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The Determinants of Exchange Rate in Sudan: (1980-2016)

Badr eldeen Abdalmalik Alhaj Abouzeed
University of Kurdofan Faculty of Economics Department of Economics and ommercial studies

المستخلص :

الهدف من هذه الدراسة اختبار وجود العلاقة في الأجل الطويل والأجل القصير بين سعر الصرف ومحدداته(الناتج المحلي الاجمالي الحقيقي، عرض النقود، والاستثمار المحلي، معدل التضخم، الصادرات، الواردات والإنفاق الحكومي) في السودان. تشير فرضيات الدراسة الي وجود علاقة إحصائية ومعنوية بين سعر الصرف كمتغير تابع ومحدداتة كمتغيرات مستقلة. المستحدث في هذه الدراسة علي بيانات سنوية تغطي الفترة (1980−2016) والتي تم الحصول عليها من التقارير السنوية لبنك السودان والجهاز المركزي للإحصاء، استخدمت الدراسة طريقة منهجية الانحدار ذو التباطؤ الموزع (ARDL) بالإضافة إلى نموذج تصحيحِ الخطأ (ECM). تشير النَتائج الي أن الناتج المحلي الإجمالي الحقيقي والصادرات لهما تأثير سلبي على سعر الصرف في المدى الطويل، بينما الإستثمار المحلي، معدل التضخم، الإنفاق الحكومي، الواردات وعرض النقود لهم أثر إيجابي على سعر الصرف. وبالإضافة إلى ذلك، تشير النتائج إلى أن الناتج المحلي الإجمالي الحقيقي والصادرات لَهما تأثير سلبي على سعر الصرف في المدى القصير. بينما الإستثمار المحلي، معدل التضخم، الإنفاق الحكومي، الواردات وعرض النقود لَهما أثر إيجابي على سعر الصرف. وأظهرت النتائج أن معامل التكيف (EC_{-1}) ذو علاقة سلبية ومعنوي إحصائيا، تشير هذه النتائج إلى أن آلية تصحيح الخطأ تعمل في هذا النموذج. إن معامل EC_{-1} تساوي (−0.56) وتعني أن الانحراف عن سعر الصرف طويل الأجل يتم تصحيحه بنسبة 56٪ فقط في النموذج. وأوصت الدراسة لإستقرار سعر الصرف بتبنى سياسات مالية ونقدية مناسبة من قبل واضعي السياسات والتي تعمل على زيادة الناتج المحلي الإجمالي الحقيقي والصادرات.

ABSTRACT:

The objective of the study is to examine the existence of long– run and short-run relationship between exchange rate and it is determinants (Real GDP, money supply, domestic investment, inflation rate, exports, imports, and government spending) in Sudan. The study hypotheses indicated the existence of a statistically significant relationship between the exchange rate as a dependent variable and it is determinant as independent variables. The study depended on annual time series data covering the period (1980-2016), which were collected from the Central Bank of Sudan and Central Bureau of Statistics. The study used the Auto Regressive Distributed Lag (ARDL) method associated with Error Correction Method (ECM). The results indicate that real GDP and exports have negative effect on exchange rate in both the long run and short-

run, while domestic investment, inflation rate, government spending, imports, and money supply have positive effect on exchange rate in both long-run and short-run. The results showed that the adjustment coefficient (EC_{-1}) has a negative sign and statistically significant, these findings indicate that the presence of an error correction mechanism works in this form. The coefficients of EC_{-1} are equal to (-0.56), which imply that deviation from the long-term exchange rate is corrected by only 56% in the model. The study recommended that to stabilize the exchange rate, policy makers should adopt suitable monetary and fiscal policies that aim at increasing real GDP and exports

Keywords: exchange rate, domestic investment, autoregressive distributed lag (ARDL).Real GDP, Inflation.

Introduction:

The real exchange ratehas been considered as one of popular phenomena in developing countries.The real exchange rate is the product of the nominal exchange rate and the price ratio between the foreign and domestic economies. (Robert 1983).The nominal exchange rate is the number of units of foreign currency that can be obtained for one unit of domestic currency. The real exchange rate is number of units of foreign goods that can be obtained for one unit of domestic good. Todaro, M. P (1989). There are two major types of exchange rate systems; flexible or floating – exchange rate system, in which the value of the nominal exchange rate is determent by market forces; and fixed-exchange rate system, in which the value of the exchange rate is officially set by the government or group of government. In a flexible-exchange rate system, an exchange rate increases is called an appreciation, and exchange rate decrease is called a depreciation Abel and Bernanke (2001).

Problem of the Study:

Like other developing countries that aim to enhance their external balance and achieve economic stability, Sudan has adopted a number of different exchange rate regimes in the last five decades. These include the fixed, floating and dual exchange rate regimes. The change in exchange rate policy during such period resulted in remarkable exchange rate fluctuations, accompanied by dismal performance in the exports sector and the flow of foreign private capital into Sudan. Numerous factors have been identified as causing Sudan's unfavorable economic performance. According to that, the average of exchange rate fluctuatedin the whole period under study 1980-2016.Based on the above, the study main question can be as follows: What are the determinants of the exchange rate in Sudan?

Objective of the Study:

The objective of this research is to examine the determinants of real exchange rate in Sudan by using time series data covering the period (1980-2016).

The more specific objectives are: To estimate whether there is a long- run and short-run relationship between exchange rate, gross domestic product, domestic investment, inflation rate, exports, money supply government spending, and imports in Sudan.To examine the possible impacts of (Real Gross Domestic Product (RGDP), domestic investment, inflation rate, exports, money supply government spending, and imports) on exchange rate in Sudan.

The hypotheses:

The study hypotheses indicated that there is statistically significant relationship betweenthe exchange rate as a dependent variable and (real gross domestic product, domestic investment, inflation rate, exports, money supply government spending, and imports) as independent variables

Importance of the Study:

The importance of this study is that it will help to identify the factors that affecting real exchange rate in Sudan. The policy maker can use the results of this study on implementing monetary and fiscal policies to manage the real exchange rate in Sudan.

