integration, provided none is integrated of I(2).

In the spirit of Pesaran, *et at* (2001), equation (8) can be rewritten in error correction form as follows:

$$\Delta EG_{(i,t)} = \xi_i \vartheta_{i,t-1} + + \sum_{j=1}^{N1} \Delta EG_{i,t-j} + \sum_{j=1}^{N2} \Delta GCG_{i,t-j} + \sum_{j=1}^{N3} \Delta M2G_{i,t-j} + \sum_{j=1}^{N4} \Delta LRER_{i,t-j} + \delta_t + \varepsilon_{i,t} \quad (9)$$

where $\vartheta_{i,t-1}$ depicts the error correction term, ξ_i represents the speed of adjustment of the model to equilibrium. The speed of adjustment ξ_i is expected to be negative and statistically significant at the conventional levels. The error term is portrayed by $\varepsilon_{i,t}$ assumed to be independently and identically distributed. The variables remain as defined in equation (8).

The Asymmetric Panel ARDL

The study next implements the asymmetric version of the panel ARDL estimators to assess the nonlinear response of economic growth to positive and negative components of the real effective exchange rate. Consistent with Shin et al. (2014), the decomposition of the real effective exchange rate can be based on the following panel expressions:

$$LRER_{ij}^{+} = \sum_{j=1}^{l} \Delta LRER_{i,j}^{+} = \sum_{j=1}^{l} \max\left(\Delta LRER_{i,j}^{+}, 0\right) \quad (10)$$

$$LRER_{ij}^{-} = \sum_{j=1}^{l} \Delta LRER_{i,j}^{-} = \sum_{j=1}^{l} \min\left(\Delta LRER_{i,j}^{-}, 0\right) \quad (11)$$

To formulate the asymmetric panel ARDL estimators, the negative and positive components of the real effective exchange rate are incorporated into equation (8) as follows:

$$\Delta EG_{(i,t)} = \beta_{0i} + \beta_1 EG_{it} + \beta_2 GCG_{it} + \beta_3 M2G_{i,t} + \beta_4 LRER_{i,t} + \sum_{j=1}^{N1} \Delta EG_{i,t-j} + \sum_{j=1}^{N2} \Delta GCG_{i,t-j} + \sum_{j=1}^{N3} \Delta M2G_{i,t-j} + \sum_{j=1}^{N4} (\varphi_{ij}^{-} \Delta LRER_{i,t-j}^{-} + \varphi_{ij}^{+} \Delta LRER_{i,t-j}^{+}) + \delta_t + \varepsilon_{i,t} \quad (12)$$

Equation (12) can be rewritten in error correction form as follows:

$$\Delta EG_{(i,t)} = \varphi_i \lambda_{i,t-1} + \sum_{j=1}^{N1} \Delta EG_{i,t-j} + \sum_{j=1}^{N2} \Delta GCG_{i,t-j} + \sum_{j=1}^{N3} \Delta M2G_{i,t-j} + \sum_{j=1}^{N4} (\varphi_{ij}^{-} \Delta LRER_{i,t-j}^{-} + \varphi_{ij}^{+} \Delta LRER_{i,t-j}^{+}) + \delta_t + \varepsilon_{i,t} \quad (13)$$

In equation (13), the error correction term is represented by $\lambda_{i,t-1}$. The speed of adjustment is measured by φ_i. The speed of adjustment (φ_i) indicates the time it takes the system to revert to long run equilibrium in the event of an imbalance. The error term is expected to be negative and statistically significant with a value between 0 and -1. The variables remain as defined in equation (8).

Data and Descriptive Statistics

The data consists of annual observations on economic growth, real effective exchange rates, broad money supply growth rate of final government consumption. The sample comprises 11 African countries, namely Benin, Botswana, Burkina Faso, Kenya, Madagascar, Mali, Niger, Rwanda, Senegal, South Africa, Togo, and Uganda. Data availability was the main consideration in selecting the countries. The study period spans 1990 to 2022. Given that the economic growth, broad money supply, and government consumption variables were all expressed in growth terms, it was necessary to convert the real effective exchange rate variable to a natural logarithm to control for outliers and ensure consistency in the unit of measurement. The data on economic growth rate, growth rate of broad money supply, and growth rate of final government consumption were taken from the World Development Indicators published by the World Bank. On the other hand, the real effective exchange rate data were taken from the Bruegel Dataset published by Darvas (2021).

