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# The Effect Of The Exchange Rate On Demand For Money In Sudan: The Question Of Asymmetry

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*Abstract:* ***In this study, we intended to examine the asymmetric effect of exchange rates on demand for money in Sudan. Applying the Non-linear ARDL model to annual data for the period 1960 to 2019, using inflation, real GDP, and profit margin of Murabaha as control variables. Few studies found that test the non-linearity effect of the exchange rate on money demand in Sudan. This paper tried to fill this gap by testing the impact of the Sudanese Pound exchange rate non-linearity on the money demand in Sudan. The findings show that asymmetric effect of the exchange rate on money demand both the short run as well as long run were found. The policy implication of our results is that assuming a symmetry relationship between the exchange rate and demand for money may affect the economic planning negatively. Thus, non-linear ARDL assumes to be more suitable than the linear ARDL for examining such a relationship.***

***Keywords: Exchange rate, Money Demand, NARDL, ARDL, Asymmetry, Symmetry***

## 1. INTRODUCTION:

The effective monetary policy requires investigating the behaviour of the money demand function, which needs, in turn, understanding of the determinants of the demand for real money balances in the economy. Moreover, the stability of the demand for money function provides a strong base for economic stabilization. To ensure an adequate prediction of the effect of a given change in macroeconomic variables on demand for money, we need first to determine whether these relationships are symmetric or asymmetric. More recently, the literature shows a noticeable growth in the non-linear adjustment mechanism. Much of them may come from a large number of studies showing that key macroeconomic variables such as real GDP, unemployment, interest rates, money demand, and exchange rates display asymmetry of adjustment during the economic process.
Theoretically, there are two effects of changes in the exchange rate on the demand for domestic currency, wealth effect and currency substitution effect. According to Sahadudheen (2011), assuming that wealth holders evaluate their assets in terms of the domestic currency, the depreciation of the exchange rate would increase the value of their foreign assets held and hence increase wealth. Maintaining a fixed share of their wealth invested in domestic assets, they will transfer part of their foreign assets to domestic currency and other domestic assets. That is to say; exchange rate depreciation would increase the demand for domestic currency. On the other hand, exchange rate changes may make a currency substitution effect, in which the expectation of investors plays a vital role. If asset holders develop an expectation that the exchange rate is likely to fall further following an initial depreciation, they will raise the share of foreign assets in the portfolio. Depreciation, in a sense, means the higher opportunity

cost of holding domestic money. Hence, exchange rate depreciation would decrease the demand for domestic money (Sahadudheen (2011)).

Sudan, during the last era suffered from acute deterioration in the value of the domestic currency, so it is essential to investigate the interrelation between the exchange rate and the demand for money to establish an effective monetary policy in Sudan. However, few studies have been empirically analyzed for the Sudanese economy to investigate such cloud relationship. El Ghoul (1977), Dowaitz and EL Badawi (1987), and Abdel-Rahman (1997), Suliman and Dafaalla (2011), and Elshwin (2016) are the main studies of the demand for money in Sudan.

The objective of this paper is to determine whether changes in the nominal exchange rate of the Sudanese Pound have asymmetric or symmetric effects on the demand for money in Sudan. To achieve this objective, we use annual data from Sudan and employ the Nonlinear Autoregressive Distributed Lag (NARDL) approach of Shin et al. (2014) beside the linear Autoregressive Distributed Lag (ARDL) approach of Pesaran et al.'s (2001). The contribution of this study is that by decomposing the change in the nominal exchange rate into the partial sum of positive changes and negative changes, we prove that the changes in the exchange rate have asymmetric effects on money demand in Sudan both in the short and long run. As I know, similar studies are absent in the literature about Sudan.

The remaining of the study is as follows; we review the related literature in section (2), outline the model, and explain the methodology in Section (3). The results are reported and analyzed in Section (4), whereas, in section (5), we conclude for the sake of researchers and policymakers.

## 2. LITERATURE REVIEW:

In literature, the demand for money function has been studied using many approaches in different countries. The coming sections give a review of the empirical studies on the money demand function at the international level and then at the national level.

