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The Determinants of Inflation in Sudan

” Empirical Assessment Based on an Application of the Autoregressive Distributed Lag (ARDL) Model 1980-2014”

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المستخلص :

الهدف من هذه الدراسة معرفة العلاقة في الأجل الطويل والأجل القصير بين التضخم ومحدداته (النمو الاقتصادي، عرض النقود، الصادرات ، والاستثمار المحلي ، وتكلفة التمويل) في السودان. كذلك تم تضمين ثلاثة متغيرات محكمة وهي : سعر الصرف ، الإنفاق الحكومي ، والاستثمار الاجنبي المباشر. اعتمدت الدراسة علي بيانات سنوية تغطي الفترة (1980-2014) والتي تم الحصول عليها من التقارير السنوية لبنك السودان والجهاز المركزي للإحصاء، اضافة لاستخدام اسلوب الانحدار ذو التباطؤ الموزع (ARDL) بالإضافة إلى نموذج تصحيح الخطأ (ECM). تشير النتائج الي أن الناتج المحلي الإجمالي الحقيقي والاستثمار لهما تأثير سلبي على التضخم في المدى الطويل، بينما الصادرات وعرض النقود لهما أثر إيجابي على التضخم. وبالإضافة إلى ذلك، تشير النتائج إلى أن الناتج المحلي الإجمالي الحقيقي والاستثمار والعرض النقدي لها تأثير إيجابي على التضخم في المدى القصير، في حين أن للصادرات تأثير سلبي على التضخم. وفيما يتعلق بمتغيرات التحكم، تشير النتيجة إلى أن سعر الصرف والاستثمار الأجنبي المباشر والإنفاق الحكومي لها تأثير إيجابي على التضخم في المدى القصير. حيث أن عرض النقود وسعر الصرف من أهم محددات التضخم في السودان. وأظهرت النتائج أن معامل التكيف (EC_1) ذو علاقة سلبية ومعنوي إحصائيا، تشير هذه النتائج إلى أن آلية تصحيح الخطأ تعمل في هذا النموذج، كما إن معامل EC_1 تساوي (-1.74) وتعني أن الانحراف عن التضخم طويل الأجل يتم تصحيحه بنسبة 174% فقط في النموذج. وأوصت الدراسة بتخفيض التضخم وذلك بإتباع سياسات مالية ونقدية مناسبة.

ABSTRACT:

The objective of the study is to examine the existence of a long and short run relationship between inflation and its determinants (GDP growth, money supply, domestic investment, exports, and cost of finance) in Sudan. Three control variables are included in the analysis, namely, exchange rate, government spending, and foreign direct investment. The study depended on annual time series data covering the period (1980-2014), which are collected from the Central Bank of Sudan and Central Bureau of Statistics. In addition, the study used Auto Regressive Distributed Lag (ARDL) approach associated with Error Correction Method (ECM). The results indicated that real GDP and investment have negative effect on inflation in the long run, while exports and money supply have positive effect on inflation. With regard to control variables, the result indicated that exchange rate and government spending have positive effect on inflation. In addition, the results indicated that real GDP, investment and money supply have positive effect on inflation in the short-run, while exports has a negative effect on inflation. With regard to control variables, the result indicated that exchange rate, foreign direct investment and government spending have positive effect on inflation in the

short run; since money supply and exchange rate are considered to be among the key determinants of inflation in Sudan. The results showed that the adjustment coefficient (EC_{-1}) has a negative sign and statistically significant, these findings indicated that the presence of error correction mechanism operates in this model. Also, the coefficients of EC_{-1} are equal to (-1.74), which imply that deviation from the long-term inflation is corrected by only 174% in the model. The study calls for reducing the inflation through adopting suitable monetary and fiscal policies.

Keyword : Inflation, Domestic Investment, Autoregressive Distributed Lag (ARDL)

Introduction:

Inflation is defined as sustained rise in the general price level, which results in the depreciation of the value of the currency during a specific period of the time. Inflation is calculated from the weighted price index of group of goods (basket of goods and services) and weighted them (the percentage of expenditure on the goods to total expenditure) over certain period of time. Economists often use inflation to refer only to increases in the price level that continue over some significant period. We will refer to such periods as periods of sustained inflation (Case and Fair 2004). Theoretically, it has been established that inflation causes many distortions in an economy. When prices of consumables increase, real income of households decreases and hence, they cannot buy as much as they used to buy previously. Another devastating effect of inflation is that it makes it more difficult for entrepreneurs to plan their activities, especially with regard to how much to produce since under inflationary periods, it is more difficult to predict effective demand and the average costs of production. In this regard, higher rates of inflation usually culminate in increasing the level of uncertainty with respect to future prices, interest rates, and exchange rates, which in turn increase the risks among potential trade partners, and thereby discouraging both domestic and foreign trade. The rationale behind used data from (1980-2014) this period witness high inflation and some radical policies e.g move from government intervention to liberalization in early 1992, there was a process of very high inflation from 1980-1996. at the end of 2000s average annual inflation rate increases from an average of 9.50% during the sub-period 2005-2009 to an average of 21.80% during 2010-2014. Against this background, the main questions of this study are: what are the determinants of inflation in Sudan.

