بسم الله الرحمن الرحيم

The Central Bank of Sudan

Inflation Determinants in Sudan 1970-2009

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Abstract[1]

The present research investigates 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 (Seignorage) which caused monetary expansion also found to be the main determinant of inflation in Sudan over the period (1970-2008).

Methodologically, to avoid spurious regressions ADF and PP tests of stationarity were carried out; it appeared that the data were non stationary in level but stationary in differences. (the case of most of the time series in economic data), hence after cointegration methods were used to examine the relationship between inflation and the main determinants, the results revealed a strong evidence not to reject the two hypotheses, moreover, Granger causality test was pursed to examine the causality between inflation and the main determinants embodied in the models.

The results obtained also confirmed the validity of the argument that short run changes in inflation were explained by currency fluctuations while long term behavior of inflation is mainly explained by deficit financing and money growth.

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As a policy recommendation, the research emphasized that 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. It's recommended to reduce deficit financing, moreover, it is important to develop the OMO operations which will help managing liquidity in the economy and activate the central bank tools for controlling money instead of deficit financing through printing money (seignorage).

(Key words: inflation, monetary expansion, exchange rate depreciation seignorage, stationarity – cointegration and ECM)

1. Conceptual framework:

Theoretically inflation is a monetary phenomenon; it may also be demand pull, cost push or imported inflation. The quantity theory of money is used to explain inflation as a monetary phenomenon, however, inflation determinants also include; exchange rate, foreign inflation, external deficits, government deficit financing, cost of finance etc. Therefore, inflation is basically affected by various factors that represent economic fundamentals which interact to shape the domestic and foreign imbalances.

The central bank mechanism to control inflation differ enormously, on one hand; targeting low and stable money growth is an anchor of the economy, in most cases price stability is a mean and target of monetary policy. Alternatively, in order to control inflation it is required to stabilize the exchange rate, thus the exchange rate becomes a nominal anchor if it proved to have influence on inflation in a drastic way.

Wojciech Maliszewski (2003) estimated long- and short-run relationships of inflation and its determinants in Georgia; it is apparent that inflation in Georgia exhibits very low persistence. The empirical findings revealed that inflation excreted high pressure on exchange rate, hence budget deficit requires monetary tightening, and this explains why the central bank is always anxious about keeping inflation at a low level.

Magda Kandil and Hanan Morsy (2009) provided an empirical evidence that inflation in trading countries

(partners) represents the most important foreign factor that influence domestic inflation in oil-rich Gulf Cooperation Council (GCC).

Hossain, Akhtar (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.

Diana N. Weymark et-al (2006) captured the impact of systematic monetary policy on inflation; using GMM method, she estimated quarterly time series of inflation pressure in US economy.

Ignacio Lozano (2008) Using a vector error correction (VEC) model found a close relationship between inflation and money growth on one hand, and between money growth and fiscal deficit on the other. The results coincided with the arguments raised in Sargent and Wallace hypothesis.

Falnita, Eugen and Sipos, Ciprian(2007) emphasized that; labor market, the exchange rate, the interest rates, and monetary policy – Broad Money (M2) and Non-government Credit were the main inflation determinants in Romanian economy, they provided empirical evidence that shapes the relationship between inflation and unemployment, and they also revealed that inflation and money growth have different trends.

Cem Saatçioğlu and H.Levent Korap (2007) in their study of inflation determinants in Turkey found that the smaller the growth performance of the economy given the cost-pressure through exchange-rate pass-through effects, wage indexation

mechanism and the real interest structure be imposed, the larger would be the inflation structure.

Obinyeluaku, Moses and Viegi, Nicola (2009) using a sample of 10 countries in SADC[2] provided an empirical evidence based on the dynamic response of inflation to different shocks, the findings revealed equivocal fiscal and monetary dominance effects on inflation.

Ana Cuvak and Zilvinas Kalinauskas (2009) used linear regression models and a vector autoregression model (VAR) to examine inflation determinants and establish forecasting model of inflation in Lithuania, the methodology was used to generate inflation forecasts, in spite of many criticisms raised against the predictions based on VAR system that it may lack sound economic explanation, the system of equations found to be capable of forecasting inflation in Lithuania in a precise way.