Empirical Studies about the Determinants of Exchange rate:

Nucu (2011) examined the influence of gross domestic product (GDP), inflation rate, money supply, interest rates and balance of payments on exchange rate of Romanian against the most important currencies (EUR, USD) for the period 2000-2010. He found that an inverse relationship existed between exchange rate (EUR/RON) GDP, and money supply. On other hand a direct relationship was found between EUR/RON, Inflation and Interest rate. The validation of the correlation between exchange rate and balance of payment could not be established because it is not significant.Elbadawi et al. (2012) evaluated the relationship between RER misalignment and economic performance measures, focusing on economic growth, export diversification and sophistication for a sample of 83 countries. They found that countries that have experienced some growth associated with a measure of export diversification were also likely to have avoided disequilibrium RER overvaluation. They also point out that not only is overvaluation bad for growth and export diversification, but undervaluation is good for both. Interestingly, their findings indicate that Sudan is among the group of SSA countries that has seen some increasing overvaluation in the latter 1990s and early 2000s.Ebaidalla. M (2014) investigated the behavior of equilibrium exchange rate and real exchange rate misalignment in Sudan over the period 1979–2009. In addition, the impact of real exchange rate misalignment on economic performance is examined. The empirical results show that the equilibrium exchange rate is significantly influenced by economic policy variables such as trade openness, government expenditure and taxes. The results also reveal that the Sudanese economy has exhibited an exchange rate overvaluation over the period under consideration. Consistent with our expectations for the period that related to oil exploitation, the real exchange rate has shown a low volatility owing to huge inflows of foreign exchange. Moreover, the results demonstrate that exchange rate misalignment has a deleterious impact on Sudanese export performance.Khalafalla. (2015) examined the pass-through effect of exchange rate on import and consumer prices in Sudan via Vector Error Correction Model. Short-run estimates of either import prices or consumer price are insignificant, suggesting that the adjustment in Sudan tends to be slow. NEER affects consumer and import prices in the long-run by –1.07 and -1.92 respectively. The ratio of cumulative responses of import prices to exchange rate changes i.e. Exchange rate pass-through (ERPT) into consumer and import prices has been increased gradually with an average of 47 and 50 respectively. Variance decomposition indicates that one standard deviation shock to the CPI creates downward trend of its own innovations, upward

trend of real GDP, excess money and the exchange rate respectively. This means that there is strong link between consumer prices and monetary policy.Talha. A. A (2016) examined the response on inflation to changes in nominal exchange rate in Sudan over two different exchange regimes (fixed and managed floating regime) by focusing on the currency devaluation in 2012 and 2013. Found that the inflation rate should react positively in the short-run and negatively in the long-run. Accordingly, 1% depreciation in the exchange rate leads inflation to increase by 1.7% (over the period) before the break and 2.7% (over the period). Also this paper figures-out that the devaluation is infeasible for Sudan where there is a shortage of foreign currencies.Ebaidalla. M (2017) examined the factors that influencing the parallel exchange rate premium in Sudan during the period 1979–2014. He found that the parallel exchange rate premium is significantly affected by policy variables such as real exchange rate, trade openness and money supply. The results also reveal that GDP growth, expected rate of devaluation, and foreign aid have a significant effect on the parallel exchange premium.

Recently, Elfaki. K (2018) investigated the effects of growth rate of real gross domestic product (RGDP), real money supply (M), inflation rate (INF), and trade openness (OP) on exchange rate (EXR) stability in Sudan. For this purpose the autoregressive distributed lag model approach was applied to estimate long run and short run relationship among exchange rate determinants, annual data covering period (1991-2016) have been analyzed. The results reveal that, there is a long run relationship between exchange rate and its determinants and statistically significant. An increase in growth rate of real GDP leads to decrease in EXR. The coefficient of error correction model reveals that exchange rate (EXR) will restore back to its equilibrium with speed of adjustment of 23.2% whenever there is a shock to its equilibrium.

Dafalla.M and Ahmad. S (2018) examined the factors affect the exchange rate inSudan. Found that there is a statistically significant positive relationship between the exchange rate and (GDP, Op). Also, there is a statistically significant negative relationship between the exchange rate with (money supply and inflation rate). Moreover, the presence of a statistical significance negative relationship between (Rs) and (Ex). In addition, conclude that the best econometric model for the exchange rate in Sudan during the period of the study (1972-2013) is that model which contains the money supply and foreign exchange reserves as independent variables with an exchange rate. However, the main factors affect exchange rate in Sudan is money supply and foreign exchange reserves.

Exchange rate and some Macroeconomics indicators in Sudan:

Table (1) showed average value of RGDP, exchange rate, exports, imports, investment to GDP%, rate of inflation, government spending and money supply (M2)SDG million in Sudan.It is shows that the trade balance suffered from deficit in most years, because of increase of the imports over exports.Table (1) showed that average of exchange rate and Average Money Supply increase in whole period 1980-2016. In general average value of investment increased in the whole period of the study. Also the rate of inflation rose from an average rate of 36.72% percent during the sub period 1980-1984

to 44.32% percent during the 1985-1989, this sub-period has considered the most critical periods in the national economy, where it witnessed the drought and decreased foreign aid and grants flows, in addition to the beginning of the civil war in the South.