The objective of this research is to examine the determinants of inflation in Sudan by using time series data covering the period (1980-2014).

The hypotheses to be tested can be stated as follow:

1. There are a long- run and short-run relationship between inflation and some macroeconomic indicators in Sudan.
2. It is hypothesized that real GDP affect inflation negatively in the long run and short run.
3. It is hypothesized that money supply and exports affects inflation positively in the long run and short run.
4. It is hypothesized that domestic investment affects inflation negatively in the long run and short run.

The important of this study is that it will help to identify the factors that affecting inflation in Sudan. Policy makers can use the result of this study on implementing monetary and fiscal policies to overcome the inflation rate in Sudan.

Empirical Studies about the Determinants of Inflation:

Recently, there have been several studies of inflation in low-income countries. For example, Abdalla. M, M (2009) examined inflation dynamics in Sudan, it focuses essentially on empirical methodology, the research adopted Structural Vector Autoregressive (SVAR), Error

Corrections and fiscal dominance models, the findings revealed that the exchange rate is the major cause behind inflation; deficit financing by printing money which caused monetary expansion also found to be the main determinant of inflation in Sudan over the period (1970-2008).

Hossain, (2005) examined the dynamic relationship between money, output, prices, and the exchange rate within an error-correction modeling framework, the results confirmed the long run relationship between money growth and inflation.

Kandil and Morsy (2009) provided an empirical evidence that inflation in trading countries represents the most important foreign factor that influence domestic inflation in oil-rich Gulf Cooperation Council (GCC).

Islam. et al., (2017) examined the determinants of factors that affecting inflation in Malaysia. The results showed that the relationship between the independent variables namely money supply, exchange rate and unemployment rate on inflation, proved the negative relationship between inflation and unemployment rate. Exchange rate also has a negative relationship with inflation as well and there is a positive relationship between inflation and money supply

Christensen (2001) and Alvarez et al. (2001), Grauwe and Polan (2005) said that money supply and inflation rate have a positive relationship in long term. This is because, when Central Bank decided to increase the money supply in market, undoubtedly it will decrease the interest rate at the same time. So, this situation will lead to problem of inflation as the money supply in market is increasing unlimitedly.

Gkal and Hanif (2004), Ahmed and Mortaza (2005), and Sweidan (2004) examined relationship between inflation and economic growth. They found that a statistically significant long-run negative relationship between inflation and economic growth.

Fraia and Carneiro (2001) and Chimobi (2010) investigated the relationship between inflation and output in Brazil, during the period 1980-95. They found that inflation does not impact real output in the long run, but that in the short run there exists a negative effect from inflation on output. Moriyama, K (2008) investigated inflation dynamics in Sudan using three different approaches: The estimated results suggest that money supply growth and nominal exchange rate changes affect inflation with 18-24 months time lag.

Determinants of Inflation:

There are many factors determine inflation first money supply (Inflation rate depends on growth rate of money supply and growth rate of money demand. If rapid money growth rate causes inflations, government sometimes find that printing money (borrowing from the central bank) is the only way that they can finance their expenditures. According to classical theory the relationship between money supply and inflation is positive. Monetarist views suggest a single direction of causation from monetary growth and inflation is clear that expansion of the rate of growth of money supply, through an open-market operation, will increase the inflation rate by the same amount if there is no effect of monetary growth on growth of output (McNabb and Mckenna; 1990)); second interest rate (Taylor rules give a useful way of thinking about the choice of the nominal interest rate. The rule state that the Central Bank should move its interest rate in the response to two main factors; the deviation of inflation rate from the target rate of inflation, and the deviation of the unemployment rate from the natural rate of unemployment); third, potential GDP (An increase in potential GDP reduces the output and lowers inflation at each level of output). The relationship between real output and inflation is negative. Because of surplus of aggregate supply led to decrease on general price level. In the short-run the relationship between inflation and real GDP it depend upon the slope of the Phillips curve and the fixed parameter that related GDP and unemployment); four Cost of Production (An increase in any factor of production, energy price raises the cost of production at given level of the output this leads to increase in

inflation. In response to the increase in their cost, firms raised price of its production, leading to a jump in the inflation rate.); five domestic investment; finally exports;

Inflation in Sudan:

Table (1) reports the annual average rate of inflation during (1980-2014) computed by the consumer price index (CPI).