Kenji M (2008) also adopted the same methodology and applied the same techniques with minor changes to the case of sudan economy, however, Kenji and Naseer(2009)included Autoregressive Moving Average (ARMA) to forecast inflation in Sudan, but, their findings seem to be irrelevant to the actual reality of Sudan economy, because they predicted low level of inflation in 2009, while in reality inflation reported double digits and represented a major concern for policy makers in Sudan, several reasons may be identified here, data precision, the effect of foreign shock (crisis) and model specification problems.

[2] SADC: South Africa Development Cooperation

Based on conventional econometric models and dynamic models the present research investigated the following two hypotheses; first: exchange rate depreciation was the major cause behind inflation in Sudan economy, second: deficit financing by printing money (seignorage) had raised monetary expansion which in turn resulted in inflationary pressures.

The direction of the causality between real wages and inflation gives the nature of inflation in the national economy, if real wages caused inflation this is typically cost push inflation, on the other hand if inflation raised real wages then inflation is said to be demand pull, empirically its quite difficult to investigate such a norm in developing countries due to lack of data, even conventional econometric models face severe challenges in examining the dynamics of inflation, simply because records of output figures were not available in shorter terms (quarterly or monthly data), researchers tried to extrapolate data, in this research we avoided data interpolation and extrapolation on the basis of the argument that by employing such techniques this implies that we let the data behave in a way that might not be the real behavior of the data, the philosophy behind the procedures we adopt is to let the facts tell the story, empirical facts will be followed to investigate the main determinants of inflation, in this case output figures are only available on annual data basis, other variables were available both annually and quarterly and even on monthly basis.

The equation of the exchange[3]

The equation of the exchange is used mainly to interpret inflation as a long run phenomenon; In order to investigate whether inflation is a monetary phenomenon in Sudan economy, the study starts with the equation of the equation of exchange as follows:

$MV = PY$ …… (1)

Where M= Money supply, V= velocity of money circulation, P= price level and Y= nominal output. Solving for P and adding an error term results in the following log-form model:

$Ln\ p = Ln\ m + Lnv - Lny + \mu$ ……..(2)

Estimating equation (2) for Sudan data over the period 1970-2008 revealed the following results:

Table (1)
Equation of exchange model results

Dependent Variable: LOG(INF)				
Method: ML - ARCH				
Sample(adjusted): 1971 2008				
Included observations: 38 after adjusting endpoints				
Convergence achieved after 40 iterations				
	Coefficient	Std. Error	z-Statistic	Prob.
C	-2.005164	3.320645	-0.603848	0.5459
LOG(GDP)	-1.021477	0.493628	-2.069326	0.0385
LOG(M2)	0.928918	0.541430	1.715674	0.0862
VELO	0.132701	0.062589	2.120178	0.0340
AR(1)	0.751965	0.096965	7.755011	0.0000
	Variance Equation			
C	0.018678	0.005358	3.485953	0.0005
ARCH(1)	-0.156049	0.035559	-4.388520	0.0000
GARCH(1)	1.145217	0.055059	20.79972	0.0000
R-squared	0.541234	Mean dependent var		3.177354
Adjusted R-squared	0.434188	S.D. dependent var		1.005600
S.E. of regression	0.756417	Akaike info criterion		1.948983
Sum squared resid	17.16501	Schwarz criterion		2.293737