Table (1):, Exchange rate and some Macroeconomics indicators

Years	Average value of RGDP	Average of Exchange rate	Average value of Exports	Average value of Imports	Average value of Investment(In Million Sudanese SDG)	Average Rate of inflation	Average value of Government Spending	Average Money Supply (M2)SDG Million
1980-1984	7.5	0.01	0.78032	1.60716	1.078	36.72	0.8	2.48
1985-189	40.3	0.04	1.90362	3.53332	5.196	44.32	2.9	12.10
1990-1994	710.9	0.11	31.11344	92.02524	144.722	127.42	70.6	180.02
1995-1999	15932	1.55	939.3859	2720.317	3064.392	52.06	1305.3	1623.54
2000-2004	49306.5	2.60	6252.385	8609.613	8,686.27	6.96	6200.6	6073.38
2005-2009	111742.3	2.19	17590.63	23814.08	25,150.50	9.50	20716	20573.10
2010-2016	960232.9	4.32	16715	24923.88	166,843.42	25.80	42765.8	54025.10

Source: Authors own Calculation Based on Central Bureau of Statistics and Central Bank of Sudan (CBOS).

Table (1) showed that average of exchange rate increased in the whole period 1980-2016. Over the period of 1980s the exchange rate was devaluated for many years without any noticeable increased in the competitiveness of Sudanese exports.

During rhe period (1990-1994), the government pursued a liberalization policy, in which the official and free markets for foreign exchange were abolished. Instead, a unified free market for foreign exchange was established, with its own sources, and uses for foreign exchange were clearly defined. The exchange rate was initially unified at the official exchange rate at LS 4.50; while the free market rate was devalued to LS 30, 00. A committee of commercial banks was established to fix the unified exchange rate on a daily basis, according to its supply and demand. Moreover, a liberalization policy was accompanied by the lifting of the ban on possession of foreign exchange by individuals, which allow them unrestricted dealing in foreign exchange through official channels. Furthermore, imports of 35 luxury goods, including cars, and cosmetics were banned (Central Bank of Sudan 1993).

In July 1994, the government introduced another reforms to the 1992 exchange rate policy. The two channels for foreign exchange (CBOS and commercial banks) were replaced by a free market for foreign exchange. Thus commercial banks were given complete freedom to determine their exchange rates in accordance with supply and demand of foreign exchange. In addition, the commercial banks were obliged to declare their daily exchange rates to the Bank of Sudan. On this basis, the CBOS calculated a weighted average exchange rate, called the Bank of Sudan’s exchange

rate, which the bank used to buy its share of foreign exchange. And, allowing for 20 percent of export (mainly agricultural) to be evaluated at the free market exchange rate (Central Bank of Sudan 1994).The concerned policies of the foreign exchange market aimed to achieve real exchange rate by continually liberalizing the foreign exchange rate. Also, the banks were directed to sell the export at the current price determined by the bank without adding any margin. According to these policies the average of exchange rate approximately remain stable during (1995-1999), recording an average of 1.55% per year until the end of 2005. After that the average of exchange rate increased to 2.56 during (2000-2004), due to finance crises.In sub section (2005-2009) the average of exchange rate decreased to 2.16, attributed to peace agreement with South Sudan. From 2010–2016 the exchange rate saw many fluctuations, because ofdecrease in oil prices due to the global economic crisis. The decline in the inflow of foreign currency that followed led to another split in the exchange markets, into official and black market rate. Recently, in the aftermath of the secession of South Sudan in July 2011, Sudan has suffered numerous economic challenges due to the sudden lack of oil revenues. As a result, the exchange rate depreciated rapidly, leading to increase in the black market premium.

The Theoretical Model:

The level of a country's exchange rate at any point in time depends on macroeconomics polices: namely monetary policy, financial policy and foreign trade policy. The government intervenein the market to manage the exchange rate (Supply and demand for foreign and domestic currency in the foreign exchange market)(Stiglitz and Walsh; 2002). According to these policy factors, we can build the exchange rate function as:

$REX_t = F (InG_t, RGDP_t, XPG, M2_t, Inf_t, GG_t, IM_{t,})$ …… (1)

Where, REX_t, GDP_t, InG_t, $Inf_{t,}XPG_t$, Ms_t, GG_t and IM_t are real exchange rate, real gross domestic product, domestic investment, inflation rate, exports, money supply,government spending, and imports.

According to theoretical and empirical evidence, the coefficient of real growth rate of real GDP is expected to be negative; Increase in real growth domestic product is also expected to boost the investment capability of the government in providing investment-enhancing facilities necessary to promote the exchange rate stability. On the other hand, the exchange rate has positive relationship with investment, an increase in exchange rate rise investment demand (Blanchard; 2006). The decline in real exchange rate will make domestic goods cheaper relative to foreign goods and thus increase net exports in the long-run. Because a drop in the real exchange rate raises the cost of imports, however, it may cause net exports to fall in the short-run before physical flows of exports and imports have had time to adjust (Abel and Bernanke, 2001).Based on the concept of the exchange rate, any increase in the supply of money would lead to the purchase of a unit. Foreign exchange is the result of any other commodity whose price will be increased for a limited term at least in the short term. However, the increase in the money supply will push the exchange rate upwards and this reflects a direct and strong relationship between money supply and exchange rate and moving in a positive direction. Abdul-Hussain. (2011).

The empirical Model: Autoregressive Distributed Lag (ARDL) Approach Estimation Procedures:

