**Measuring Non-linear Effects of Currency Devaluation and Exchange Rate Movements on Reserve Holdings in Africa**

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**Abstract**

*This study examines the impact of exchange rate devaluation and exchange rate movement on the volume reserves in ten African economies which are Nigeria, Morocco, Ghana, Kenya, Malawi, Mauritius, Egypt, Namibia, South Africa and Zambia from 2002M06 to 2021M12. This study adopts non-linear Autoregressive Distributed Lag (NARDL) model. The findings showed there is an asymmetric co-integrating relationship between exchange rate movements and reserves holdings in Egypt, Ghana, Kenya, Malawi, Mauritius, Morocco, Nigeria and South Africa. The findings also indicate the presence of short-run relationship exist in Egypt, Kenya and Malawi. In addition, the long-run asymmetric relationship also exists in Egypt, Ghana, Kenya, Malawi, Mauritius, Morocco, Nigeria and South Africa. The NARDL model estimates indicate Exchange rate devaluation/depreciation has a statistically significant impact on reserves in Egypt, Ghana, Malawi and Mauritius, Morocco and South Africa. Exchange rate appreciation/revaluation leads to a statistically significant decrease in reserves only in Kenya and Malawi. The volatility index (VIX) has statistically significant effect only in Kenya, Nigeria and South Africa. An increase in VIX leads to 0.04 and 0.01 decrease in reserves for Nigeria and South Africa. A decrease in exchange rate leads to a statistically significant increase in reserves for all the countries except Nigeria. The long-run relationship indicates Ghana and South Africa external reserves decrease significantly due to exchange rate devaluation/depreciation. Kenya, Malawi and South Africa external reserves increases significantly due to exchange rate appreciation/revaluation. This study recommends the need for the policy makers in these countries to be cautions of the incessant devaluation in the case where it can transmit to increasing price instability and worsening inflation expectations.*

Key words: NARDL, currency devaluation, exchange rate movements, reserves, Africa countries

**INTRODUCTION**

Exchange rate volatility, described as persistent variations in currency values, has attracted much interest in the literature recently. Concerns about exchange rate swings have mostly emerged in emerging countries as a result of their influence on foreign trade, international commerce, investments, inflation, and economic prowess. Exchange rate changes may impact investment and economic development in a variety of ways. Based on the assumptions, the sign of the relationship might possibly vary. Since most global businesses are conducted in the currency of the exchange countries, several studies back up the theory that the rise in exchange rate volatility reduces transnational commercial flow and economic development.

The impact of forex rate changes on transnational business and business improvement is currently being contested due to these discrepancies. According to Demir (2013), the detrimental consequences of exchange rate risk present themselves in the following ways: Lower the price of credit from the financial sector through contraction impact on workers and business start-ups in nations at lower stages of financial growth, lower labour productivity with overall growth, reduce employment and by raising inflation unpredictability, harm the balance of payments and negatively affect growth by raising interest rates. Generally, due to flaws in fiscal and financial structures, currency rate changes has a bigger effect in emerging economies. The lack of financial protection tools and insufficient levels of financial market development leave African nations exposed to the detrimental consequences of rate of exchange volatility because unpredicted change and volatility in the rates of currency exchange should result in a detrimental impact on global trade cum economic development due to their effect on profitability.

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Asymmetric shocks have long been recognized as a beneficial technique for dealing with adjustable exchange rates. Shin and Pesaran (1999) pioneered the ARDL system, sometimes known as the Bounds test, Pesaran et al. developed it further (2001). It's widely regarded as one of the most adaptable methodologies for econometric study of the link between energy and growth, especially if the study contexts are altered by transitions in era and disturbances. The latter modify the forms of power usage or the development of components in power-growth models. Also, the capacity of the ARDL system to tolerate a variety of delays in various variables makes it extremely attractive, adaptive, and versatile. The ability to accommodate sufficient delays provides for the specification of the data-generating process approach. This indicates that the method may be applied regardless of whether the time series is I (0) (stationary at levels), I (1) (stationary at first differences), or fractionally integrated (Pesaran et al. 2001).

This study attempt to examine the asymmetric effect of exchange rate movements and currency devaluation on the volume of reserves held by African countries struggling to maintain enough earnings to warrant floating their currency against the dollar. The selected ten African economies based on data availability include, Egypt, Ghana, Kenya, Malawi, Mauritius, Morocco, Namibia, Nigeria, South Africa and Zambia. The remaining part of this research is broken down into four sections. Section 2 covers the review of literature. Variable definition, model specification, estimation procedure and data sources are discussed in Section 3. The results presentation and interpretation are exhibited in Section 4. Summary of findings, recommendation and conclusion are exhibited in Section 5.