[3] Quantity theory of money or Fisher equation

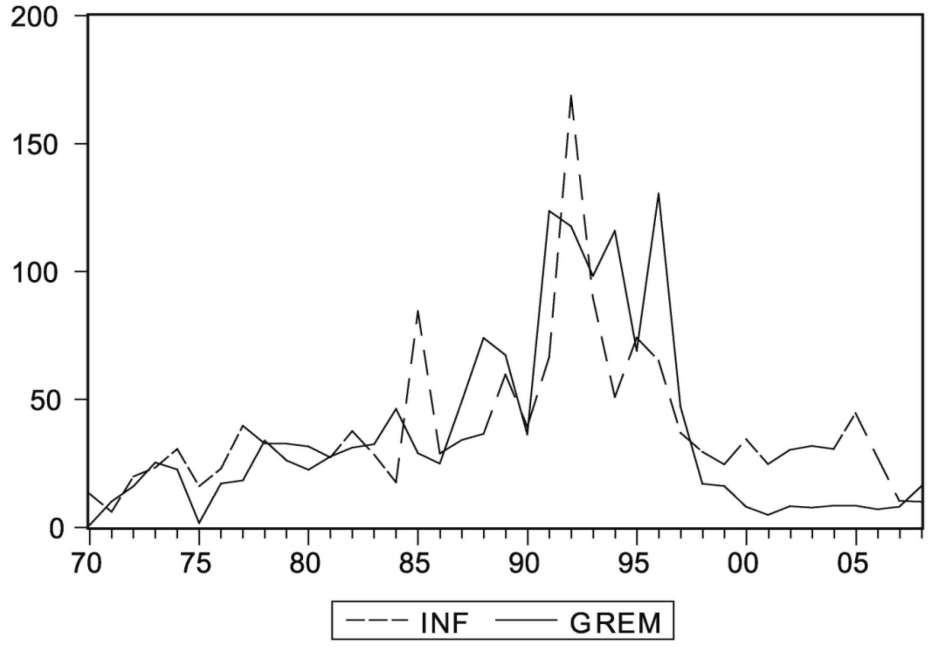
Log likelihood	-29.03067	F-statistic	5.056108
Durbin-Watson stat	2.244270	Prob(F-statistic)	0.000713
Inverted AR Roots	.75		

The coefficients of all explanatory variables are statistically significant correctly signed as the theory predicts, 54% of changes in inflation were explained by the model, the model revealed that output and monetary expansion worked equivocally to clear out the effects in different directions, since all variables were entered in logarithmic forms the coefficients represent elasticities, the coefficient of money supply is positive indicating that 1% change in inflation is associated with 0.9% changes in money growth, while output worked on the opposite direction but with almost the same magnitude -1.02 (there is an inverse relationship between inflation and output), this confirms that inflation is a monetary phenomena in Sudan economy. the velocity of circulation has a coefficient of 0.13 which indicates that velocity of circulation has a low effect on inflation.

The sum of α & β (ARCH (1) and GARCH (1) coefficients) is equal to unity indicating the persistence of inflation in Sudanese economy during the period of the study, after introducing the AR(1) the autocorrelation problem is eliminated (DW=2.2) .

Moreover, the figure (1) below depicts the relationship between inflation and monetary expansion; a casual interpretation of the figure could lead to the conclusion that there is strong evidence in Sudan economy that inflation is highly linked with money growth.

Figure (1)
Inflation and money growth in Sudan 1970-2008

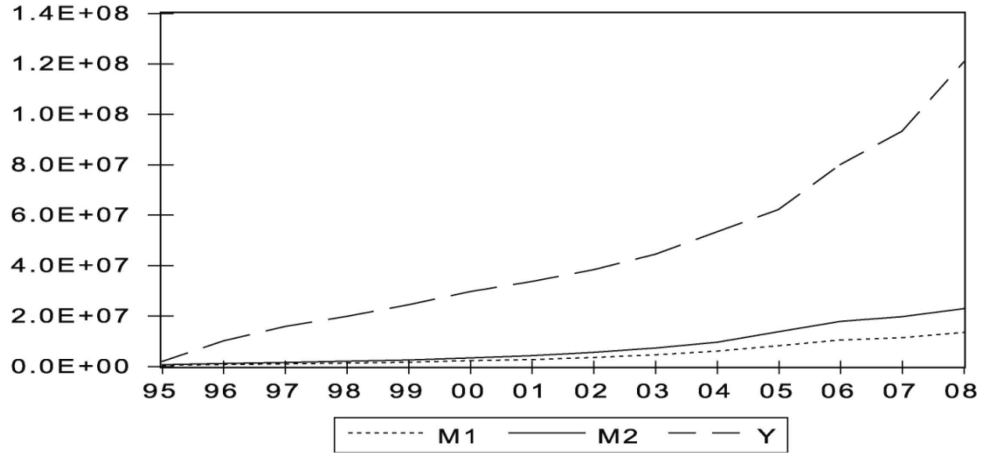


Changes in inflation were highly correlated with growth of money during period 1970-2008, Sudan experienced hyper inflation during 1990s, the economy was overheating and inflation recoded double and treble digits, this necessitated further fiscal and monetary policies that intended to curb inflation, thanks to oil proceeds, Sudan economy successfully attained one digit inflation rate as sketched by the graph, by early 2000s inflation rate was under control (one digit),however, after mid 2008 inflation reached 14%, (double digits) given the rise of food and oil prices, in addition to inflationary pressures brought by the financial crisis of 2008-2009, unlike the world trends of inflation that shrink at low

levels, in Sudan inflation reported double digits and persisted up to the moments of writing this passage, this necessitates a deep investigation of inflation main determinants

The financial crisis imposed inflationary pressures mainly caused by the drop in oil prices that resulted in severe budgetary deficits and large money injections to the banking system, it is evident that money expansion and currency depreciation pull inflation given a certain lag period, these lags' effects will be explained by VAR and ECM models.