### Review of International Empirical Studies

The literature on demand for money has grown vastly so that each country has its literature because it is an effective tool for monetary policy. Most studies try to identify the determinants of demand for money and try to apply a new econometrics method to test its stability. Mundell (1963) was the first who specified the demand for money as a function of the exchange rate besides interest rate and income. Arango and Nadiri (1981) argued that an appreciation of foreign currency raises the domestic currency value of foreign assets held by domestic residents, which leads to the demand for money increase if the increase is perceived as an improvement in wealth, due to the rise in consumption. On the other hand, when the foreign currency appreciates domestic residents may hold more of foreign currency and less of the domestic currency if there are expectations of further appreciation (Bahmani-Oskooee and Pourheydarian (1990)). Many studies in many countries across the world tried to handle this conflict between wealth effect versus substitution effect.

Previous studies of the exchange rate change effects on demand for money have assumed a symmetry relationship. Regarding the exchange rate, the symmetry assumption implies that if depreciation raises the demand for money, say due to a relatively strong wealth effect, the appreciation should lower it. More recently, many research efforts directed to test symmetry versus asymmetry hypothesis demand for money. In this section, we try to review some of these studies in different countries (Table 1).

**Table 1: studies that test the symmetry versus asymmetry hypothesis demand for money**

| Study | Country | Sample | Methodology | Variables | Findings |
|---|---|---|---|---|---|
| Bahmani-Oskooee and Bahmani S (2015) | Iran | Quarterly data (1996 – 2013) | A non-linear ARDL analysis | Real M1, M2, real income, inflation rate and exchange rate | The asymmetric effect in both the short and long run |
| Bahmani-Oskooee et.al (2016) | China | Quarterly data (1996 – 2015) | A non-linear ARDL analysis | Real M2, real income, inflation rate and exchange rate | The asymmetric effect in both the short and long run |
| Bahmani-Oskooee and Baek, J (2017) | Korea | Quarterly data (1973 – 2014) | A non-linear ARDL analysis | Real M2, real income, inflation rate and exchange rate | The asymmetric effect in both the short and long run |
| Alsamara, M and Mrabet, Z (2018) | Turkey | Quarterly data (1986 – 2014) | A non-linear ARDL analysis | Real M2, real income, inflation rate and exchange rate | The asymmetric effect in both the short and long run |
| Bahmani-Oskooee et.al (2019) | Albania | Quarterly data (1996 – 2016) | A non-linear ARDL analysis | Real M2, real income, inflation rate and exchange rate | The asymmetric effect in both the short and long run |
| Leong, C et al. (2019) | Malaysia | Quarterly data (1991 – 2018) | Divisia M2 monetary aggregate | Real M2, real income, interest rate and exchange rate | The asymmetric effect in both the short and long run |
| Aworinde, O. and Akintoye, I (2019) | Nigeria | Quarterly data (1960 – 2017) | A non-linear ARDL analysis | Real M2, real income, CPI and exchange rate | The asymmetric effect in both the short and long run |
| Ho, H., and Saadaoui, J. (2019) | Vietnam | Quarterly data (2000 – 2018) | A non-linear ARDL analysis | Real M2, real income, interest rate and exchange rate | The asymmetric effect in both the short and long run |

| | | | | | |
|---|---|---|---|---|---|
| Bahmani-Oskooee, and Gelan, A. (2019) | Africa | Quarterly data (1971 – 2016) | A non-linear ARDL analysis | Real M2, real income, inflation rate and exchange rate | The asymmetric effect in both short and long run in 11 countries out of 16. |
| Bahmani-Oskooee et.al (2019) | Emerging Economies | Different Periods | A non-linear ARDL analysis | Real M2, real income, inflation rate and exchange rate | The asymmetric effect both in the short and long run in all countries under study is found. |

From the reviewed literature on the demand for money across the world, it was observed that the results are similar, concerning the effects of exchange rate changes on demand for money, it is found to be asymmetric. We can also notice that the majority of studies use non-linear ARDL analysis to test the asymmetry assumption in different countries.