**LITERATURE REVIEW**

The Marshall-Lerner (M-L) condition (Bahmani-Oskooee, 1991) relates to the long-run influence of the exchange rate on trade balance. Indeed, because trade balances take time to adjust under the influence of devaluation, short-run and long-run effects of exchange rates can be distinguished; and Magee (1973) coined the term J-curve effect to describe the situation in which devaluation can reduce trade balance in the short run but increase it in the long run (Bahmani-Oskooee & Mitra, 2010). Despite this, many studies provide insignificant results, with previous research pointing to two main causes: aggregate prejudice and linear assumption (Bahmani-Oskooee et al., 2016; Bahmani-Oskooee & Aftab, 2018; Iyke & Ho, 2018). One, while evaluating the impact of the real exchange rate on a country's trade account with the rest of the globe at the aggregate level may be quite valuable and give important information about a country's international commerce as a whole, the results may be skewed (Rose & Yellen, 1989; Bahmani-Oskooee & Brooks, 1999; Phong et al., 2018).

Researchers use data at the bilateral and commodity levels in trade between a nation and each of its partners to try to eliminate aggregation bias and find greater evidence of exchange rate implications on commercial balance account (Bahmani-Oskooee & Ratha, 2007; Bahmani- Oskooee & Hajilee, 2009). Also, while disaggregating data helps lessen aggregation bias, the linear assumption (that a 1% depreciation and a 1% appreciation of the home currency have the same effect on the trade balance) is another reason why a vast number of studies have failed to identify the effect.

In 2020, there was the EU-Vietnam FTA agreement while in 2021, the UK-Vietnam FTA agreement all emphasizing the significance of Vietnam's commerce with both the EU-27 and the UK. Furthermore, the aforementioned free trade agreements have a magnificent significance on Vietnam's economy integration with the countries involved. Furthermore, the fact that the United States designated Vietnam as a currency manipulator for the first time in December 2020 (Mohsin & McCormick, 2020) draws increased attention to Vietnam's forex management generally and the USD/VND exchange rate. With USD accounting for about 90% of Russia's total trade value, an adjustment in the USD/VND exchange rate affect trade balance with US of Russia, EU and UK. When the sum of price elasticities for exports and imports exceeds 1, the M-L condition states that a country's trade balance is positively influenced by currency depreciation (Bahmani et al 2013). It was established by Magee (1973) that such aforementioned influence might emerge after an amount of time when the balance of trade falls, and developed the term "J-curve" to characterize it. Since then, studies have been undertaken in different nations to understudy at the J-influence curve's as well as the link between exchange rate and trade balance, with mixed results (Umoru, 2012; Umoru 2013a; Umoru, 2013b; Umoru, 2013c; Umoru & Odjegba, 2013b; Umoru & Oseme, 2013a; Umoru & Eborieme, 2013a; Eborieme & Umoru, 2016; Ratha & Bahmani-Oskooee, 2004; Umoru & Okungbowa, 2016; Umoru & Tizhe, 2016; Umoru & Isedu, 2018; Phong 2019; Umoru, 2020).

Many of J-curve understudy assumes that exchange rate and the commercial trade have a symmetric relationship (Bahmani-Oskooee & Aftab, 2017). To investigate the J-curve phenomena, this collection of research used a variety of methodologies. Early articles on the relationship between currency exchange with import and export balance employed the natural logarithm of level variables, which had a non-stationarity issue (Rose & Yellen, 1989). The approach for assessing the J-curve effect by permitting certain delays in the exchange rate and then measuring the change of signs was initially introduced by Bahmani-Oskooee (1985). Rose & Yellen (1989) using Engle-Granger cointegration methodology found negative short-run exchange rate coefficients mixed with positive long-run coefficients in trade between the United States and Canada, France, Germany, Italy, Japan, and the United Kingdom.

Researchers can now distinguish the impact of local currency depreciation from appreciation following Shin et al. (2014)'s construction of the Nonlinear Autoregressive Distributed Lag framework. To Amoah & Ahiabor (2019) real effective exchange rate volatility has a negative and statistically significant impact on Ghana's economic development between 1980 to 2015. They also had consistent findings when they estimated models using standard control variables as well as a unique measure of financial market fragility. Hussain & Farooq (2009) examine the relationship between macroeconomic development and exchange rate fluctuations in Pakistan using an ARDL model. Except for exports and imports, growth, exchange rate volatility, reserves, and production have a long-term co-integration connection. In the distant future, it seems exchange rate volatility has a significant effect on domestic economic performance.