TABLE 1
DESCRIPTIVE STATISTICS

	GCG	EG	M2G	LRER
Mean	4.90	4.20	13.76	4.63
Maximum	82.56	35.22	72.39	5.09
Minimum	-60.86	-50.25	-21.31	3.99
Std. Dev.	10.88	4.89	12.93	0.16
Kurtosis	18.26	49.11	7.04	4.57
Jarque-Bera	3614.95^{***}	32874.06^{***}	343.51^{***}	38.91^{***}
Probability	0.00	0.00	0.00	0.00
Observations	363	363	363	363

*** denotes rejection of the normality assumption at the 1% level of significance. GCG = growth of final government consumption, EG = economic growth rate, M2G = Growth rate of broad money supply (M2) and LRER = natural logarithm of real effective exchange rate.

Table 1 furnishes the descriptive statistics for economic growth, growth rate of final government consumption, growth rate of broad money supply (M2), and the real effective exchange rate. The mean values are 4.90, 4.20, 13.76, and 4.63, respectively for growth rate of final government consumption, economic growth, the growth rate of broad money supply (M2), and real effective exchange rate. The minimum and maximum statistics reported in Table 1 show that the four variables in the study varied among the countries in the panel. For example, the growth rate of final government consumption varied from a minimum of 60.86 to a maximum of 82.56. The standard deviations are 10.88, 4.89, 12.93, and 0.16, respectively for growth rate of final government consumption, economic growth, the growth rate of broad money supply (M2), and real effective exchange rate. The reported Kurtosis statistics exceeded 3 in all the cases suggesting that the distributions of the four variables are heavy tailed. The Jarque-Bera statistics are statistically significant at the 1 percent level in all of the cases. The results from the Jarque-Bera test suggest that the null hypothesis that variables are normally distributed should be rejected.

Empirical Results

This section discusses the study's empirical results beginning with pre-tests including cross-sectional dependence test, panel unit root test, and slope homogeneity test. It also discusses two panel ARDL frameworks including the Pooled Mean Group (PMG) estimator advanced by Pesaran, et at (2001) and the Mean Group (MG) estimator postulated by Pesaran and Smith (1995). Blackburn and Frank (2007) highlight the basic difference between the MG and PMG techniques. According to them, the MG technique estimates N time-series regressions and averages their coefficients. On the other hand, the PMG estimator entails the amalgamation of pooling and averaging of coefficients. The Hausman procedure can be used to determine the most appropriate of the two techniques for a given panel data set.

Table 2 displays the results from the various cross-sectional dependence procedures. The results presented in panels A, C, and D suggest that the null hypothesis of no cross-sectional dependence should be rejected in economic growth cases, the real effective exchange rate and growth rate of broad money supply at the 1 percent significance level. For instance, the computed CD test statistics for economic growth from the Breusch-Pagan LM, Pesaran scaled LM, Bias-corrected scaled LM, and Pesaran CD procedures are 136.86, 7.81, 7.63, and 8.35, respectively. However, for government consumption, the results from the various CD tests failed to reject the null hypothesis at the conventional levels. Given the mixed results of the CD tests for the individual variables, the study applied the model-based CD tests. Panel E of Table 2 furnishes the results from the Breusch-Pagan LM, Pesaran scaled LM, Bias-corrected scaled LM, and Pesaran CD procedures for the entire model. The computed test statistics from the Breusch-Pagan LM, Pesaran scaled LM, Bias-corrected scaled LM, and Pesaran CD techniques are 144.52, 8.54, 5.74, and 5.22, respectively. These test statistics are statistically significant at the 1 percent level, implying that the null hypothesis of no homogeneity in the panel should be rejected. In all, the results in Panel E of Table 2 provide evidence of cross-sectional dependence in the panel.

TABLE 2
CROSS-SECTIONAL DEPENDENCE TEST RESULTS

Test	Statistic	Prob.
Panel A: Economic Growth (EG)		
Breusch-Pagan LM	136.86^{***}	0.00
Pesaran scaled LM	7.81^{***}	0.00
Bias-corrected scaled LM	7.63^{***}	0.00
Pesaran CD	8.35^{***}	0.00
Panel B: Government Consumption (GCG)		
Breusch-Pagan LM	52.02	0.59
Pesaran scaled LM	-0.28	0.78
Bias-corrected scaled LM	-0.46	0.65
Pesaran CD	-1.34	0.18
Panel C: Real Effective Exchange Rate (LRER)		
Breusch-Pagan LM	505.98^{***}	0.00
Pesaran scaled LM	43.00^{***}	0.00
Bias-corrected scaled LM	42.83^{***}	0.00
Pesaran CD	4.50^{***}	0.00
Panel D: Broad Money Supply (M2G)		
Breusch-Pagan LM	98.19^{***}	0.00
Pesaran scaled LM	4.12^{***}	0.00
Bias-corrected scaled LM	3.95^{***}	0.00
Pesaran CD	3.26^{***}	0.00
Panel E: Model-Based CD Tests		
LM_{BP} (Breusch and Pagan 1980)	144.52^{***}	0.00
CDlm (Pesaran 2004)	8.54^{***}	0.00
CD (Pesaran 2004)	5.74^{***}	0.00
Bias-adjusted CD test	5.22^{***}	0.00