**Review of National Empirical Studies**

The first research work handling the demand of money in Sudan consists of the unpublished working paper by ElGhoul (1977), who employs a partial adjustment specification to test the stability of the money demand function. Domowitz I and Elbadawi I (1987) try to reexamine the stability issue in the context of a model which nests the usual partial adjustment specification, using out of sample forecasting performance as a metric. A brief review of the studies in Sudan context has been provided in Table 2 below

**Table 2: Demand for money studies in Sudan**

| **Study** | **Objective** | **Sample** | **Methodology** | **Variables** | **Findings** |
|---|---|---|---|---|---|
| Domowitz, I and Elbadawi, I (1987) | An empirical analysis of money demand behaviour | Annual data (1956 – 1982) | The dynamic error-correction model | M2, EX, Income; and foreign interest rate | Refute previous requires that income and price effects may be very high in Sudan, partly by accounting for both foreign exchange and inflation. |
| M. Abdel-Rahman (1994) | To test the effects of high inflation on basic money demand functions | Quarterly Data (190 -1991) | Adjustment and error correction methodology | M1, RGDP, and Inflation. | During high inflation, errors were small in magnitude. Corrections in real balances were undertaken with respect to inflation expectations, not income. |

| | | | | | |
|---|---|---|---|---|---|
| Suliman, Z., and Dafaalla, H. (2011) | To test the stability of the demand for demand function. | Annual data (1960 – 2010) | Error correction model (ECM) | Real M1, RGDP, EX and Inflation. | The money demand function is stable |
| Ashwin (2016) | Empirically assess the main determinates of demand for money | Annual data (1970 – 2003) | Cointegration and error correction methodology | M1, M2, GDP, Inflation, parallel EX, and CPI | Money demand is stable and influenced in the short run by income, the expected inflation and the exchange rate |
| Ahmed, A. A. (2020) | To know the most important factors affecting the demand for money | Annual data (1990 – 2019) | Analytical descriptive approach (Bartlett test and KMO test) | Ex, GDP, MS, Public budget, Import, and Export, inflation and funding cost | The first factor saturates with the following variables (Ex, GDP, MS, Public budget and Import and Export). The second factor saturated with (Inflation, GDP, and Funding Cost). The third factor saturated with (Velocity Circulation of Money). |

From the previous studies in Sudan, the assumption is that exchange rate changes have symmetric effects on the demand for money. However, exchange rate changes may be asymmetric, where appreciation may have different effects than depreciations. This remains the major gap in the literature of demand for money in Sudan, which we try to fill by this study.

## 3. METHODOLOGY:

This study employs annual secondary data covering the period from 1960 to 2019, sourced from the Central Bank of Sudan (CBS) (https://cbos.gov.sd/en) and the National Bureau of Statistics. To accomplish the study objective, we use Linear Autoregressive Distributed Lag (ARDL) and Nonlinear Autoregressive Distributed Lag (NARDL) models. Starting with linear error correction:

$$RMD_t = a + \beta_1 LEX_t + \beta_2 INF_t + \beta_3 RGDP_t + \beta_4 MM_t + \varepsilon t \qquad (1)$$

Where RMD is the measure of the real amount of money held by the Sudanese measured by M2, EX is the official annual nominal exchange rate per unit of Sudanese Pound. By definition, a negative change in the exchange rate will mean depreciation; in contrast, a positive change will imply appreciation. MM denotes Morabaha profit margin, INF is the level of inflation, and both MM and INF are the opportunity cost of holding money. RGDP is the measure of real income or output, which is supposed to account for the transaction demand for money. We expect an estimate of $\beta_3$ to be positive and significant. To account for the effects of other variables, we employ this model, which contains, besides the exchange rate, variables that affect the demand for money, as mentioned in the literature on this topic.

Following Pesaran et al.'s (2001) bounds testing approach, we can rewrite equation (1) as the error-correction model:

$$\Delta RMD_t = a + \sum_{k=1}^{n1} \beta_1 \Delta RMD_{t-k} + \sum_{k=0}^{n2} \beta_2 \Delta LEX_{t-k} + \sum_{k=0}^{n4} \beta_3 \Delta INF_{t-k} + \sum_{k=0}^{n5} \beta_4 \Delta RGDP_{t-k} + \sum_{k=0}^{n3} \beta_5 \Delta MM_{t-k} + \lambda_1 RMD_{t-1} + \lambda_2 LEX_{t-1} + \lambda_3 INF_{t-1} + \lambda_4 RGDP_{t-1} + \lambda_5 MM_{t-1} + \mu_t \quad (2)$$