Table (1): Consumer price index, Rate of inflation and Money Supply (M2)

Years	Average Consumer price index	Average Rate of inflation	Average Money Supply (M2)SDG Million
1980-1984	0.02	36.72	2.48
1985-1989	0.07	44.32	12.10
1990-1994	2.76	127.42	180.02
1995-1999	37.62	52.06	1623.54
2000-2004	70.31	6.96	6073.38
2005-2009	104.69	9.50	20573.10
2010-2014	212.65	21.80	54025.10

Source: Researchers Own Calculation Based on Central Bureau of Statistics and Central Bank of Sudan (CBOS)

Table (1) shows that the rate of inflation raised 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 war. Also during this period the growth rates of the amount of money were increased with the exception of the years 1981 and 1982.

It is obvious from table (1) above that the average rate of inflation raises dramatically to 127.42 percent in sub period 1990-1994, with an average of more than 100 percent during the early 1990s. The possible explanation of increase inflation rates is that due to low production and productivity. In addition to the large change on the economy, which resulted from oil and wheat import. This period also witnessed the application of certain economic policies (Liberalization policies), to control the management of fiscal policy (government spending and taxes) and monetary policy.

Average annual inflation rate declined from an average of 127.42% percent during the period 1990-1994, to historical low rate of 52.06% percent in the sub-period 1995-1999, and to 6.96 percent in 2000-2004, then to rise slowly to an average of 9.50% percent during 2005-2009. That was mainly attributed to the continuous efforts aimed at reducing inflation rate, encouraging investment, reducing public expenditure and resort to bank deficit financing, in addition to the stability of the exchange rate.

At the end of 2000s average annual inflation rate increases from an average of 9.50% during the sub-period 2005-2009 to an average of 21.80% during 2010-2014, due to the secession of Southern Sudan, the country lost more than 80% of oil exports in favor of the South and therefore Sudan has lost an important part of its revenue, where this period witnessed a rise in the general price level, as the highest rate of inflation over the past fifteen years (Central Bureau of Statistics; 2012).

The Theoretical Model:

The policies can affect inflation and then affect positively or negatively economy's level of output (Stiglitz and Walsh; 2002). According to these policy factors, we can build inflation function as:

$$Inf_t = F(Y_t, In_t, Ms_t, XP_t, CF_t) \quad (1)$$

Where, Y_t , In_t , Inf_t , XP_t , Ms_t and CF_t are gross domestic product, domestic investment, inflation rate, exports, money supply and cost of finance. According to classical theory the relationship between money supply and inflation is positive; implying that increasing money supply would lead to higher prices given the money demand as a function of the velocity and real GDP. It is clear that expansion of money supply, through an open-market operation, will increase the inflation rate by the same amount if there is no effect of monetary growth on growth of output (McNabb and Mckenna, 1990). But the relationship between real output and inflation is negative, an increasing in real output would lead to a decrease in inflation rate (Cherneck, 1983).

Other variable were added to control for the possible effects of other inflation determinants such as exchange rate (EX), government spending (G), and foreign direct investment (FDI). These variables are used as measure of financial, monetary and trade policies, which not only exert direct influence on inflation.

Equation (1) can be written as follow:

$$Inf_t = F(In_t, Y_t, Xp, M2_t, G_t, Ex_t, FDI_t, Cf_t) \dots\dots\dots (2)$$

Domestic investment, exports, money supply, government expenditure, and foreign direct investment measured as ratio to GDP.

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). The first step in the ARDL bounds testing approach is to estimate equations (2) by ordinary least squares (OLS) in order to test for the existence of the long-run relationship between the variables by conducting an F-test for the joint significance of the coefficients of the lagged levels of the variables. In this process of testing co-integration, it is important to determine the order of the lags on the first differenced variables. Bahmani-Oskoe 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 (2) are;