*** Denotes rejection of the null hypothesis of no cross-sectional dependence at the 1% level.

Based on the finding of the presence of cross-sectional dependence in the panel, the study used both the CADF and CIPS panel unit root tests. Table 3 displays the panel unit root test results. The results from CADF, CIPS, and TR-CIPS panel unit root procedures show that economic growth (EG), government consumption (GCG), and broad money supply (M2G) are level stationary [i.e., I(o)]. The null hypothesis of a unit root is rejected given that the test statistics are statistically significant at the 1 percent level. The results show that the real effective exchange is stationary after first differencing [i.e., I(1)]. These results show that EG, GCG, and M2G have zero order of integration while LRER has one order of integration. Above all, none of the test results show that the four variables in the study exhibit a second order of integration [i.e., I(2)]. In short, applying the ARDL–PMG model does not require that all the variables have the same order of integration. The findings that the variables have mixed order of integration - I(1) and I(0), justify this study's adoption of the ARDL- PMG model.

TABLE 3
PANEL UNIT ROOT TEST RESULTS

	EG		GCG		M2G		LRER	
Method	*Statistic*	*P-value*	*Statistic*	*P-value*	*Statistic*	*P-value*	*Statistic*	*P-value*
Panel A: *CADF*								
Level	-2.46***	0.00	-2.95***	0.00	-2.95***	0.00	-1.58	0.75
First Difference	-4.49***	0.00	-4.54***	0.00	-3.98***	0.00	-2.51***	0.00
Panel B: *CIPS*								
Level	-2.56***	0.00	-4.41***	0.00	-3.11***	0.00	-2.09	0.12
First Difference	-4.51***	0.00	-3.32***	0.00	-4.13***	0.00	-2.76***	0.00
Panel C: Adjusted *CIPS (TR-CIPS)*								
Level	-2.56***	0.00	-3.60***	0.00	-3.12***	0.00	-1.58	0.13
First Difference	-4.33***	0.00	-3.27***	0.00	-3.99***	0.00	-2.51***	0.00

*** indicates rejection of the null hypothesis of a unit root process at the 1% level. The 1%, 5%, and 10% critical values for the CADF test are -2.44, -2.25, and -2.14, respectively. The 1%, 5%, and 10% critical values for both the CIPS and the truncated CIPS tests are -3.07, -2.84, and -2.72, respectively. The various lag lengths were determined by the Akaike Information Criterion (AIC).

Prior to implementing the panel ARDL model, the study tests for slope homogeneity using the procedures advanced by Pesaran and Yamagata (2008). The results from the delta ($\breve{\Delta}$) and delta-adjusted ($\breve{\Delta}$adj) slope homogeneity tests are presented in Table 7. The test statistics are 2.48 and 2.69, respectively for$\breve{\Delta}$ and $\breve{\Delta}$adj tests. The test statistics are all statistically significant at the 1 percent level. The result from the Swamy (1970) procedure collaborates the results from both for$\breve{\Delta}$ and $\breve{\Delta}$adj tests. In a nutshell, these results imply that the alternative hypothesis of slope heterogeneity across the panel is to be accepted.

TABLE 4
SLOPE HOMOGENEITY TEST RESULTS

Test	Statistic	*P*-value
$\tilde{\Delta}$	2.48***	0.00
$\tilde{\Delta}_{adj}$	2.69***	0.00
$\tilde{S}$ (Swamy 1970)	128.27***	0.00

*** denotes rejection of the null hypothesis of slope homogeneity at the 1% level.

Linear ARDL-PMG Estimation Results

The study next applies the linear versions of the MG and PMG models. The Hausman procedure was used to determine whether the MG or PMG is the most appropriate for the study. The rejection of the null hypothesis of the Hausman test indicates that the MG estimator should be preferred over the PMG estimator. On the other hand, failure to reject the null hypothesis suggests that the PMG estimator should be preferred over the MG approach. The Hausman test statistic reported in Table 5 is -4.06. Although the sign of the Hausman test statistic is negative, Schreiber (2008) suggests that the absolute value of the test statistic should be used in such a case. Besides, Pesaran, *et al*. (1999) have shown that the PMG model tends to produce unbiased estimates in the presence of heterogeneity in the panel. To this effect, the study fails to reject the null hypothesis and adopts the PMG model as the efficient estimator.