In the current study, the ARDL test for co-integration is employed for the following certain econometric advantages in comparison to other co-integration procedures, it is mentioned by Oztutk and Acaravic (2010). The ARDL modeling approach was originally introduced by Pesaran and Shin (1999) and later extended by Pesaran et al. (2001). Basically, the ARDL approach to co-integration involves two steps for estimating long-run relationship (Pesaran et al. 2001). Bahmani-Oskoee and Bohi (2000) suggest that the results of this first step are usually sensitive to the order of lags. The optimal lag is selected by using Akik Information Criteria (AIC).Then the study imposes different lags order on the first difference of each variable and computes the F- statistic for the joint significance of lagged levels of variables. The computed F-statistic for each order of the lags is compared with F-critical value in testing the existence of a long-run relationship. Thus, the unrestricted error correction model (UECM) frameworks for Equations (1) are;

$$\begin{aligned}\Delta \mathrm{LnEXR_t} = \alpha_4 &+ \sum_{i=1}^{p} \beta_{1i}\Delta \mathrm{Ln\ EXR_{t-1}} + \sum_{i=0}^{p} \beta_{2i}\Delta \mathrm{LnRGDP_{t-1}} + \sum_{i=0}^{p} \beta_{3i}\mathrm{i}\Delta \mathrm{LnXPG_{t-1}} \\ &+ \sum_{i=0}^{p} \beta_{4i}\Delta \mathrm{Ln}InG_{t-1} + \sum_{i=0}^{p} \beta_{5i}\Delta \mathrm{LnM2_{t-1}} + \sum_{i=0}^{p} \beta_{6i}\Delta \mathrm{LnGG_{t-1}} \\ &+ \sum_{i=0}^{p} \beta_{8i}\Delta \mathrm{Ln\ Inf_{t-1}} + \sum_{i=0}^{p} \beta_{9i}\Delta \mathrm{Ln\ IM_{t-1}} + +\delta 8\mathrm{LnEXR_{t-1}} \\ &+ \delta 1\mathrm{LnRGDP_{t-1}} + \delta 2\mathrm{Ln\ XPG_{t-1}} + \delta 3\mathrm{Ln\ InG_{t-1}} + \delta 4\mathrm{Ln}\ Inf_{t-1} \\ &+ \delta 5\mathrm{LnM2_{t-1}} + \delta 6\mathrm{LnGG_{t-1}} + \delta 7\mathrm{LnIM_{t-1}} + \varphi it4 \dots\dots\dots\dots\dots\dots (2)\end{aligned}$$

Where all the variables are as previously defined in equations (1), Δ is the first difference operator, p is optimal lag length, the residuals are φit assumed to be normally distributed and white noise. For these equations, the F-test can be used to examine whether a long-run equilibrium relationship exists between the variables, by testing the significance of the lagged level variables. The null hypothesis of no co-integration in each equation above is that:

Ho: δ1= δ2= δ3= δ4= δ5= δ6= δ7= δ8= δ9=0 while, the alternative hypothesis (existence of co integration) is that;H_1: δ1≠ δ2≠ δ3≠ δ4≠ δ5≠ δ6≠ δ7≠ δ8≠ δ9≠0

The rejection of the Ho in a particular equation implies that the independent variables are the long run forcing variables for the dependent variable. On other words, if the dependent variables deviate from the long run equilibrium path as results of shock, the independents variables interact together and correct this disequilibrium and bring the dependent variable to it is long run path.

The F-test has a non-standard distribution which depends on (i) whether variables included in the model are I(0) or I(1), (ii) the number of regressors, and (iii) whether the model contains an intercept and/or a trend. Given a relatively small sample size in this study the critical values used are as reported by Pesaran and Pesaran (1997).The

test involves asymptotic critical value bounds, depending whether the variables are I(0) or I(1) or a mixture of both. Two sets of critical values are generated where one set refers to the, I (1) series; and the other for the, I (0) series.

Critical values for the I(1) series are referred to as the upper bound critical values, while the critical values for I(0) series are referred to as the lower bound critical values. If the F test statistic exceeds their respective upper critical values, we can conclude that there is evidence of a long-run relationship between the variables regardless of the order of integration of the variables. If the test statistic is below the lower critical value, we cannot reject the null hypothesis of no co-integration. If it lies between the bounds, a conclusive inference cannot be made without knowing the order of integration of the underlying regressors. In the case where the F statistic falls between the lower bound and the upper bound critical value, it is recommended to consider the t- test corresponding EC_{T-1}, if it is significant, this suggests the existence of co-integration among the variables (Mosayeb and Mohammad 2009).Thus, if there is evidence for the existence of cointegration (long-run relationship) between variables, the next step involves selecting the appropriate lag orders of the dependent variable and regressors involved to obtain what is known as the conditional (restricted) ARDL model (Saber, 2013). This is normally accomplished by applying OLS methods to estimate the general ARDL model of the form:

$$\begin{aligned}\Delta \mathrm{LnEXR}_t = \alpha_4 &+ \sum_{i=1}^{q} \gamma_{1i} \mathrm{Ln\ RGDP}_{t-1} + \sum_{i=0}^{p1} \gamma_{2i} \mathrm{Ln\ InG}_{t-1} + \sum_{i=0}^{p2} \gamma_{3i} \mathrm{LnXPG}_{t-1} \\ &+ \sum_{i=0}^{p3} \gamma_{4i} \mathrm{Ln} Inf_{t-1} + \sum_{i=o}^{p4} \gamma_{5i} \mathrm{Ln\ M2}_{t-1} + \sum_{i=o}^{p5} \gamma_{6i} \mathrm{LnEXR}_{t-1} \\ &+ \sum_{i=0}^{p6} \gamma_{7i} \mathrm{Ln\ GG}_{t-1} + \sum_{i=o}^{p7} \gamma_{8i} \mathrm{LnIM}_{t-1} + \sum_{i=0}^{p8} \gamma_{9i} \mathrm{Ln\ Ex}_{t-1} \\ &+ \mathrm{U}_t \dots\dots\dots\dots\dots\dots (3)\end{aligned}$$

Where, all variables in equations (2 and 3) are as previously defined in equation (1) above.