$$\begin{aligned} \Delta \text{Ln}Inf_t = & \alpha_4 + \sum_{i=1}^p \beta_{1i} \Delta \text{Ln} Inf_{t-1} + \sum_{i=0}^p \beta_{2i} \Delta \text{Ln} Y_{t-1} + \sum_{i=0}^p \beta_{3i} \Delta \text{Ln} XP_{t-1} + \sum_{i=0}^p \beta_{4i} \Delta \text{Ln} In_{t-1} + \sum_{i=0}^p \beta_{5i} \Delta \text{Ln} M2_{t-1} \\ & + \sum_{i=0}^p \beta_{6i} \Delta \text{Ln} G_{t-1} + \sum_{i=0}^p \beta_{7i} \Delta \text{Ln} FDI_{t-1} + \sum_{i=0}^p \beta_{8i} \Delta \text{Ln} Ex_{t-1} + \sum_{i=0}^p \beta_{9i} \Delta \text{Ln} CF_{t-1} + \delta_1 \text{Ln} Y_{t-1} \\ & + \delta_2 \text{Ln} XP_{t-1} + \delta_3 \text{Ln} In_{t-1} + \delta_4 \text{Ln} Inf_{t-1} + \delta_5 \text{Ln} M2_{t-1} + \delta_6 \text{Ln} G_{t-1} + \delta_7 \text{Ln} FDI_{t-1} + \delta_8 \text{Ln} EX_{t-1} \\ & + \delta_9 \text{Ln} CF_{t-1} + \phi it4 \dots \dots \dots (3) \end{aligned}$$

Where all the variables are as previously defined in equations (1.2), 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:

$$Ho: \delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = \delta_6 = \delta_7 = \delta_8 = \delta_9 = 0$$

while, the alternative hypothesis (existence of co integration) is that;

$$H_1: \delta_1 \neq \delta_2 \neq \delta_3 \neq \delta_4 \neq \delta_5 \neq \delta_6 \neq \delta_7 \neq \delta_8 \neq \delta_9 \neq 0$$

The rejection of the H_0 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 (Bannerjee et al. 1998, Mosayeb and Mohammad 2009).

The ARDL model requires prior knowledge of the lag orders of variables, which is also sufficient to correct for autocorrelated residuals and the problem of endogenous regressors simultaneously. 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:

$$\Delta \text{LnInf}_t = \alpha_4 + \sum_{i=1}^q \gamma_{1i} \text{Ln } Y_{t-1} + \sum_{i=0}^{p1} \gamma_{2i} \text{Ln } \text{In}_{t-1} + \sum_{i=0}^{p2} \gamma_{3i} \text{LnXP}_{t-1} + \sum_{i=0}^{p3} \gamma_{4i} \text{LnInf}_{t-1} + \sum_{i=0}^{p4} \gamma_{5i} \text{Ln } M2_{t-1} + \sum_{i=0}^{p5} \gamma_{6i} \text{LnCF}_{t-1} + \sum_{i=0}^{p6} \gamma_{7i} \text{Ln } G_{t-1} + \sum_{i=0}^{p7} \gamma_{8i} \text{LnFDI}_{t-1} + \sum_{i=0}^{p8} \gamma_{9i} \text{Ln } Ex_{t-1} + U_t \dots \dots \dots (4)$$

Where, all variables in equations (25, 26, 27 and 28) are as previously definite in equation (2) 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 (25, 26, 27 and 28) as:

$$ECT_t = \text{LnInf}_t - \alpha_4 - \sum_{i=1}^q \gamma_{1i} \text{Ln } Y_{t-1} - \sum_{i=0}^{p1} \gamma_{2i} \text{Ln } \text{In}_{t-1} - \sum_{i=0}^{p2} \gamma_{3i} \text{LnXP}_{t-1} - \sum_{i=0}^{p3} \gamma_{4i} \text{LnInf}_{t-1} - \sum_{i=0}^{p4} \gamma_{5i} \text{Ln } M2_{t-1} - \sum_{i=0}^{p5} \gamma_{6i} \text{LnCF}_{t-1} - \sum_{i=0}^{p6} \gamma_{7i} \text{Ln } G_{t-1} - \sum_{i=0}^{p7} \gamma_{8i} \text{LnFDI}_{t-1} - \sum_{i=0}^{p8} \gamma_{9i} \text{Ln } Ex_{t-1} \dots \dots \dots (5)$$

where all variables in equations (5) is a previously definite in equation (2) 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 (5). The ECM models are given by:

$$\begin{aligned} \Delta \text{LnInf}_t = & \alpha_t + \sum_{i=1}^q \gamma_{1i} \Delta \text{Ln Inf}_{t-1} + \sum_{i=0}^{p1} \gamma_{2i} \Delta \text{Ln In}_{t-1} + \sum_{i=0}^{p2} \gamma_{3i} \Delta \text{LnXP}_{t-1} + \sum_{i=0}^{p3} \gamma_{4i} \Delta \text{LnY}_{t-1} + \sum_{i=0}^{p4} \gamma_{5i} \Delta \text{Ln M2}_{t-1} \\ & + \sum_{i=0}^{p5} \gamma_{6i} \Delta \text{LnCF}_{t-1} + \sum_{i=0}^{p6} \gamma_{7i} \Delta \text{Ln G}_{t-1} + \sum_{i=0}^{p7} \gamma_{8i} \Delta \text{LnFDI}_{t-1} + \sum_{i=0}^{p8} \gamma_{9i} \Delta \text{Ln Ex}_{t-1} \\ & + \phi_1 \text{ECT}_t \dots \dots \dots (6) \end{aligned}$$

where ECT is the error correction terms in (6) obtained from Equations (5). 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.