Aliyu (2010) examined the influence of forex fluctuation on Nigeria's non-oil exports from 1986 Q1 to 2006 Q4 using vector error correction and the VAR framework. The study revealed a long-run steady and negative association between Nigerian non-oil exports and Naira exchange rate variation. In the alternative, the result was beneficial for non-oil exports and US Dollar exchange rate volatility. Joseph (2011) used the GARCH model to analyse annual datasets on trade flows in Nigeria from 1970 to 2009. According to this study, exchange rate fluctuations and aggregate trade have a negative and statistically negligible association. The negative result utilizing annual time series datasets, alternatively, is in line with Aliyu's findings (2010).

Odili (2015) studied the correlation of real exchange rate variation and economic development on Nigerian imports and exports using yearly records from 1971 to 2012. Nigeria's commerce were primarily impacted by exchange rate real exchange rates, volatility, real foreign income, terms of trade, real gross domestic product, and exchange rate policy switch in both the near and distant future, according to the study. The data also show forex rate variation has a distant future detrimental impact on commercial flow and trade. To understudy the influence of real effective exchange rate volatility on economic development in Ghana, Amoah & Ahiabor (2019) utilize the fully adjusted OLS method with yearly periodical data from 1980 to 2015. According to regression studies, real effective exchange rate volatility has a negative and statistically significant impact on Ghana's economic development. They also had consistent findings when they estimated models using standard control variables as well as a unique measure of financial market fragility.

Hussain & Farooq (2009) examine the relationship between macroeconomic development and exchange rate fluctuations in Pakistan using an ARDL model. Except for exports and imports, growth, exchange rate volatility, reserves, and production have a long-term co-integration connection. In the distant future, it seems exchange rate volatility has a significant effect on domestic economic performance. There have been a variety of research that have tried to empirically analyze the correlation in exchange rate variation and commerce. Aliyu (2010) examined the influence of forex fluctuation on Nigeria's non-oil exports from 1986 Q1 to 2006 Q4 using vector error correction and the VAR framework. The study revealed a long-run steady and negative association between Nigerian non-oil exports and Naira exchange rate variation. In the alternative, the result was beneficial for non-oil exports and US Dollar exchange rate volatility. Joseph (2011) used the GARCH model to analyze annual datasets on trade flows in Nigeria from 1970 to 2009. According to this study, exchange rate fluctuations and aggregate trade have a negative and statistically negligible association. The negative result utilizing annual time series datasets, alternatively, is in line with Aliyu's findings (2010).

# **METHODOLOGY**

The theoretical work of Obstfeldo & Rogoffe (1995) reveals that forex rate fluctuations are expensive to the local economy because of their direct and indirect impacts on individuals and companies. Its first impact is premised on the idea that families remain unsatisfied with exchange rate fluctuations owing to the challenges of smoothing consumption and the unpredictability of leisure expenditure. The indirect effect, on the other hand, implies that in order to hedge against forex risk, firms set higher fee to pay on insurance (Alagidede and Muazu, 2016).

The nonlinear Autoregressive Distributed Lag (NARDL) model was developed by Shin et al. (2014) as an offshoot of error correction model specification of the ARDL model, which capture the asymmetric/differential effect of an increase and decrease in one of the explanatory variable on the dependent variable. In this study where we are interested in examining the effect of exchange rate devaluation/depreciation and exchange rate appreciation/revaluation, the NARDL model best estimate this function. In this study, the following NARDL model specification guides our estimation procedure:

$$ressss\_{t}= a\_{0}+a\_{1}ressss\_{t-1}+ s^{+}excrateee\_{t}^{+}+ s^{-}excrateee\_{t}^{-} +\sum\_{i=0}^{p}g\_{i}Δressss\_{t-i}+\sum\_{j=1}^{q}d\_{j}^{+}Δexcrateee\_{t-j}^{+}+\sum\_{j=1}^{q}α\_{j}^{-}Δexcrateee\_{t-j}^{-}+ e\_{t} 1$$

Where $ressss\_{t}$ is foreign reserves, $a\_{0}$ is constant. $a\_{1}$ is autoregressive lag of the dependent variable $ressss\_{t}, s^{+}$ and $s^{-}$ are the long-run coefficient of decomposed time series, exchange rate $excrateee,$ $g$ is the short-run coefficient of differenced $(Δ)$ reserves and $d$ is the shortrun coefficient of the differenced exchange rate. Equation 1 above assumed a time series playing the role of explanatory of the response variable can have asymmetric effect where a positive increase in the time series (in our case exchange rate) can have an impact magnitude on the dependent variable say reserves which differ in magnitude when compared to decrease in the explanatory variable. In this case, exchange rate is decomposed in positive increase $excrateee\_{t}^{+}$ and negative decrease$ excrate\_{t}^{-}$.