Error Correction Model (ECM):

After obtaining estimates of the long-run parameters, the estimated equation is also used to obtain an estimate of the error correction term (EC_{t-1}), which is obtained from above Equations (4) as:

$$ECT_t = LnEXR_t - \alpha_4 - \sum_{i=1}^{q} \gamma_{1i} Ln\ RGDP_{t-1} - \sum_{i=0}^{p1} \gamma_{2i}\ Ln\ InG_{t-1} - \sum_{i=0}^{p2} \gamma_{3i}\ LnXPG_{t-1} - \sum_{i=0}^{p3} \gamma_{4i}\ Ln Inf_{t-1} - \sum_{i=o}^{p4} \gamma_{5i} Ln\ M2_{t-1} - \sum_{i=o}^{p5} \gamma_{6i}\ LnEXR_{t-1} - \sum_{i=0}^{p6} \gamma_{7i} Ln\ GG_{t-1} - \sum_{i=o}^{p7} \gamma_{8i}\ LnIM_{t-1} - \sum_{i=0}^{p8} \gamma_{9i} Ln\ EXR_{t-1} \dots\dots\dots\dots\dots\dots (4)$$

where all variables in equations (4) is a previously defined in equation (1) above.

After the long-run parameters and the error correction terms are estimated, the final step involves estimating the short-run dynamic parameters by applying OLS to the error correction representation of the conditional ARDL model in Equation (4). The ECM models are given by:

$$\Delta LnEXR_t = \alpha_t + \sum_{i=1}^{q} \gamma_{1i} \Delta Ln\ EXR_{t-1} + \sum_{i=1}^{q} \gamma_{1i} Ln\ RGDP_{t-1} + \sum_{i=0}^{p1} \gamma_{2i}\ Ln\ InG_{t-1} + \sum_{i=0}^{p2} \gamma_{3i}\ LnXPG_{t-1} + \sum_{i=0}^{p3} \gamma_{4i}\ Ln Inf_{t-1} + \sum_{i=o}^{p4} \gamma_{5i} Ln\ M2_{t-1} + \sum_{i=o}^{p5} \gamma_{6i}\ LnEXR_{t-1} + \sum_{i=0}^{p6} \gamma_{7i} Ln\ GG_{t-1} + \sum_{i=o}^{p7} \gamma_{8i}\ LnIM_{t-1} + \varphi_1 ECT_t \dots\dots\dots\dots\dots\dots (5)$$

where EC_T is the error correction terms in (5) obtained from Equations (4). The parameters γ_{th} in the above Equations are the short-run dynamic coefficients which measure the model's convergence to equilibrium, while the coefficient of the error correction terms are the adjustment parameters, which gives the proportion of the deviations (errors) of the dependent variables from their long-run equilibrium values that have been adjusted (corrected). The coefficients must be negative and statistically significant. The negative sign of the coefficients mean that the dependent variables adjust back to their equilibrium values (or the dynamic model converges to equilibrium) following a disturbance, the magnitude of the coefficients measure the speed of adjustment.

Data:

The data set included all the variables under study for the Sudan and generally covered the period (1980-2016). The data obtained primarily from the annual reports from the Central Bank of Sudan (CBOS) database, Central Bureau of Statistic and World Bankreports. Thus, the data used is essentially of secondary nature.

Analytical Methods:

In this study, non-stationarity was tested with the Augmented Dickey-Fuller test. So, initially we have to investigate the order of integration. This is to ensure that the variables are not 1(2) stationary to avoid spurious results. In the presence of 1(2) variables the computed F-statistics provided by Pesaran et al (2001) are not valid. Because the bound test is based on the assumption that the variables are 1(0) or 1(1), therefore, the implementation of unit root tests in the ARDL procedure might still be necessary in order to ensure that none of the variables is 1(2) or beyond.

ADF Unit Root Tests:

The results of the ADF test are reported in Table (2). The results suggest that all the variables are integrated of order one i.e. stationary after first difference. This result gives support to the use of ARDL bounds approach to determine the long-run relationships among the variables.

Table(2): ADF Unit Root Tests for Stationarity of Variables

Variable	Calculated ADF statistic					Order of IntegrationI(d)
	Levels		Ist differenced			
	With Intercept	With Intercept and trend	With intercept	With Intercept and trend	Without intercept and trend	
LnRGDP	-0.680176	-2.058810	-5.379695**	-5.417128**	-5.417422**	I(1)
LnXPG	-1.886255	-2.887360	-7.180707**	-7.072949**	-7.290872**	I(1)
LnInG	-3.522168*	-4.026731*	-6.364763**	-6.326205**	-6.461124**	I(0)
LnInf	-1.977088	-2.097878	-8.237375**	-8.117117**	-8.361493**	I(1)
Ln GG	-1.593625	-1.976441	-5.008720**	-4.931988**	-5.083879**	I(1)
LnREX	-5.872502**	-6.348835**	-6.922744**	-6.817308**	-7.030082**	I(0)
LnM2	-1.195243	-1.481329	-5.071152**	-4.996690**	-5.086086**	I(1)
LnIM	-8.836993**	-8.642659**	-5.062302**	-2.265592	-6.706555**	I(0)

Source: Author's calculations. **, and * mean significant at 1% and 5%, respectively

Bounds test for Co-integration Analysis:

Now having the fact that variables under consideration are stationary at their first difference, long-run equilibrium relationship will be now investigated by using the bounds test for co-integration within ARDL modeling approach (Pesaranet al (2001). In the first step of the ARDL analysis we test for the presence of long-run relationships in model. Given the fact that we have annual time series data and limited number of observations (35), the lag length will be restricted to three. Table (3) reports results of the bound test for the existence of a long run relationship.

Table (3): Bounds test for Co-integration Analysis

Model	F-statistics	Critical value bounds of the F-statistics			
		1% Level		5% Level	
		1(0)	1(1)	1(0)	1(1)
REX	3.60	2.45	3.79	1.91	3.11

Source: Author's calculations. Critical Values are from Pesaran et al. (1999)

As showed in table (3) the calculated F-statistics in the model is higher than the upper bound critical value at the 1% significant level. This implies that the null hypothesis of no co-integration cannot be accepted and that there is indeed a co-integration relationship among the variables in each of the models.

Estimation of Long-run Coefficients of (ln(REX):

Table 4 reports the estimation results of exchange rate model in the long run, it indicates that the values of adjust R- square equal to 99%. F value is higher than its critical value suggesting a good overall significance of the estimated model.