Then, we modify equation (2) to analyze the asymmetric effects of the exchange rate on stock prices. To accomplish this task, we insert the negative and positive changes in LEX following Shin et al. (2014) as below:

$$\Delta RMD_t = a + \sum_{k=1}^{n1} \beta_1 \Delta RMD_{t-k} + \sum_{k=0}^{n2} \beta_2 \Delta LEX\_POS_{t-k} + \sum_{k=0}^{n3} \beta_3 \Delta LEX\_NEG_{t-k} + \sum_{k=0}^{n5} \beta_4 \Delta INF_{t-k} + \sum_{k=0}^{n6} \beta_5 \Delta RGDP_{t-k} + \sum_{k=0}^{n4} \beta_6 \Delta MM_{t-k} + \lambda_1 LnRMD_{t-1} + \lambda_2 LEX\_POS_{t-1} + \lambda_3 LEX\_NEG_{t-1} + \lambda_4 INF_{t-1} + \lambda_5 RGDP_{t-1} + \lambda_6 MM_{t-1} + \mu t \quad (3)$$

Shin et al. (2014) illustrate that we can apply Pesaran et al.'s (2001) bounded testing approach to equation (3) so that we can judge short-run symmetry or asymmetry as well as long-run symmetry or asymmetry which is labelled non-linear ARDL model.

**Empirical Results and Analysis:**

The augmented Dickey-Fuller (ADF) test was used to determine stationarity at a level and first difference, taking into account that cointegration requires I (0) or I (1) variables. The ADF statistics in Table 3 indicate that all variables satisfied the required condition.

**Table-3.** Levels and first differences.

| **Variable** | **Level** | | **First Difference** | |
|---|---|---|---|---|
| | **ADF Statistics** | **Result** | **ADF Statistics** | **Result** |
| RMD | 2.4132 | Nonstationary | -4.9380 | stationary*** |
| INF | -2.5939 | stationary* | -10.4505 | stationary*** |
| LEX | 1.6217 | Nonstationary | -5.6993 | stationary*** |
| RGDP | 0.6913 | Nonstationary | -4.1867 | stationary*** |

| | | | | |
|---|---|---|---|---|
| MM | -1.6670 | Nonstationary | -7.2905 | stationary*** |

***** = significant at 1%. ** = significant at 5%. * = significant at 10%**.

According to the VAR Lag Order Selection Criteria, a maximum of 5 lags were then imposed on each first-difference variable as Akaike's information criterion (AIC) was used to select an optimum specification. Short- and long-run estimates, in addition to diagnostic statistics, were calculated using first the linear ARDL model and then the non-linear ARDL model.

**Table-4.** Short-run coefficient estimates.

| Variable | Coefficient | t-Statistic | Probability |
|---|---|---|---|
| Δ (RMD (-1)) | 0.629844*** | 4.265024 | 0.0001 |
| Δ (RMD (-2)) | 0.685836*** | 4.255718 | 0.0001 |
| Δ (RMD (-3)) | 0.345212** | 2.235483 | 0.0313 |
| Δ (RGDP) | 4.94E-10 | 0.429623 | 0.6699 |
| Δ (MM) | -0.073819 | -0.112754 | 0.9108 |
| Δ (LEX) | -1.346182 | -0.158660 | 0.8748 |
| Δ (LEX (-1)) | 20.61281** | 2.417365 | 0.0205 |
| Δ (LEX (-2)) | 9.980031 | 1.062094 | 0.2949 |
| Δ (LEX (-3)) | 31.79702** | 2.654790 | 0.0115 |
| Δ (INF) | 0.177072 | 1.234292 | 0.2247 |
| Δ (INF (-1)) | 0.700460*** | 3.810808 | 0.0005 |
| Δ (INF (-2)) | 0.396446*** | 2.867448 | 0.0067 |

***** = significant at 1%. ** = significant at 5%. * = significant at 10%.**

The short-run estimates reported in Table 4 indicate that only changes in the lags of RMD, LEX, and IMF significantly affect money demand in Sudan at different significance levels.

**Table-5.** Long-run coefficient estimates.

| Variable | Coefficient | t-Statistic | Probability |
|---|---|---|---|
| C | -136.0477*** | -4.598340 | 0.0000 |
| RGDP | 5.30E-09*** | 10.76875 | 0.0000 |
| MM | 1.787114* | 1.747267 | 0.0887 |
| LEX | -25.79197*** | -5.412818 | 0.0000 |
| INF | -0.469253 | -1.348421 | 0.1855 |

***** = significant at 1%. ** = significant at 5%. * = significant at 10%.**

Regarding the long-run estimates (Table 5), cointegration had to be established first using the ARDL bounds test, which the F-statistic of 3.589340 is higher than the upper-bound critical value of 3.48 at 5% significance level. Table 3 shows that INF still insignificantly affects real money demand in the long run, whereas LEX and RGDP are significant at a1% level of significance. The variable MM is also significant but at a 10% level of significance.