Diagnostic Tests:

The diagnostic tests examine the stability of the long-run coefficients together with the short-run dynamics based on Pesaran and Pesaran (1997) by applying the CUSUM and the CUSUMSQ proposed by Brown et al (1975). The CUSUM tests basically use the cumulative sum of the recursive residuals based on the first set of N observations and is updated recursively and then plotted against the break points. If the plot of CUSUM remains within the critical bounds at 5%, significance level (represented by clear and straight lines drawn at 5%) the null hypothesis that all the coefficients and the error correction model are stable, cannot be rejected. However, if the two lines are crossed, the null hypothesis of coefficient constancy cannot be rejected. The same analysis applies in the CUSUMSQ test, which is based on the squared recursive residuals. Furthermore, some diagnostic tests for the model are carried out for (1) the serial correlation (F- statistics of Breusch-Godfrey test). (2) The model specification (F- statistics of ARCH) (3) the normality (Skewness, Kurtosis and Jargue- Bera test). (4) The Heteroskedasticity test (F-statistics of white Heteroskedasticity test). The next step is to estimate the short-run relationship.

Data:

The data set included all the variables under study for the Sudan and generally covered the period (1980-2014). The data obtained primarily from the annual reports from the Central Bank of Sudan (CBOS) database, Central Bureau of Statistic and World Bank reports. 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 Integration I(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)
LnCF	-1.528112	-1.703748	-5.587790**	-5.727330**	-5.666216**	I(1)
Ln GG	-1.593625	-1.976441	-5.008720**	-4.931988**	-5.083879**	I(1)
LnFDIG	-8.836993**	-8.642659**	-5.062302**	-2.265592	-6.706555**	I(0)
LnREX	-5.872502**	-6.348835**	-6.922744**	-6.817308**	-7.030082**	I(0)
LnM2G	-1.195243	-1.481329	-5.071152**	-4.996690**	-5.086086**	I(1)

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

Co-integration Analysis:

In this sub-section Co-integration test was used to find the long-run relationship between (real GDP, real exports, investment, cost of finance and money supply) and inflation. Other variables were added to control for the possible effects of other inflation determinants such as government spending, exchange rates, and foreign direct investment.

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 (Pesaran et 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 two. Table (3) reports results of the bound test for the existence of a long run relationship.

Table(3): Co-integration Tests

Model	F-statistics	Critical value bounds of the F-statistics			
		1% Level		5% Level	
		1(0)	1(1)	1(0)	1(1)
INF	4.119865	2.45	3.79	1.91	3.11

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

As showed in the table 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(INF)):

Table 4 reports the estimation results of inflation model in the long run.

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

Variable	Coefficient	t-Statistic	Prob	R ²	R ⁻²
Log(RGDP(-1))	-0.292352	-0.868932	0.3970	0.65	0.63
Log(XPG(-1))	0.405795	2.232799	0.0393		
Log(ING(-1))	-0.283629	-1.068383	0.3003		
Log(INF(-1))	-0.562015	-2.012738	0.0603		
Log(CF(-1))	-0.048487	-0.151310	0.8815		
Log(M2G(-1))	1.506060	1.757063	0.0969		

Log(CF(-1))	-0.048487	-0.151310	0.8815
Log(REX(-1))	-0.336594	-2.313803	0.0335
Log(FDIG (-1))	0.039934	0.412852	0.6849
Log(GG(-1))	-1.004358	-1.723339	0.1030

Source: Authors calculation.

It is obvious from Table 4 that in the long run real GDP have negative and statistically insignificant effects on inflation in the long run. Other things being equal; a 1% rise real GDP leads to decrease on inflation over time by -0.29 percentage points. As expected the coefficient of exports is positive (0.41) statistically significant. This indicates that an increase in exports leads to a decrease of goods in local market, thus the prices increase and then inflation. This result is consistent with economic theory. Also investment has negative but statistically insignificant effect on inflation in the long run in Sudan. Other things being equal; a 1% rise domestic investment leads to a decrease on inflation over time by 0.28 percentage points. This finding is consistent with economic theory, an increase in domestic investment leads to an increase of production of goods, then the excess supply increases and then the prices of goods will decline in the long run (Shapiro; 1982). Also the results show that the coefficient of money supply is positive and statistically significant. Other things being equal; a 1% rise money supply leads to increase on inflation over time by 1.50 percentage points. This finding is consistent with classical and Abdalla (2009) theory because a higher money supply leads to increases the general price level. The cost of finance, as expected, negatively affects inflation rate in the long run. But the relation statistically is insignificant. Other things being equal; a 1% rise in cost of finance leads to a decrease on inflation over time by 0.05 percentage points. This finding is consistent with classical theory because a higher cost of finance leads to lower money supply then the general price level decrease. But this finding is inconsistent with Keynesian theory which argued that an increase in real interest rate will reduce investment spending; by affecting of multiplayer of investment output will change as well as economy's equilibrium level.