Table; (4): Estimation of long-run Coefficients Using the Selected ARDL Model for (ln(REX)

Variable	Coefficient	t-Statistic	Prob	R^2	R^{-2}	F-statistic	Prob(F-statistic
C	1.018360	0.694934	0.4933	0.99	0.99	1627.088	0.000000
LOG(RGDP(-1))	-1.155022	-4.945891	0.0000				
LOG(XPG(-1))	-0.573055	-2.924229	0.0071				
LOG(ING(-1))	0.033904	0.195026	0.8469				
LOG(INF(-1))	0.486963	3.952159	0.0005				
LOG(REX(-2))	0.770092	5.740249	0.0000				
LOG(M2(-3))	0.560465	1.816457	0.0808				
LOG(GG(-1))	0.525711	2.045437	0.0511				
LOG(IM(-2))	0.457531	2.434074	0.0221				

Source: Author's calculation.

It is obvious from Table 4 that in the long run real gross domestic product GDP has negative and statistically significant effects on real exchange rate REX in the long run. Other things being equal; a 1% rise real GDP leads to a decrease in real exchange rate REX over time by -1.16 percentage points (appreciation of domestic currency). The relation between them in terms of elasticity remains very strong this means that the real GDP is aconsidered important factor for exchange rate. This result is consistent with Elfaki. K (2018) and Dafalla.M and, Ahmad.S (2018). As expected the coefficient of exports is negative and statistically significant effects on real exchange rate REX in the long run.a 1% rise exports leads to decrease on real exchange rate REX over time by -0.57 percentage points (appreciation of domestic currency). This result it is consistent with economic theory, and it is consistent with Elfaki. K (2018) and Dafalla.M and, Ahmad.S (2018). While investment has a positive and statistically insignificant effect on real exchange rate REX in the long run in Sudan. Other things being equal; a 1% rise domestic investment leads to an increase in real exchange rate REX over time by 0.03 percentage points (depreciation in Sudanese pound). Also the results show that the coefficient of inflation rate is positive and statistically significant at 1% level. Other things being equal; a 1% rise inflation rate leads to an increase on real exchange rate REX over time by 0.49 percentage points (depreciation in Sudanese pound). The results show that the coefficient of money supply is positive and statistically significant at 1% level. Other things being equal; a 1% rise money supply leads to an increase in real exchange rate REX over time by 0.56 percentage points (depreciation in Sudanese pound). The coefficient of government spending (GG) is positive and statistically significant at 1% level. Other things being equal; a 1% rise government spending (GG) leads to an increase in real exchange rate REX over time by 0.10 percentage points

(depreciation in Sudanese pound). Lastly the results show that the coefficient of imports is positive and statistically significant at 10% level. Other things being equal; a 1% rise imports leads to an increase in real exchange rate REX over time by 0.46 percentage points. According to the results in table (4) it is clear that the real GDP, exports, government spending and money Supply are the most important factors impacted on real exchange rate REX in long-run in Sudan.

Diagnostic Tests of the Estimated Long-run ARDL Models:

In this subsection we discuss the diagnostic test of the estimation long run (ARDL) models, namely normality, functional form, Autocorrelation and Heteroscedasticity Tests.

Normality and Functional Form Test:

The Jarque-Bera test for normality compares the third and fourth moments of the residuals to those of the normal distribution and analyzes under the null hypothesis of normal distribution.

The results of the residual analysis tests for equation are summarized in table (5). It can also be observed that the residuals are normally distributed in model.

Table:(5): Normality and Functional Form Tests

Models	Normality					Functional form	
	(Jarque-Bera)		Kurtosis	Skewness	AIC	Ramsey Reset	
	F-statistic	Prob				F-statistic	Prob
Ln(EXR)	1.88877	0.443154	2.076295	0.256364	0.578788	3.90007	0.9951

Source: Authors' calculation.

Autocorrelation and Heteroscedasticity Tests

We used Darbin-Watson (D-W) test, and Breusch – Godfrey test to detecting the autocorrelation problem. The results are summarized in the table (6) below. Also we used the White test to know whether the models are suffering from heteroscedasticity problem or not.

Table:(6): Autocorrelation and Heteroscedasticity

model	Autocorrelation			Heteroscedasticity	
	D-W	Breusch-godfrey		White	
		F-statistic	Prob	F-statistic	Prob
Ln(EXR)	2.23	2.755450	0.0837	0.0837	0.7406

Source: Authors' calculation.

Table (6) showed that White heteroscedasticity test statistic with cross terms it is significant, suggesting that there is no heteroscedasticity in the models. Table (6) Above shows that the Durbin Watson test is almost equal or near to 2 Breusch-Godfrey test statistics for serial correlation are significant for the all models.

Stability Testing of the Parameters:

The plots of the CUSUM and CUSUMSQ in Figs (1, 2) are obtained from a recursive estimation of the model. These plots indicate stability in the coefficients of the models.