Several conclusions can be drawn from the diagnostic statistics reported in Table 6. The significant negative coefficient for ECM (t−1) confirms the existence of cointegration in the long run and implies that the estimate will adjust to its long-run equilibrium by 7% within one year. Meanwhile, the Lagrange multiplier (LM), although not significant at a 5% significance level, indicates the absence of any serial correlation problems. Ramsey's regression equation specification error test (RESET), which, with a t-value of 0.942931, is also not significant, shows the model to be correct in its assumptions. Moreover, Heteroskedasticity test, which, with a t-value of 0.1363, is also not significant, shows the absence of the heteroscedasticity. The normality test illustrates that the distribution of residuals is normal at a 5% level of significance. Furthermore, the 42% coefficient of determination (Adj. R2) demonstrates the goodness of fit for the model. Finally, the CUSUM test found the estimates to be stable, as shown in Figure 1.

**Table-6.** Diagnostic statistics.

| **F-Bounds Test** | **ECM (t–1)** | **LM** | **RESET** | **Hetero. Test** | **Adj. $R^2$** | **Normality** | **CUSUM (**Figure 1**)** | **Walt-S** |
|---|---|---|---|---|---|---|---|---|
| 3.589340** | -0.7027*** (-4.936570) | 0.9108 (0.4113) | 0.9429 (0.3518) | 1.5294 (0.1363) | 0.420975 | 0.511156 (0.774469) | Stable** | 8.254*** (0.0075) |

**Notes:**

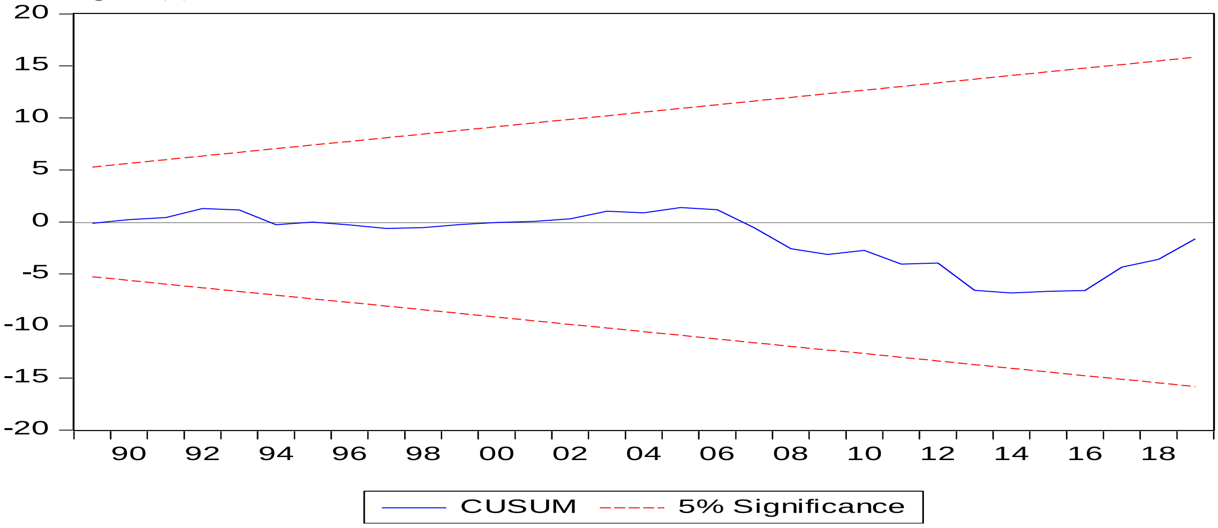
- ECM: error correction model.
- LM: Lagrange multiplier.
- RESET regression equation specification error test.
- Hetero. Test: Heteroskedasticity test.
- Adj. $R^2$: coefficient of determination.
- A normality test: Residuals distribution test.
- CUSUM statistics: stability test.
- Wald-S statistics: short-run Walt test
- Numbers inside parentheses are expected (E) values of the t-statistics.
- The value of upper bound critical at the 5% significance level is 4.01 (when there are four exogenous variables) for the F-statistic (Pesaran et al., 2001).