$$excrateee\_{t}^{-}= \sum\_{i=0}^{k}max⁡(Δexcrateee\_{i},d) $$

$$excrateee\_{t}^{-}=\sum\_{i=0}^{l}min⁡(Δexcrateee\_{i},d) (2)$$

The positive and negative long-run relations can be obtained from equation 1 as $N^{+}= -s^{+}/a\_{1}$, $N^{-}= -s^{-}/a\_{1}$ with the following wald test $N^{+}=N^{-}=0.$ Similarly, the null hypothesis of bounds test for long-run asymmetric co-integration, which we are aiming to reject is obtained as $a\_{1}=s^{+}=s^{-}=0$.

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## **Data Description**

This study adopts monthly data from 2002M06 to 2021M12. Sourced from IMF’s international financial statistics, the data are transformed to logarithm form. Exchange rate proxy as exchange rates, national currency per U.S. dollar, end of period, rate. Exchange rate devaluation was proxy using the positive increase in exchange rate obtained using the nonlinear ARDL model partial decomposition of Exchange rate. Reserves is proxy as international reserves and liquidity, liquidity, total reserves excluding gold, foreign exchange, SDRs. The study adopts volatility index using the Chicago Options Delayed Price to account for exogenous shocks emanating from the international financial market.

## **Estimation Procedure**

The study first examining the stationarity level of the time series just to ensure any variable integrated of order (2) are not captured in the model. Thereafter, the NARDL model was estimated using the NARD R package of Zaghdoudi (2018). The bounds test for co-integration is then obtained.

# **DISCUSSION OF RESULTS**

## **Descriptive Analysis**

Table 1 presents the descriptive statistics for Volatility index, exchange rate and reserves of Egypt, Ghana, Kenya, Malawi and Mauritius. The values indicate the mean VIX is 20.04 and the standard deviation is 8.18. The exchange rate of Malawi is quite high among these countries with standard deviation of 272.93. Kenya exchange rate is also high with the mean value of 86.42 and standard deviation of 13.06. Mauritius is next in order of mean value exchange rate magnitude in table 1. The countries’ external reserves are high for Egypt with standard deviation of 6781.64, followed by Kenya with a standard deviation of 1770.22 and then Ghana.

Table 1: Descriptive statistics

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|   |   | Egypt | Ghana | Kenya | Malawi | Mauritius |
|   | VIX | Exchange rate | Exchange rate | Exchange rate | Exchange rate | Exchange rate |
| Mean | 20.04 | 8.43 | 2.34 | 86.42 | 333.43 | 31.86 |
| Sd | 8.18 | 4.77 | 1.75 | 13.06 | 272.93 | 3.95 |
| min | 9.51 | 3.41 | 0.36 | 62.03 | 46.60 | 25.35 |
| max | 59.89 | 18.73 | 5.90 | 113.14 | 822.17 | 43.53 |
| kurtosis | 3.99 | -0.46 | -0.98 | -1.14 | -1.32 | 0.42 |
|  |  | Reserves | Reserves | Reserves | Reserves | Reserves |
| Mean |  | 15131.63 | 2391.07 | 3225.89 | 238.49 | 2007.33 |
| Sd |  | 6781.64 | 1770.22 | 2130.25 | 169.61 | 1361.97 |
| min |  | 5819.68 | 95.37 | 536.46 | 46.76 | 462.07 |
| max |  | 29227.40 | 7060.61 | 7282.00 | 660.11 | 5336.66 |
| kurtosis |   | -1.02 | -0.50 | -1.46 | -1.05 | -0.65 |

Source: Author computation

Table 2 also present the descriptive statistics for Morocco, Namibia, Nigeria, South Africa and Zambia. The exchange rate of Nigeria is quite high among these countries with standard deviation of 187.44. Namibia and South are next in mean ranking order with the mean value of 10.00 and standard deviation of 3.29 and 3.28 respectively. The countries’ external reserves are high for Nigeria and South Africa with standard deviation of 8963.11 and 9900.59 respectively.