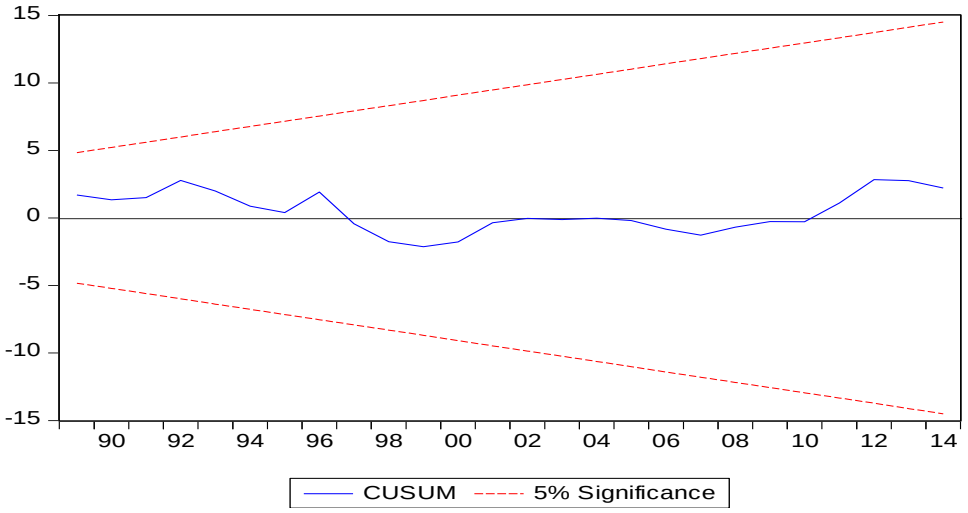

Fig.(1): Cumulative sum of recursive of residuals

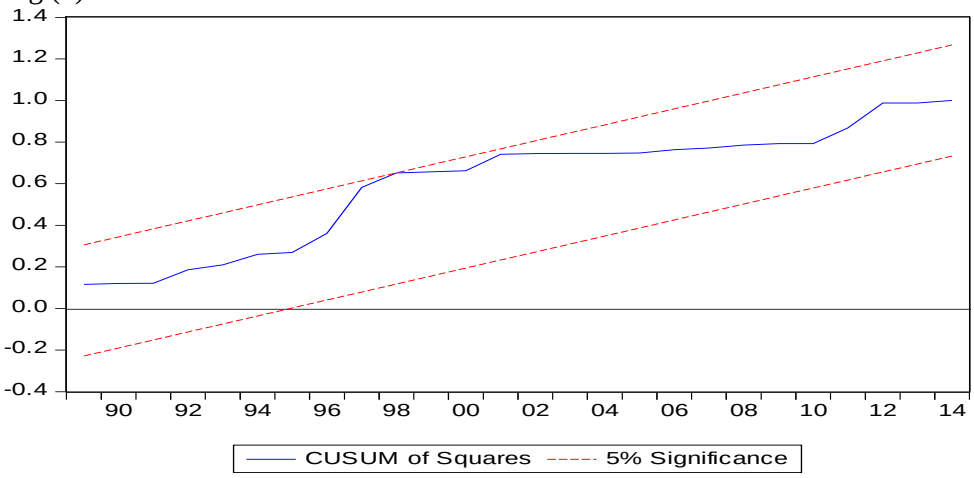

Fig.(2): Cumulative sum of recursive of residuals:

Estimation of the Short-run Dynamic Coefficients: D (LnREX):

The estimation results given in table (7) clearly indicate a very good values of adjust R- square, since 97% variation in dependent variable has been explained by variations in independent variables. F value is higher than its critical value suggesting a good overall significance of the estimated model.

Table (7): Estimation of the Short-run Dynamic Coefficients of the Error Correction Representations of the ARDL Model D(LnREX)

Variable	Coefficient	t-Statistic	Prob	R^2	R^{-2}	F-test	prob
C	-0.106842	-1.668729	0.1705	0.99	0.97	211.5329	0.000054
D(LOG(RGDP(-2)))	-3.274128	-4.510586	0.0107				
D(LOG(XPG(-2)))	-0.401087	-4.725793	0.0091				
D(LOG(ING(-1)))	0.697122	4.780953	0.0088				
D(LOG(INF(-1)))	-0.484888	-4.666733	0.0095				

D(LOG(REX(-1)))	3.615275	23.10982	0.0000
D(LOG(M2(-3)))	3.801095	6.634785	0.0027
D(LOG(GG(-1)))	0.660011	2.399430	0.0744
D(LOG(IM(-1)))	0.452482	2.392659	0.0750
EC (-1)	-0.566882	-4.905190	0.0080

Source: Author's calculation

The results indicate that, in the short run real GDP variable affect on real exchange rate REX in Sudan negatively. This coefficient indicates that, other things being equal, a 1% rise in real GDP leads to decrease on real exchange rate REX over time by 3.27 percentage points. This result is consistent with economic theory (see empirical literature). The relation between them in term of elasticity remains very strong this means that the real GDP is considered important factor for exchange rate.As well as the results show that exports has negative effect on real exchange rate REX in the short run. But despite the fact that, the level of exports exerts negative and statistically significant impact on on real exchange rate REX at 5 percent in the short run, the relationship between them in term of elasticity remains very low i.e. a one percent increase in export leads to a fall in on real exchange rate REX by 0.40 in the short run. The results indicate that real domestic investment has positive and statistically insignificant effect on real exchange rate REX in the short – run. This coefficient indicates that, other things being equal, a 1% rise in real domestic investment has leads to an increase on real exchange rate REX over time by 0.70 percentage points. The coefficient of the real domestic investment has wrong sign in the short run, which is inconsistent with economic theory (see empirical literature). Also the results show that the coefficient of inflation rate is negative and statistically significant at 1% level. Other things being equal; a 1% rise inflation rate leads to a decrease on real exchange rate REX over time by 0.49 percentage points. Money supply has positive and statistically significant effects on real exchange rate REX. This coefficient indicates that, other things being equal, a 1% rise in money supply leads to increase on real exchange rate REX over time by 3.80 percentage points. The relation between them in term of elasticity remains very strong this means that the money supply is considered one important factor for exchange rate. The coefficient of the government spending is positive and statistically significant, a 1% rise in government spending leads to increase on real exchange rate REX over time by 0.66 percentage points. This result is consistent with economic theory. Lastly the results show that the coefficient of imports is positive and statistically significant at 1% level. Other things being equal; a 1% rise imports leads to an increase on real exchange rate REX over time by 0.45 percentage points.The results showed that the adjustment coefficient (EC_{-1}) with a negative sign and statistically significant, these findings indicate that the presence of error correction mechanism works in this form. The coefficients of EC_{-1} are equal to (-0.57) and imply that deviation from the long-term real exchange rate REX is corrected by only 57% percent in the model. According to the results in table (7) above it is clear that the real

GDP, exports, government spending andmoney Supply are the most important factors affected on real exchange rate REX in short-run in Sudan.