– The value of upper bound critical at the 5% and 10% significance levels are –3.99 and (–3.66), respectively (when there are four exogenous variables) for the t-statistic (Pesaran et al., 2001). These values are usually used to determine the significance of ECM (–1).

- *** = significant at 1%. ** = significant at 5%. * = significant at 10%.

Figure 1 plots the breakpoints (i.e., significant changes). As the CUSUM statistics remain within the 5% significance level, the estimated coefficients are regarded as stable.

Figure (1): CUSUM Test




Repeating the short- and long-run estimates using the non-linear ARDL model, the results are found in Tables 7 and 8, whereas their diagnostic statistics are reported in Table 9.

**Table-7.** Short-run coefficient estimates.

| **Variable** | **Coefficient** | **t-Statistic** | **Probability** |
|---|---|---|---|
| Δ (RMD (-1)) | 0.587169*** | 4.907216 | 0.0000 |
| Δ (RMD (-2)) | 0.638160*** | 5.318327 | 0.0000 |
| Δ (RMD (-3)) | 0.724162*** | 5.125232 | 0.0000 |
| Δ (MM) | 0.133194 | 0.237245 | 0.8141 |
| Δ (MM (-1)) | -0.043301 | -0.081822 | 0.9354 |
| Δ (MM (-2)) | 2.201165*** | 3.839715 | 0.0006 |
| Δ (MM (-3)) | 3.645369*** | 5.483910 | 0.0000 |
| Δ (LEX_POS) | 5.909649 | 0.937899 | 0.3560 |
| Δ (LEX_POS (-1)) | 43.27848*** | 5.138459 | 0.0000 |
| Δ (LEX_POS (-2)) | 33.34904*** | 3.678944 | 0.0009 |
| Δ (LEX_POS (-3)) | 42.03033*** | 4.481779 | 0.0001 |
| Δ (LEX_POS (-4)) | -26.83118*** | -2.926401 | 0.0066 |
| Δ (LEX_NEG) | 497.2932*** | 4.579626 | 0.0001 |
| Δ (LEX_NEG (-1)) | -309.7817*** | -3.145122 | 0.0038 |
| Δ (LEX_NEG (-2)) | 279.9763*** | 3.343015 | 0.0023 |
| Δ (INF) | 0.449086*** | 3.475469 | 0.0016 |
| Δ (INF (-1)) | 0.784096*** | 5.549008 | 0.0000 |
| Δ (INF (-2)) | 0.503010*** | 4.191938 | 0.0002 |

***** = significant at 1%. ** = significant at 5%. * = significant at 10%.**

The short-run estimates reported in Table 7 indicate that only changes in INF and LEX_NEG significantly affect the real money demand in Sudan at the 1% significance level, while the other variables, except for RGDP, exert significant effects once lags are imposed.

**Table-8.** Long-run coefficient estimates.

| Variable | Coefficient | t-Statistic | Probability |
|---|---|---|---|
| C | -68.36063*** | -3.253635 | 0.0029 |
| RGDP | 9.79E-09*** | 5.400206 | 0.0000 |
| MM | -1.292806 | -0.826686 | 0.4152 |
| LEX_POS | -29.30170*** | -4.215769 | 0.0002 |
| LEX_NEG | 705.8717** | 2.642974 | 0.0131 |
| INF | -0.489684 | -1.553544 | 0.1311 |

***** = significant at 1%. ** = significant at 5%. * = significant at 10%.**

Regarding the long-run estimates (Table 8), cointegration had to be established first using the ARDL bounds test, which the F-statistic of 7.587798being higher than the upper-bound critical value of 4.15 at all significance levels. Table 6 shows that RGDP and LEX_POS significantly affect real money demand in Sudan in the long run at a 1% level of significance, and LEX_NEG is also significant to abut at a 5% level of significance. Whereas, none of the other variables showed a significant effect.

Several conclusions can be drawn from the diagnostic statistics reported in Table 9. The significant negative coefficient for ECM (t−1) confirms the existence of cointegration in the long run and implies that the estimate will adjust to its long-run equilibrium by 7% within one year. Meanwhile, the Lagrange multiplier (LM), although not significant at a 5% significance level, indicates the absence of any serial correlation problems. Ramsey's regression equation specification error test (RESET), which, with a t-value of 3.542311, is found to be significant, shows the model to be incorrect in its assumptions. Moreover, Heteroskedasticity test, which, with a t-value of 0.6838, is also not significant, shows the absence of the heteroscedasticity. The normality test illustrates that the distribution of residuals is normal at a 5% level of significance. Furthermore, the 67% coefficient of determination (Adj. R2) demonstrates the goodness of fit for the model. Finally, the CUSUM test found the estimates to be stable at a 5% level of significance, as shown in Figure 2.