Table 2: Descriptive statistics

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|   | Morocco | Namibia | Nigeria | South Africa | Zambia |
|   | Exchange rate | Exchange rate | Exchange rate | Exchange rate | Exchange rate |
| Mean | 9.17 | 10.00 | 187.44 | 10.00 | 7.20 |
| Sd | 0.99 | 3.29 | 87.00 | 3.28 | 4.69 |
| min | 7.26 | 5.63 | 98.90 | 5.63 | 2.66 |
| max | 11.97 | 18.13 | 411.25 | 18.06 | 22.64 |
| kurtosis | 0.10 | -1.00 | -0.08 | -1.01 | 1.98 |
|  | Reserves | Reserves | Reserves | Reserves | Reserves |
| mean | 12809.81 | 885.67 | 20491.02 | 20107.43 | 846.30 |
| Sd | 4475.85 | 537.87 | 8963.11 | 9900.59 | 533.72 |
| Min | 3374.27 | 172.65 | 4279.18 | 3979.31 | 6.45 |
| Max | 23396.96 | 2052.01 | 39866.63 | 33674.02 | 2462.76 |
| kurtosis | -0.14 | -1.17 | -0.78 | -1.26 | -0.48 |

## **Panel Unit Root Test**

The panel unit root test is presented on Table 3. At level, the exchange rate and reserves do poses unit root. At first difference, the variable becomes stationary. VIX at level and first difference are stationary. We then proceed to assess the level of integration using the Levin, Lin and Chu test below.

Table3: Breitung panel unit root test

|  |  |
| --- | --- |
|  | Breitung t-stat |
|   | Statistic | Prob.\*\* |
| excrateee | -0.23 | 0.41 |
| dexcrateee | -34.75 | 0.00 |
| ressss | 0.95 | 0.83 |
| dressss | -13.34 | 0.00 |
| VIX | -9.21 | 0.00 |
| DVIX | -22.16 | 0.00 |
| \*\* Probabilities are computed assuming asympotic normality |

Table 4: Levin, Lin and Chu panel unit root test

|  |  |
| --- | --- |
|   | Levin, Lin & Chu t |
|   | Statistic | Prob.\*\* |
| excrateee | -1.90 | 0.03 |
| dexcrateee | -61.18 | 0.00 |
| ressss | -1.80 | 0.04 |
| dressss | -45.65 | 0.00 |
| VIX | -11.81 | 0.00 |
| DVIX | -85.29 | 0.00 |

The panel unit root test is presented on Table 4. At level, the exchange rate and reserves does not poses unit root. Similar, at first difference, the variable still maintain its stationary properties. VIX at level and first difference are stationary.

Table 5: Lm, Pesaran andShin W panel unit root test

|  |  |
| --- | --- |
|   | Im, Pesaran and Shin W-stat  |
|   | Statistic | Prob.\*\* |   |
| excrateee | -1.32 | 0.09 |  |
| dexcrateee | -46.37 | 0.00 |  |
| ressss | -0.35 | 0.36 |  |
| dressss | -37.15 | 0.00 |  |
| VIX | -9.85 | 0.00 |  |
| DVIX | -64.02 | 0.00 |   |

We further examine the panel unit root test using the Lm Pesaran and Shin test. The panel unit root test is presented on Table 5. At level, the exchange rate and reserves poses unit root. At first difference, the variable becomes stationary. VIX at level and first difference are stationary. We then proceed to assess the level of co-integration between these variables, using the Pesaran et al (2001) bounds test.

## **Co-integration Test Results**

Before interpreting our NARDL model estimates, we must assess the relationship using the Pesaran et al (2001) bounds test for cointegration using. The result is presented in Table 6A. Presence of cointegration indicate the NARDL model inferences on the reserves and exchange rate and volatility index are informative and the relationship can be interpreted. Table 6 indicate there is asymmetric cointegrating relationship for all countries except Namibia and Zambia.

Table 6A: PSS(2001) Bounds Test: Co-integration

|  |  |  |  |
| --- | --- | --- | --- |
| Country | Critical value I(0) - I(1) | stat | Conclusion |
| Egypt | 2.45 - 3.61 | 6.69 | YES |
| Ghana | 2.62 - 3.79 | 4.96 | YES |
| Kenya | 2.86 - 4.01 | 6.13 | YES |
| Malawi | 2.62 - 3.79 | 9.66 | YES |
| Mauritius | 2.45 - 3.61 | 3.73 | YES |
| Morocco | 2.45 - 3.61 | 7.59 | YES |
| Namibia | 2.62 - 3.79 | 2.92 | INC |
| Nigeria | 2.86 - 4.01 | 6.21 | YES |
| South Africa | 2.86 - 4.01 | 10.13 | YES |
| Zambia | 2.86 - 4.01 | 2.48 | NO |

Haven’t established the relationship, we move to examine the NARD model diagnostics which is presented below.