With regard to control variables, the results show that the coefficient of exchange rate is negative and statistically significant at 1% level. This result it is consistent with Islam. R. (2017) this is means that exchange rate is important factor that affect inflation in Sudan in the long run, the coefficient of foreign direct investment also is positive and statistically insignificant. Other things being equal a 1% rise foreign direct investment leads to a decrease on inflation over time by 0.04 percentage points. The positive relationship between foreign direct investment and inflation is logical because foreign direct investment in Sudan usually tend to increase funds for investment as well money supply. In addition to that are decreases in output because of lag infrastructural and instability of macroeconomic policies in Sudan. The negative relationship between government spending and inflation is as expected although it is statistically insignificant. Other things being equal a 1% rise in government spending leads to a decrease on inflation over time by 1.00 percentage points. According to the results in table above it is clear that the money supply and real exports are the most important factors impacted on inflation 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					
Ln(INF)	1.627677	0.443154	2.076295	0.256364	0.732315	3.377248	0.0847

Source: Authors' calculation.

Autocorrelation and Heteroscedasticity Tests:

We used Darbin-Watson (D-W) test, and Breusch – Godfrey test to detect the autocorrelation problem. The results are summarized in the table (6) Also we used the White test to know where 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(INF)	1.428061	0.468899	0.6346	0.921044	0.5701

Source: Authors' calculation.

Table (6) above showed that White heteroscedasticity test statistic with cross terms it is significant, suggesting that there is no heteroscedasticity in the models. Table (6) 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.

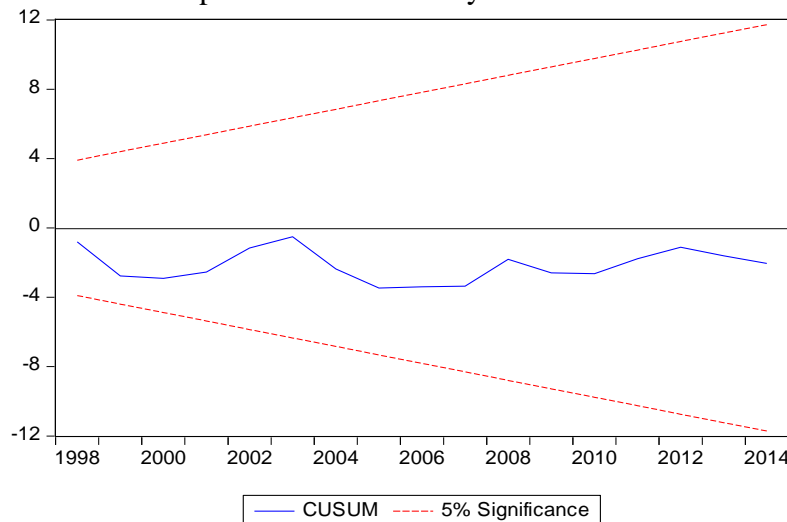
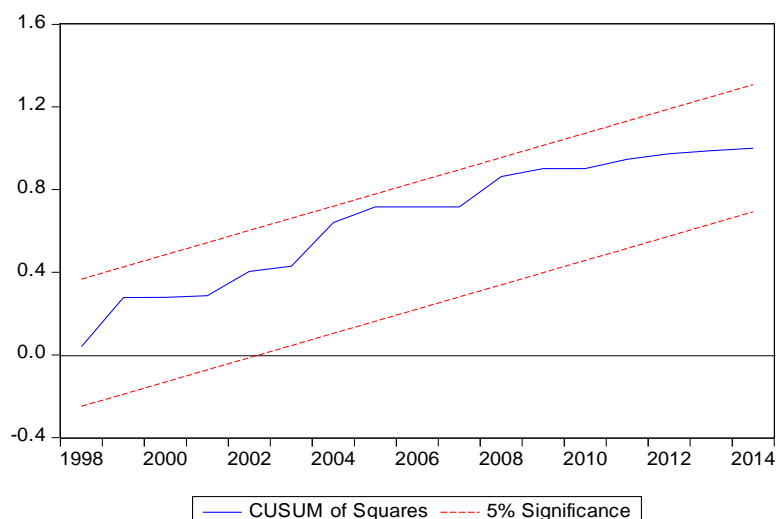