**Table-9**. Diagnostic statistics.

| **F-Bounds Test** | **ECM (t–1)** | **LM** | **RESET** | **Hetero. Test** | **Adj. $R^2$** | **Normality** | **CUSUM (Figure 2)** | **Walt -L** |
|---|---|---|---|---|---|---|---|---|
| 7.587798*** | -0.6983*** (-8.0064) | 0.8434 (0.4412) | 3.5423*** (0.0014) | 0.8236 (0.6838) | 0.6743 | 2.6277 (0.26878) | Stable** | 5.1727*** (0.0005) |

**Notes:**

- ECM: error correction model.
- LM: Lagrange multiplier.
- RESET regression equation specification error test.
- Hetero. Test: Heteroskedasticity test.
- Adj. $R^2$: coefficient of determination.
- A normality test: Residuals distribution test.
- CUSUM statistics: stability test.
- Numbers inside parentheses are expected (E) values of the t-statistics.
- Wald-L statistics: long-run Walt test
- The value of upper bound critical at the 5% significance level is 4.01 (when there are four exogenous variables) for the F-statistic (Pesaran et al., 2001).

– The upper bound critical value at the 5% and 10% significance levels are –3.99 and (–3.66), respectively (when there are four exogenous variables) for the t-statistic (Pesaran et al., 2001). These values are usually used to determine the significance of ECM (–1).

- *** = significant at 1%. ** = significant at 5%. * = significant at 10%.

Figure 2 plots the breakpoints (i.e., significant changes). As the CUSUM statistics remain within the 5% significance level, the estimated coefficients are regarded as stable.

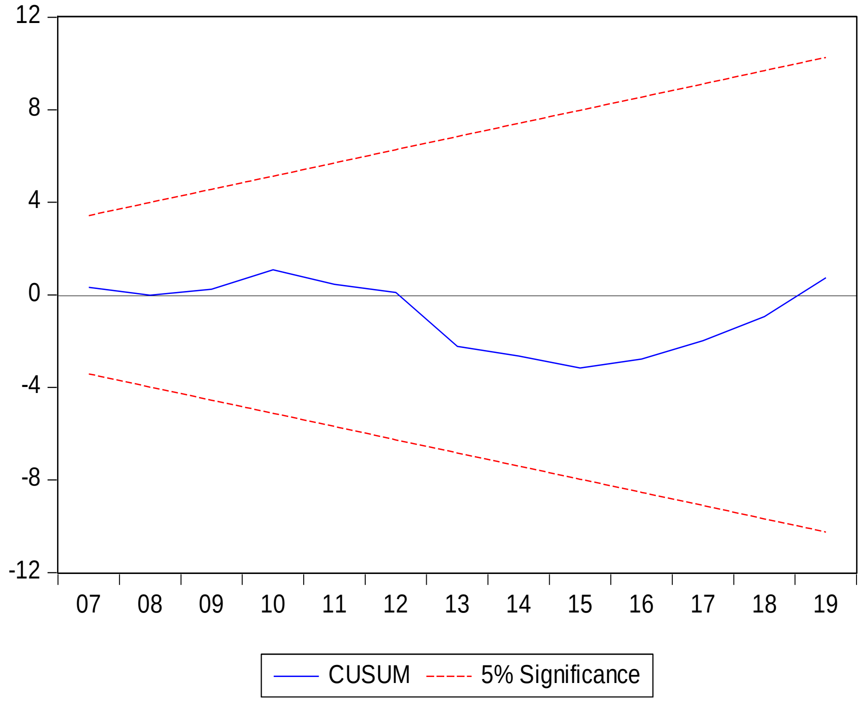



**Figure-2.** CUSUM tes

As discussed above, regarding the results obtained by using linear ARDL, we found that the nominal effective exchange rate had no short-run effect on the demand for money in Sudan. To investigate if this result will change if we use non-linear ARDL (separate currency depreciation (LEX_NEG) from appreciation (LEX_POS)). From the NARDL short-run results in Table 7 and Table 9, we found that the depreciation of Sudanese Pound has significant short-run effects, but the appreciation does not. This result means that the short-run effects of exchange rate are asymmetric. Furthermore, we also observe short-run adjustment asymmetry because depreciation and appreciation take different lag orders. The Wald test supports this conclusion since its statistic is significant at the 1% level.