Table 6B: PSS(2001) Bounds Test: Cointegration

|  |  |  |  |
| --- | --- | --- | --- |
| Country | F\_stat | critical value I(0) - I(1) | Cointegration |
| Egypt | 4.58 | 3.79 - 4.85 | NO |
| Malawi | 1.1 | 3.79 - 4.85 | NO |
| Mauritius | 9.18 | 3.79 - 4.85 | YES |
| Morocco | 0.31 | 3.79 - 4.85 | NO |
| Namibia | 1.52 | 3.79 - 4.85 | NO |
| Nigeria | 1.02 | 3.79 - 4.85 | NO |
| South Africa | 4.12 | 3.79 - 4.85 | NO |
| Zambia | 8.2 | 3.79 - 4.85 | YES |

For comparative purpose, the cointegration test for the linear ARDL is presented on table 7B. In all, cointegration only exist in Mauritius and Zambia. Inconclusive results appear for Egypt, however, we can still conclude the absence of linear cointegration thus indicating the cointegrating relationship be best be examined using the nonlinear relationship.

## **Short and Long-Run Estimates**

Table 6 presents the NARDL model estimates. Panel A displays the results for Egypt, Ghana, Kenya, Malawi and Mauritius. Panel A, our major focus is exchange rate devaluation/depreciation proxied as increase in exchange rate and exchange rate appreciation/revaluation proxied as decrease in exchange rate. For Egypt, Ghana, Malawi and Mauritius, increase in exchange rate has statistical significant impact on reserves in each respectively countries. For Egypt and Malawi, increase in exchange translate to increase in reserves. For Ghana and Mauritius, the reserves decrease due to the increase in exchange rate. Converse, a decrease in exchange rate leads to statistically significant decrease in reserves if Kenya and Malawi. No statistical significant changes where recorded for the rest countries contained in panel A. VIX has statistical significant effect only in Kenya respectively. Panel B of table 6 displays the results for Morocco, Namibia, Nigeria, South Africa and Zambia. For Morocco, South Africa and Zambia, increase in exchange rate has statistical significant impact on reserves in each respective country. For both countries, increase in exchange translate to decrease in reserves. A decrease in exchange rate leads to statistically significant increase in reserves for all the countries except Nigeria. VIX has statistical significant effect only in Nigeria and South Africa. An increase in VIX leads to 0.04 and 0.01 decrease in reserves for Nigeria and South Africa.

**Table 6: Nonlinear ARDL Model Estimates**

Panel A

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|   | Egypt | Ghana | Kenya | Malawi | Mauritius |
| Const | 0.1 | 0.64\*\*\* | 0.86\*\*\* | 1.10\*\*\* | 0.12\* |
|  | (0.09) | (0.15) | (0.19) | (0.20) | (0.07) |
| res(t-1) | -0.001 | -0.09\*\*\* | -0.12\*\*\* | -0.24\*\*\* | -0.02 |
|  | (0.01) | (0.02) | (0.03) | (0.04) | (0.01) |
| excrateee\_pos | 0.34\*\*\* | -0.82\*\* | -0.02 | 0.10\* | -0.33\*\*\* |
|  | (0.08) | (0.38) | (0.04) | (0.06) | (0.11) |
| D(excratee\_pos)(t-1) | -0.31\*\*\* | 0.92\*\* |  |  | 0.35\*\*\* |
|  | (0.08) | (0.40) |  |  | (0.11) |
| excrateeee\_neg | 0.09\* | 0.18 | -0.22\*\*\* | -2.85\*\*\* | -0.23 |
|  | (0.05) | (0.11) | (0.06) | (0.83) | (0.15) |
| D(excratee\_neg)(t-1) |  |  |  | 2.63\*\*\* | 0.22 |
|  |  |  |  | (0.79) | (0.15) |
| Vix | 0.02 | -0.01 | -0.02\*\*\* | -0.03 | -0.005 |
|  | (0.02) | (0.02) | (0.01) | (0.03) | (0.01) |
| vix(t-1) | -0.05\*\* |  |  |  |  |
|  | (0.02) |  |  |  |  |
| Observations | 230 | 230 | 231 | 230 | 230 |
| R2 | 0.15 | 0.1 | 0.1 | 0.18 | 0.09 |
| Adjusted R2 | 0.13 | 0.08 | 0.08 | 0.16 | 0.07 |
| Residual Std. Error | 0.06 (df = 223) | 0.10 (df = 224) | 0.05 (df = 226) | 0.18 (df = 224) | 0.03 (df = 223) |
| F Statistic | 6.69\*\*\* (df = 6; 223) | 4.96\*\*\* (df = 5; 224) | 6.13\*\*\* (df = 4; 226) | 9.66\*\*\* (df = 5; 224) | 3.73\*\*\* (df = 6; 223) |
| Note:\*p<0.1; \*\*p<0.05; \*\*\*p<0.01 |  |  |  |  |