The results from the linear PMG estimator are displayed in Table 5. The regression coefficient (-0.99) on the error correction term (ECT_{t-1}) reported in Panel A of Table 5 is negative and statistically significant at the 1% level. This result suggests that disequilibrium in the model from the short- to long-run is corrected by roughly 99 percent annually. It can be observed from Panel A of Table 5 that broad money supply and government spending have positive and significant effects on economic growth in the short run. The regression coefficients on ΔM2G(-1) (0.04) and ΔGCG(-1) (0.10) are positive and statistically significant at the 5 and 1 percent levels, respectively. However, the real effective exchange rate has a negatively significant effect on economic growth. This result implies that in the short run, an increase in the real effective exchange rate retards economic growth. The long-run estimates are presented in Panel B of Table 5. Again, it can be observed from the results that broad money supply and government spending have positive and significant effects on economic growth in the long run. The regression coefficients on M2G (0.04) and GCG (0.08) are positive and statistically significant at the 1 percent level. The real effective exchange rate has an insignificant effect on economic growth in the long run.

TABLE 5
SYMMETRIC PANEL ARDL-PMG ESTIMATION RESULTS

	Coefficient	Std. err.	Statistic	P-value	[95% conf. interval]	
Panel A: Short-Run Estimates						
ECT (-1)	-0.99^{***}	0.09	-11.60	0.00	-1.16	-0.82
ΔM2G(-1)	0.04^{**}	0.02	2.13	0.03	0.00	0.07
ΔGCG(-1)	0.10^{***}	0.02	4.47	0.00	0.06	0.14
ΔLRER(-1)	-5.97	4.56	-1.31	0.19	-14.91	2.98
CONSTANT	8.77^{***}	0.80	10.92	0.00	7.20	10.35
Panel B: Long-Run Estimates						
M2G	0.04^{***}	0.02	2.43	0.02	0.01	0.07
GCG	0.08^{***}	0.02	3.56	0.00	0.04	0.13
LRER	-1.21	1.20	-1.01	0.31	-3.56	1.14
Panel C: Diagnostic Tests						
			T-Statistic		*P*-value	
Hausman Test			-4.06		-	
Log Likelihood			-864.61		-	
Number of Observations			352		-	

***, **, and * denote level of significance at the 1%, 5%, and 10%, respectively.

Asymmetric Panel ARDL Estimation Results

In this section the study presents and discusses the nonlinear versions of the MG and PMG models to ascertain the positive and negative effects on economic growth. The Hausman procedure was used to determine whether the MG or PMG is the most appropriate for the study. The rejection of the null hypothesis of the Hausman test indicates that the MG estimator should be preferred over the PMG estimator. On the other hand, failure to reject the null hypothesis suggests that the PMG estimator should be preferred over the MG approach. The Hausman test statistic in Table 6 is 5.83 with a p-value of 0.21. This result indicates the null hypothesis should not be rejected; hence, the PMG model was selected as the efficient estimator.

The results from the nonlinear PMG model are presented in Table 6. The error correction term (ECT) reported in Panel A of Table 6 is negative and statistically significant at the 1% level. This result implies that when there is an imbalance in the system, the variables will revert to the long-run equilibrium at approximately 99 percent annually. From Panel A of Table 6, it can be seen that broad money supply and government spending have positive and significant effects on economic growth in the short run. The regression coefficients on ΔM2G(-1) (0.03) and ΔGCG(-1)(0.10) are positive and statistically at the 5 and

1 percent levels, respectively. These results imply that a percentage increase in broad money supply and government spending will increase economic growth by approximately 3 and 10 percent, respectively. Neither the positive nor the negative components of the real effective exchange rate significantly affect economic growth in the long run.

The long run estimates from the PMG estimator are presented in Panel B of Table 6. Once again, it can be observed that broad money supply and government spending have positive and significant effects on economic growth in the long run. The regression coefficients on M2G (0.04) and GCG (0.07) are positive and statistically significant at the 5 and 1 percent levels, respectively. These results imply that a percentage increase in broad money supply and government spending will increase economic growth by approximately 3 and 7 percent, respectively. The positive component of the real effective exchange rate exerts a significantly negative influence on economic growth in the long run. The regression coefficient on LRERPOS is negative and statistically significant at the 10 percent level. This result implies that a point increase in the real effective exchange rate negates economic growth by approximately 2.06 points in the long run. However, the results show that the negative component of the real effective exchange rate (LRERNEG) has an insignificant effect on economic growth in the long growth.