Diagnostic Tests of the Estimated Short-run ARDL Models:

The diagnostic tests of the estimated short run (ARDL) modelsareNormality, Functional Form, and Autocorrelation and Heteroscedasticity tests.

Normality and Functional:

The Jarque-Bera test for normality compares the third and fourth moments of the residuals to those of the normal distribution and analyze under the null hypothesis of normal distribution.

Table(8): Normality and Functional form Tests

Model	Normality				Functional form		
	(Jarque-Bera)		Kurtosis	Skewness	AIC	RamseyReset	
	F-statistic	Prob				F-statistic	Prob
Ln(REX)	0.862089	0.649830	2.080458	0.397589	-2.086344	1.960118	0.2560

Source: Author's calculation.

The results of the residual analysis tests for equation are summarized in table (8). It can also be observed that the residuals are normally distributed in the model.

Autocorrelation and Heteroscedasticity Tests

The famous test which used to detect the autocorrelation problem is Darbon-Watson (D-W) and Breusch – Godfreystatistic.

Table (9): Autocorrelation and Heteroscedasticity Tests

Model	Autocorrelation			Heteroscedasticity	
	D-W	Breusch-godfrey LM		White	
		F-statistic	Prob	F-statistic	Prob
Ln(REX)	1.7174	0.182006	0.8460	0.634108	0.7385

Source: Author's calculation

Table (9) shows that the Durbin Watson test is almost equal or near to 2, and the probability value to Breusch – Godfrey test (LM Test) using two period lags is greater than 5% level these results indicate that there are no autocorrelation problem in all equations. The result also indicate that the probability value of White test is greater than 5% level which mean that there is no heteroscedasticity problem in the equations. Therefore, fitness of the model is acceptable empirically.

The Testing of Stability for parameters in Short-run Relationships:

The plots of the CUSUM and CUSUMSQ proposed by Brown et al (1975), in Figs (3, 4) below are obtained from a recursive estimation of the model. These plots indicate stability in the coefficients of all models.

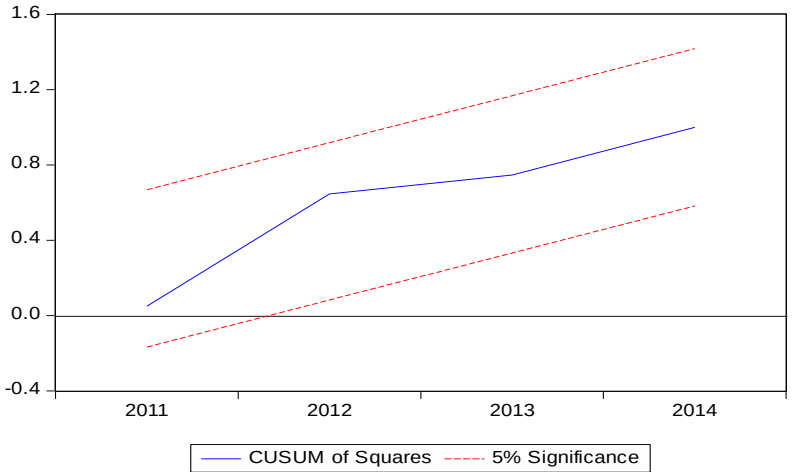

Fig.(3): Cumulative sum of recursive of residuals

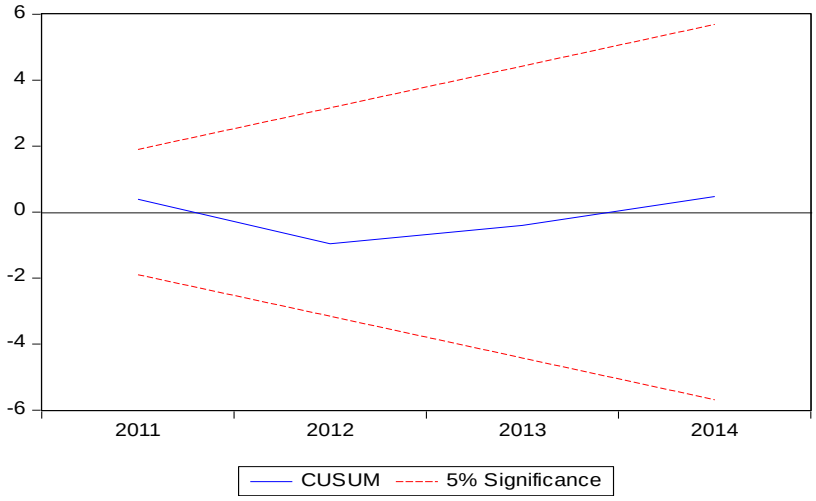

Fig.(4): Cumulative sum of recursive of residuals

The Results of Estimated Long-run Exchange Rate Model:

1. Real GDP has negative and statistically significant effects on exchange rate in the long run and short run.
2. Real exports have negative and statistically significant effects on exchange rate in the long run and short run.
3. Real money supply, real domestic investment,real government spending and real importshavepositive and statistically insignificant effects on exchange rate in the long run. While they have statistically significant effects on exchange rate in the short run.
4. The inflation rate has negative and statistically significant effects on the exchange rate in the long run and short run.

The Recommendations:

1. The real GDP has been identified as one of the principal determinants of exchange rate thus, the policy that lead to stability in exchange rate should be adopted, as well as

allocating considerable amount of expenditure to key sectors (agriculture, industrial, and infrastructure) .

2. The government should encourage and diversification of exports in order to maintain surplus or stability in the current account.

3. The government should control money supply to reduce inflation and stable exchange rate regime.

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