Panel B

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|   | Morocco | Namibia | Nigeria | South Africa | Zambia |
| Const | 0.1 | 0.39\*\*\* | 0.17\*\* | 0.22\*\*\* | 0.28\*\*\* |
|  | (0.09) | (0.13) | (0.08) | (0.06) | (0.11) |
| res(t-1) | -0.01 | -0.10\*\*\* | -0.005 | -0.02\*\*\* | -0.05\*\* |
|  | (0.01) | (0.03) | (0.01) | (0.01) | (0.02) |
| excrateee\_pos | -0.62\*\*\* | -0.42 | 0.01 | -0.03\*\*\* | -0.07\*\* |
|  | (0.15) | (0.26) | (0.01) | (0.01) | (0.03) |
| excratee\_pos)(t-1) | 0.65\*\*\* | 0.34 |  |  |  |
|  | (0.14) | (0.26) |  |  |  |
| excrateee\_neg | -0.27\* | -0.16\*\* | 0.1 | -0.05\*\*\* | -0.11\*\* |
|  | (0.16) | (0.07) | (0.07) | (0.02) | (0.05) |
| excrateee\_neg(t-1) | 0.30\* |  |  |  |  |
|  | (0.16) |  |  |  |  |
| Vix | -0.005 | 0.03 | -0.04\*\*\* | -0.01\*\* | -0.01 |
|  | (0.01) | (0.03) | (0.01) | (0.01) | (0.02) |
| Observations | 230 | 230 | 231 | 231 | 231 |
| R2 | 0.17 | 0.06 | 0.1 | 0.15 | 0.04 |
| Adjusted R2 | 0.15 | 0.04 | 0.08 | 0.14 | 0.03 |
| Residual Std. Error | 0.03 (df = 223) | 0.12 (df = 224) | 0.05 (df = 226) | 0.03 (df = 226) | 0.09 (df = 226) |
| F Statistic | 7.59\*\*\* (df = 6; 223) | 2.92\*\* (df = 5; 224) | 6.21\*\*\* (df = 4; 226) | 10.13\*\*\* (df = 4; 226) | 2.48\*\* (df = 4; 226) |
| Note:\*p<0.1; \*\*p<0.05; \*\*\*p<0.01 |  |  |  |

## **Long-Run Relation**

Table 7 presents the long-run relationship. As earlier established, asymmetric co-integrating relationship exist for Namibia and Zambia. Focusing on the countries with co-integrating relation, Ghana and South Africa external reserves decreases significantly due to increase in exchange rate. Kenya, Malawi and South Africa external reserves increases significantly due to decrease in exchange rate.

Table 7: Long-run relationship

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|   |  |   |   |   |   |
| Panel A | Egypt | Ghana | Kenya | Malawi | Mauritius |
|  | Stat | Stat | stat | stat | stat |
| excrateee\_pos | 367.26 | -9.3\*\* | -0.20 | 0.42 | -21.95 |
| excrateee\_neg | 101.83 | 2.05 | -1.9\*\*\* | -12.06\*\*\* | -15.05 |
|  |  |  |  |  |  |
| Panel B | Morocco | Namibia | Nigeria | South Africa | Zambia |
|  | Stat | Stat | stat | Stat | stat |
| excrateee\_pos | -81.64 | -4.15 | 2.15 | -1.67\*\*\* | -1.44\*\*\* |
| excrateee\_neg | -35.28 | -1.6\*\*\* | 21.32 | -2.22\*\*\* | -2.45\*\*\* |

**Model Diagnostics and Asymmetric Tests**

Table 8 panel A and B present the model diagnostics of NARDL model. The BG test for autoregressive conditional heteroscedasticity test indicates the absence of heteroscedasticity in the model for all the countries except Malawi. The LM test for autocorrelation (ARCH test) indicate the model estimates for all the countries does not suffer from autocorrelation. The absence of heteroscedasticity and serial correlation indicate our models estimates presented in the subsequent tables are robust and unbiased.

The short-run asymmetric test (SRasymmetric) indicate the absence of short-run asymmetric effect on exchange rate on reserves for Egypt, Kenya and Malawi. The long-run asymmetric is presence for all the countries.