TABLE 6
ASYMMETRIC PANEL ARDL-PMG ESTIMATION RESULTS
(DEP. VARIABLE -ECON GROWTH)

Variable	Coefficient	Std. Error	Statistic	*P* -value	95% confidence interval	
Panel A: Short-Run Estimates						
ECT (-1)	-0.99***	0.09	-10.56	0.00	-1.17	-0.80
ΔM2G(-1)	0.03**	0.02	1.97	0.05	0.00	0.06
ΔGCG(-1)	0.10***	0.02	4.04	0.00	0.05	0.15
ΔLRERPOS(-1)	-6.22	5.89	-1.06	0.29	-17.76	5.32
ΔLRERNEG(-1)	-6.19	5.94	-1.04	0.30	-17.83	5.46
CONSTANT	12.56***	1.23	10.23	0.00	10.15	14.96
Panel B: Long-Run Estimates						
M2G	0.04**	0.02	2.22	0.03	0.00	0.07
GCG	0.07***	0.02	3.13	0.00	0.03	0.12
LRERPOS	-2.06*	1.24	-1.66	0.10	-4.50	0.37
LRERNEG	-2.00	1.26	-1.59	0.11	-4.46	0.47
Panel C: Diagnostic Tests						
			T-Statistic		*P*-value	
Hausman Test			5.83		0.21	
Log Likelihood			-859.76		-	
Long run asymmetry Chi-square (χ^2) test			0.46		0.50	
Short run asymmetry Chi-square (χ^2) test			0.23		0.63	
Number of Observations			352		-	

***, **, and * denote level of significance at the 1%, 5%, and 10%, respectively.

Summary and Policy Implications

This paper explores the symmetric and asymmetric effects of the real effective exchange rate on economic growth for a panel of 11 African countries namely-Benin, Botswana, Burkina Faso, Kenya, Madagascar, Mali, Niger, Rwanda, Senegal, South Africa, Togo, and Uganda for the period running from 1990 to 2022. In particular, the study used both linear panel ARDL and nonlinear panel ARDL-PMG estimators. The study adopted the PMG model because it produces unbiased estimates, accounting for nonlinearity, heterogeneity, and nonstationarity. In addition, the panel ARDL-PMG estimator allows the researcher to assess both the short run and long run effects of the independent variables on the dependent variable.

The study finds from the linear panel ARDL-PMG estimator that broad money supply and general government consumption have positive and significant effects on economic growth in both the short run and long run. However, the real effective exchange rate has an insignificant influence on economic growth in both the short run and long run. Similarly, the results from the nonlinear panel ARDL-PMG estimator uncover that broad money supply and general government consumption have positive and significant effects on economic growth in the short and long run. The results suggest that negative shocks in the real effective exchange rate negate short-term and long-term economic growth. Nevertheless, positive shocks in the real effective exchange rate play an insignificant role in fostering economic growth in both the short run and long run. The results of this study stress the importance of accounting for the existence of nonlinearity and heterogeneity in modelling the relationship between the real effective exchange rate and economic growth. The results show that the real effective exchange rate does not exert symmetric influence on economic growth. However, the study provides evidence that the real effective exchange rate has asymmetric effect on economic growth after decomposition into positive and negative components.

From policy perspectives, the authorities should be cognizant of the asymmetric relationship between the real effective exchange rate and economic growth in formulating and implementing exchange rate policies. Such an understanding will enable them to adjust trade policies to promote exports and discourage imports, leading to an improvement in the trade balance and boosting economic growth. It is also imperative for the Central banks of the sample countries to play active roles in stabilizing their currencies to alleviate the adverse effect of the real effective exchange rate economic growth. These banks can achieve this either using foreign exchange reserves or implementing monetary policies. Furthermore, the authorities should ensure macroeconomic stability by formulating sensible fiscal and monetary policies to instill confidence among investors and businesses. It is also recommended that social safety nets be put in place to mitigate the potential negative impact on vulnerable segments of the population that could result during economic challenges due to exchange rate misalignment.

Future research on the relationship between economic growth and the real effective exchange rate can be conducted by including additional control variables such as trade openness, capital formation, and terms of trade. Depending on the availability of consistent data, it would also be interesting and informative to expand the sample by including more countries in the future.

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