Figure (2)
Monetary and Output Expansion in the Sudan (1995-2008)



When the two main determinants were plotted in the diagram, using the narrow definition and wider definitions of money supply, the graph gave the same pattern of behavior in monetary expansion as well as output expansion.

(1) Single equation model :

The results obtained from equation (2) only confirm the application of equation of exchange to the case of Sudan, other variables such as the exchange rate and foreign inflation could also be included in a single equation model, here inflation is the measure of domestic economy medium of exchange (currency), when inflation shoots high levels the value of the domestic currency eventually declines[4]:

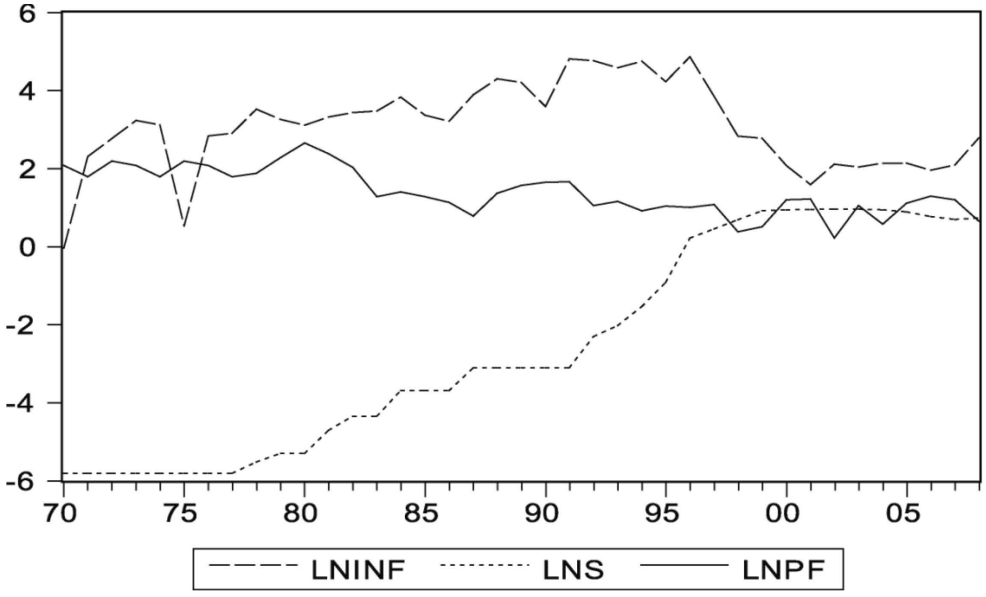
$\Delta p = \Delta xt\beta + zt\gamma + \varepsilon$ .....(3)

Where Δp: first difference of inflation, Δxt: explanatory variables (m,y,s,pf) which are money, output, exchange rate and foreign inflation respectively.

The graph below depicts the relationship between inflation and the additional explanatory variables (the exchange rate and foreign inflation), it is clear that when exchange rate depreciates inflation shoots level, i.e. we expect a positive relationship between inflation and the exchange rate, but looking into the data it seems that foreign inflation is not correlated with inflation, an empirical evidence is needed to prove such a statement,

[4] Purchasing Power Parity (PPP) in its absolute and relative versions basically links exchange rate movements to domestic and foreign inflation : $\Delta s = \Delta p / \Delta p^*$

Figure (3)
Sudan inflation, exchange rate and foreign inflation
1970-2008



After transforming the whole data into logarithmic forms[5], OLS method is used to detect the relationship between inflation and the main determinants and the following results were obtained:

[5] Note that here domestic inflation was entered in logarithmic form to the base 10, while in the first model equation (2) the whole variables were entered in Ln forms to the base e: (the exponential function).