We refer to Table 8 and Table 9 to investigate if the mentioned short-run asymmetry effects transfer to the long run. The long-run results indicate that the long-run effects of appreciation (LEX_POS) and win depreciation (LEX_NEG) are asymmetric. While the first one carries a significantly negative coefficient (-29.30170) at a statistical level of 1%, the latter one carries a significant positive coefficient (705.8717) at a statistical level of 5%. Implying that the two estimates are significantly different, which means there is an asymmetric effect in the long -run also. Again, our calculated Wald statistic is significant, supporting the long-run asymmetry effects.

Since (LEX_POS) carries a significantly negative coefficient implies that, as Sudanese Pound appreciates against foreign currencies, Sudan holds more of domestic currency and less of foreign currency, in contrast to the expectation effect. Such findings support that of Bahmani-Oskooee and Bahmani (2015) who estimated similar models using data from Iran.

To support the existence of asymmetric effects of change in Sudanese Pound, we refer to the significant F statistic that supports cointegration in our long-run analysis. In the non-linear model, ECM-1 is highly significant more than that in the case of the linear model. Finally, Figure 3 gives an overall plot for the existence of the asymmetry in the effects of exchange rate on money demand in Sudan.

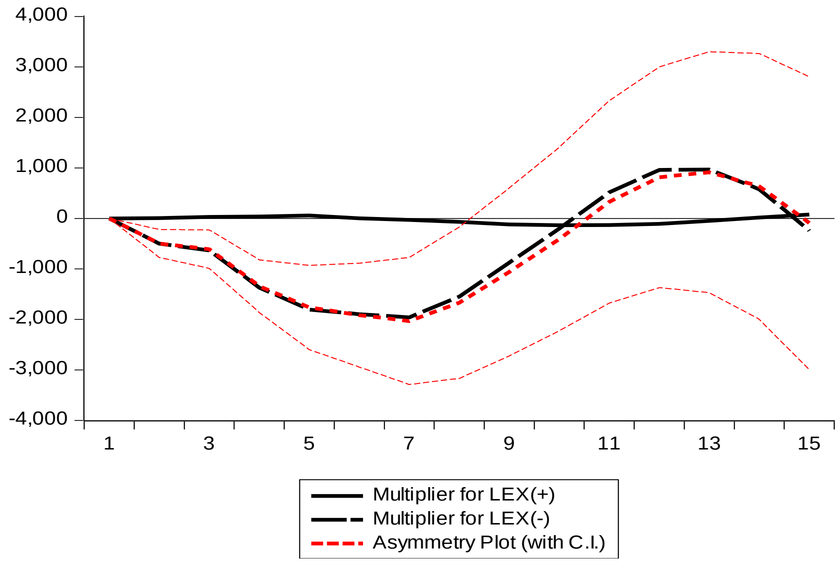



**Figure-3. Asymmetry Plot**

## 4. CONCLUSION:

We were using the Shin et al. (2014) non-linear ARDL approach and error-correction modelling to rest the asymmetric effects of exchange rate on demand in Sudan, decomposing of its changes to the partial sum of negative changes and the partial sum of positive changes. Our results show that the exchange rate has an asymmetric effect on money demand for money in Sudan both in the short and long run. We find three evidences for the asymmetric effects of exchange rate changes. First, Short-run asymmetry is evidenced because Sudanese Pound depreciation has a different impact on the money demand compared to Sudanese Pound appreciation, which is found to be insignificant. Second, adjustment asymmetry is evidenced because the impact of Sudanese Pound appreciation continues for a much more extended period than the effect of Sudanese Pound depreciation, measured by the number of lags. Finally, the long-run asymmetric effect is evidenced by the different coefficient size of Sudanese Pound appreciation versus Sudanese Pound depreciation. The implication to the policy of these results is that since modelling the exchange rate and money demand in Sudan as an asymmetric relation may lead to ineffective economic planning, NARDL emerges as a more suitable model than the ARDL model for investigating such a relationship.

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