Fig (1): Cumulative sum of recursive of residuals:



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

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

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

Variable	Coefficient	t-Statistic	Prob	R ²	R ⁻²	F-test	prob
C	-0.152590	1.565600	0.1311	0.66	0.52	4.529093	0.001326
D(LOG(RGDP(-1)))	0.586510	1.485588	0.1510				
D(LOG(XPG(-1)))	-0.164467	-1.739141	0.0954				
D(LOG(ING(-1)))	0.233663	1.542569	0.1366				
D(LOG(INF(-1)))	1.054581	4.953334	0.0001				
D(LOG(M2G(-1)))	1.035959	2.000104	0.0574				
D(LOG(CF(-1)))	0.070254	0.215507	0.8313				
D(LOG(REX(-1)))	0.357836	2.003182	0.0571				
D(LOG(FDIG(-1)))	0.053681	0.836573	0.4114				
D(LOG(GG(-1)))	0.311413	0.968324	0.3430				
EC4(-1)	-1.747311	-6.122319	0.0000				

Source: Authors calculation

The results indicate that, in the short run real GDP variable affect inflation in Sudan positively. This coefficient indicates that, other things being equal, a 1% rise in real GDP leads to increase inflation over time by 0.59 percentage points. This result is inconsistent with economic theory (see empirical literature). While the results show that exports have negative effect on inflation in the short run. But despite the fact that, the level of exports exerts negative and statistically significant impact on inflation 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 inflation by 0.16 in the short run. The results indicate that real domestic investment has positive and statistically insignificant effect on inflation in the short – run. This coefficient indicates that, other things being equal, a 1% rise in real domestic investment has leads to increase inflation over time by 0.23 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). This result is consistent with Mohamed (2004) and Ismail et al (2010) results. Money supply has positive and statistically significant effects on

inflation. This coefficient indicates that, other things being equal, a 1% rise in money supply leads to increase inflation over time by 1.04 percentage points. This result is consistent with economic theory. The coefficient of the cost of finance is positive (0.07) and statistically insignificant. This result is consistent with economic theory. Because the cost of finance leads to increase on total cost of firms thus the price of its product increase in the short run.

With control variables the results show that coefficient of exchange rate has positive and statistically significant at 10% level. This result is consistent with economic theory. This means that devaluation of value currency leads to an increase in the price of domestic goods relative to foreign prices. The results indicate that foreign direct investment has positive and statistically insignificant effect on inflation in the short run. This result is consistent with economic theory. Government spending has positive effect on inflation and statistically insignificant. This result is consistent with economic theory. The estimation results given in table (7) clearly indicate that to be very good in terms of the values of R- square indicate that 66% 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. 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 (-1.75) and imply that deviation from the long-term inflation is corrected by only 174% percent in the model. According to the results in table (7) it is clear that the money supply and real exchange rate are the most important factors impacted on inflation in short-run in Sudan.

Diagnostic Tests of the Estimated Short-run ARDL Models:

In this subsection we discuss the diagnostic test of the estimated short run (ARDL) models, namely Normality, Functional Form, 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 analyzes 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(INF)	1.199062	0.549069	2.977136	0.459857	0.714291	4.296790	0.0017

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 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		White	
		F-statistic	Prob	F-statistic	Prob
Ln(INF)	2.137174	0.585660	0.5656	1.275943	0.2997

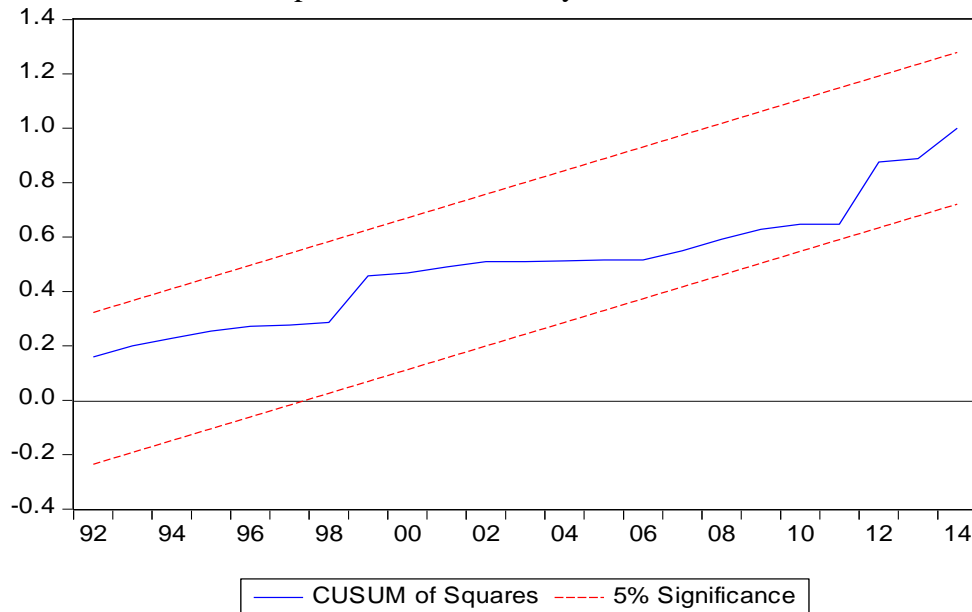
Source: Author’s calculation.