Table (2)
Single equation model results*:*

Dependent Variable: LOG(INF)
Method: ML - ARCH
Date: 06/07/10 Time: 10:15
Sample(adjusted): 1973 2008
Included observations: 36 after adjusting endpoints
Convergence achieved after 27 iterations

	Coefficient	Std. Error	z-Statistic	Prob.
C	1.903507	0.152789	12.45838	0.0000
LOG(Y)	-0.172556	0.102021	-1.691375	0.0908
LOG(M2)	0.291061	0.124212	2.343253	0.0191
INFF	0.025734	0.003454	7.450787	0.0000
S	-1.117520	0.082146	-13.60406	0.0000
AR(1)	0.019135	0.165412	0.115684	0.9079
Variance Equation				
C	0.014546	0.003296	4.413844	0.0000
ARCH(1)	-0.181634	0.070930	-2.560738	0.0104
GARCH(1)	1.068834	0.132808	8.047993	0.0000
R-squared	0.759187	Mean dependent var		3.212613
Adjusted R-squared	0.687835	S.D. dependent var		1.020621
S.E. of regression	0.570239	Akaike info criterion		0.733854
Sum squared resid	8.779645	Schwarz criterion		1.129734
Log likelihood	-4.209376	F-statistic		10.64003
Durbin-Watson stat	2.129949	Prob(F-statistic)		0.000001
Inverted AR Roots	.02			

More than 75% of the changes in inflation were explained by the model, whole the coefficients of the explanatory variables were found to be statistically significant, the coefficient of money supply is 0.29 (positive) as expected, z-value is (2.34) indicating that the coefficient is statistically significant at

99%, this also confirms the results obtained in the equation of exchange. The coefficient of the output is (-0.17) (negative) correctly signed and statistically significant at 90%, z-value (-1.69), indicating a negative relationship between inflation and output, the exchange rate has a wrong sign -1.117 (the second largest coefficient) and highly statistically significant[6], surprisingly foreign inflation although highly statistically significant z-value (7.45), but the coefficient is very low and positive 0.025 indicating a marginal effect of foreign inflation on domestic inflation . F-test reveals that the overall model fitness is highly, however, after introducing the AR(1) term the positive serial correlation had been removed (DW= 2.12) (a phenomena most likely appear in various econometric models). This implies that the coefficient of unconditional residuals (which are the errors observed using contemporaneous information and ignoring lagged residuals) did not entirely affect the model performance.

The entry of the AR (1) term not only made a remedy to the autocorrelation problem but also improved the model fitness, this indicates that past values of the exchange rate changes and money changes have crucial effects on inflation. now the results confirm that inflation is a monetary phenomenon, money changes and exchange rate depreciations were solely responsible of

[6] The explanation for a negative relationship between inflation and the exchange rate can be attributed to the way we define the exchange rate, which is how many units in local currency in terms of one unit of foreign currency, i.e. the method of quoting the exchange rate determine the sign of the coefficient, since we define the exchange rate as one unit of foreign currency in terms of local currency there should be a positive relationship between inflation and the exchange rate which is not feasible in the results obtained.

inflation changes, while foreign inflation seemed to be slightly affecting domestic inflation.

The positive signs of the results indicate that inflation was mainly caused by money growth and exchange rate depreciation (the coefficient is positive as expected) (money growth has the largest coefficient in the model followed by the coefficient of the exchange rate). In spite of the fact that the model revealed marginal effect of foreign inflation on domestic inflation, still the slighter changes in foreign inflation may be transmitted to domestic economy through changes in the exchange rate, specifically if the economy is experiencing high black market premiums, which in turn raises costs of imported goods and pushes prices upward, if domestic inflation exceeds foreign inflation rates, foreign exchange reserves decline and the exchange rate is no longer overvalued where speculations lead to depletion of foreign reserves at the central bank, this is quite evident with Sudan experience during the current financial crisis.