**Table 8: NARDL Model Diagnostics and Asymmetric Tests**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Panel A |  |  |  |  |  |
|   | Egypt | Ghana | Kenya | Malawi | Mauritius |
|  | stat | Stat | Stat | stat | stat |
| BGtest | 0.22 | 0.12 | 0.16 | 5.62\* \* | 3.17 |
| ACRtest | 0.65 | 3.03 | 1.9 | 0.47 | 0.01 |
| NormTest | 0.82\*\*\* | 0.91\*\*\* | 0.81\*\*\* | 0.91\*\*\* | 0.98\*\*\* |
| SRasymmetric | 6.52\*\* | 5.03 | 20.07\*\*\* | 13.15\*\*\* | 0.25 |
| LRasymmetriv | 7684329.02\*\*\* | 652.57\*\*\* | 1448.82\*\*\* | 234.68\*\*\* | 1080.7\*\*\* |
| Panel B |  |  |  |  |  |
|   | Morocco | Namibia | Nigeria | South Africa | Zambia |
|  | stat | Stat | Stat | Stat | stat |
| BGtest | 1.76 | 0.89 | 2.34 | 0.25 | 0.39 |
| ACRtest | 11.43 | 19.84 | 1.76 | 2.45 | 0.03 |
| NormTest | 0.92\*\*\* | 0.97\*\*\* | 0.96\*\*\* | 0.84\*\*\* | 0.76\*\*\* |
| SRasymmetric | 1.89 | 0.97 | 2.35 | 3.81 | 4.72 |
| LRasymmetriv | 33042.91\*\*\* | 97.07\*\*\* | 102146.69\*\*\* | 9105.38\*\*\* | 2216.52\*\*\* |

Note:\*p<0.1; \*\*p<0.05; \*\*\*p<0.01

## Table 9: Linear ARDL model diagnostics

|  |  |  |
| --- | --- | --- |
| country | test | Stat |
| Egypt | LM | 0.63 |
| BP | 14.72\*\* |
| SW | 0.83\*\*\* |
| Kenya | LM | 0.8 |
| BP | 7.17 |
| SW | 0.81\*\*\* |
| Malawi | LM | 0.04 |
| BP | 51.69\*\*\* |
| SW | 0.93\*\*\* |
| Mauritius | LM | 1.36 |
| BP | 25.77\*\*\* |
| SW | 0.98\*\*\* |
| Morocco | LM | 1.81 |
| BP | 2.81 |
| SW | 0.92\*\*\* |
| Namibia | LM | 0.7 |
| BP | 31.37\*\* |
| SW | 0.96\*\*\* |
| Nigeria | LM | 1.08 |
| BP | 6.2 |
| SW | 0.94\*\*\* |
| South Africa | LM | 0 |
| BP | 15.54\*\* |
| SW | 0.82\*\* |
| Zambia | LM | 0.23 |
| BP | 6.32 |
| SW | 0.82\*\*\* |

Note: \*\*\* 0.01, \*\* 0.05 significance level.

The diagnostics test for the linear ARDL is presented in table 9. The LM test for serial correlation indicate absence of for serial correlation for all the countries. The null hypothesis of studentized Breusch-Pagan test implies the presence of homoscedasticity. From the table 9, it is rejected for Malawi, Mauritius, Namibia, and South Africa indicating the models suffers from heteroscedasticity. For the rest countries, the model estimates do not suffer from heteroscedasticity.

## **CONCLUSION**

This study adopts nonlinear Autoregressive Distributed Lag model of Shin et (2014) to examine the relationship between exchange rate depreciation/devaluation and exchange rate appreciation/revaluation among ten Africa countries which are Egypt, Ghana, Kenya, Malawi, Mauritius, Morocco, Namibia, Nigeria, South Africa and Zambia between 2002 to 2021. The findings showed that:

1. There is asymmetric co-integrating relationship between exchange rate, and reserves in Egypt, Ghana, Kenya, Malawi, Mauritius, Morocco, Nigeria and South Africa.
2. There is short-run and long-run asymmetric relation among the adopted variables for most of the countries studied
3. Short-run asymmetry exist in Egypt, Kenya and Malawi
4. Long-run asymmetry exist in Egypt, Ghana, Kenya, Malawi, Mauritius, Morocco, Nigeria and South Africa.
5. For Egypt and Malawi, exchange rate depreciation/devaluation translate to increase in reserves. For Ghana and Mauritius, the reserves decrease due to exchange rate depreciation/devaluation.
6. For Morocco, South Africa, exchange rate depreciation/devaluation translate to decrease in reserves.
7. Result from the long-run relationship indicate Ghana and South Africa external reserves decreases significantly due to exchange rate devaluation/depreciation.
8. Kenya, Malawi and South Africa external reserves increases significantly due to exchange rate appreciation/revaluation.
9. The government of these countries needs to be cautions of the incessant devaluation in the case where it can transmit to increasing prices instability and worsening inflation expectations.
10. The policy makers of these countries have to weigh the trade of associated with exchange rate devaluation and revaluation since there is trade off. In the instances where it does translate to increasing reserves, cautions have to be taking to ensure price level did not worsen due to devaluation and countries trade competitiveness is not hampered in the case of exchange rate appreciation.

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