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

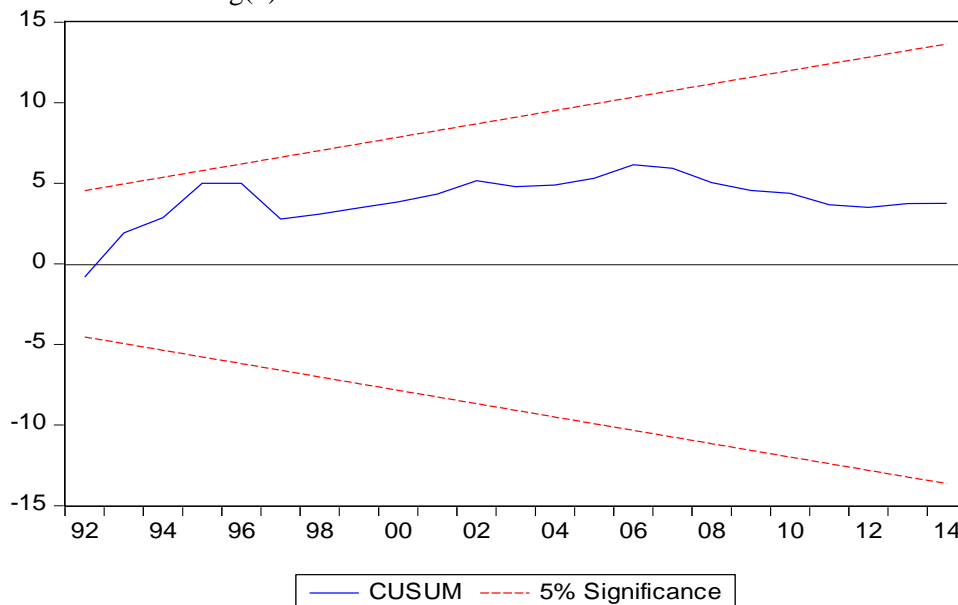
these results indicate that there are no autocorrelation problem in all equations. The result also indicate that the probability value of White test is greater than 5% level which mean that there is no heteroscedasticity problem in the equations. Therefore, fitness of the model is acceptable empirically.

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

The plots of the CUSUM and CUSUMSQ in Figs (3, 4) 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 Inflation Model:

- Real GDP has negative and statistically insignificant effects on inflation in the long run.
- As expected the coefficients of money supply and exports is positive and statistically significant.
- The results show that the coefficient of investment is negative and statistically insignificant.

- Also the coefficient of exchange rate is positive and statistically significant.
- The government spending variable also appears with the positive sign and statistically significant.
- Foreign direct investment has positive and statistically insignificant effect on inflation.
- Also the results show that the coefficient of money supply is positive and statistically insignificant.
- The coefficient of the cost of finance is negative and statistically insignificant.

The Result of Estimated Short- run Inflation Model:

- The results indicate that real GDP and investment have positive and statistically insignificant effect on the inflation in short – run.
- The coefficient of exports is negative and significant as expected, which is consistent with economic theory.
- The coefficient of exchange rate is positive and statistically significant at 10% level.
- The results indicate that foreign direct investment has positive and statistically insignificant.
- Government spending has positive effect on inflation and statistically insignificant.
- Money supply has positive and statistically significant effects on inflation. The coefficient of the cost of finance is positive and statistically insignificant.

The Recommendations:

- The government should adopt policies that reduce inflation to stimulate economic growth. Reducing the rate of inflation can be maintain by increasing the production and productivity
- The government should adopt policies that reduce money supply to reduce inflation.
- In order to control inflation it's critically important to stabilize the exchange rate, a stable exchange rate will keep inflation at a moderate level.

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