Moreover, to check for heteroskedasticity problem based on OLS and excluding the ARCH method the research adopted White's test as follows:

Table (3)
White Heteroskedasticity Test

F-statistic	1.715606	Probability	0.140244
Obs*R-squared	12.13251	Probability	0.145389

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Sample: 1973 2008
Included observations: 36

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	16.78373	16.94205	0.990655	0.3306
LOG(Y)	4.147607	3.497728	1.185800	0.2460
(LOG(Y))^2	-0.100318	0.117253	-0.855571	0.3998

LOG(M2)	-2.954243	3.318651	-0.890194	0.3812
(LOG(M2))^2	0.055096	0.129045	0.426951	0.6728
LOG(INFF)	-10.53737	7.947822	-1.325819	0.1960
(LOG(INFF))^2	1.031544	0.944182	1.092527	0.2843
LOG(S)	0.092249	0.658668	0.140054	0.8897
(LOG(S))^2	-0.077408	0.097053	-0.797580	0.4321
R-squared	0.337014	Mean dependent var		0.289829
Adjusted R-squared	0.140574	S.D. dependent var		0.735313
S.E. of regression	0.681674	Akaike info criterion		2.283788
Sum squared resid	12.54635	Schwarz criterion		2.679668
Log likelihood	-32.10818	F-statistic		1.715606
Durbin-Watson stat	2.507893	Prob(F-statistic)		0.140244

The white test computed as the number of observations (*n*) times the *R2* from the test regression which is equal to 11.88. White's test statistic is asymptotically distributed as a $\chi 2$ with degrees of freedom equal to the number of slope coefficients excluding the constant. The calculation of $\chi 2$ is found to be 11.07 which is lower than Obs*R-squared indicating there is no heteroskedasticity problem in the model estimated, therefore, there is no need to remedy heteroskedasticity.

In fact, the single equation results confirm the validity of inflation as a monetary phenomenon, it also examined the effect of the exchange rate in the long run, however, in the short run an ECM will be developed in investigate this relationship further, but the data revealed recently might not explain the relationship between inflation and the exchange rate precisely, since imported inflation seemed to be uncorrelated with black market premiums.

Table (4)

Short term exchange rate versus(head, core and imported inflation)

Date [7]	Headline	Official exchang	Parallel	Black market	Core inflatio	Imported

[7] May 2009- February 2010

	inflation	e rate	market rate	premium	n	inflation
1-Mar	10.9	2.2812	2.5000	8.61%	8.5	14.3
31-Mar	10.9	2.3078	2.4900	6.93%	8.5	14.3
29-Apr	8.5	2.3435	2.6100	9.05%	7.5	9.5
30-Apr	8.5	2.3503	2.6100	9.14%	7.5	9.5
2-May	8.9	2.3500	2.6100	9.15%	7.7	8.9
30-May	8.9	2.3394	2.6100	9.56%	7.7	8.9
1-Jun	9.9	2.3492	2.6400	9.53%	8.7	9.9
30-Jun	9.9	2.3704	2.6500	9.75%	8.7	9.9
1-Jul	9.8	2.3740	2.6500	9.61%	11	9.1
30-Jul	9.8	2.4177	2.6770	8.87%	11	9.1
1-Aug	10.4	2.4137	2.6770	9.02%	11.9	9.2
31-Aug	10.4	2.4363	2.6800	8.27%	11.9	9.2
1-Sep	13	2.4231	2.6800	8.77%	11.5	3.4
28-Sep	13	2.3068	2.7000	13.79%	11.5	3.4
1-Oct.	12.9	2.3234	2.7000	12.879 %	10.9	8.4
30 Oct.	12.9	2.2857	2.7500	15.21%	10.9	8.4
1-Nov.	14.5	2.2869	2.7500	15.83%	11.7	9.4

30–Nov.	14.5	2.2698	2.6500	10.4%	11.7	9.4
1 - Dec.	13.4	2.2595	2.6200	10.64%	12.2	9.2
30-Dec.	13.4	2.2545	2.6700	14.05%	12.2	9.2
1-Jan.	14.6	2.245	2.6800	14.26%	11.4	8.9
30 Jan.	14.6	2.2519	2.6800	16.95%	11.4	8.9
1-Feb.	n.a	2.2518	2.6800	16.85%	n.a	n.a

Table (4) reveals that methods of measuring imported inflation need to be revised, since the exchange rate had depreciated by more than 20%, then one digit reporting of inflation requires further verifications, moreover, the gap between the official and parallel rates is enlarging over time indicating real exchange rate misalignment with (16%), therefore, it is expected that as the black market premium is getting large, imported inflation also rise, but the data did not reveal such pattern[8] .

Figure (4)

[8] One explanation for this is that imported goods were represented by only 20% of the index.

Sudan Headline, Core and imported inflation
May 2009-January 2010

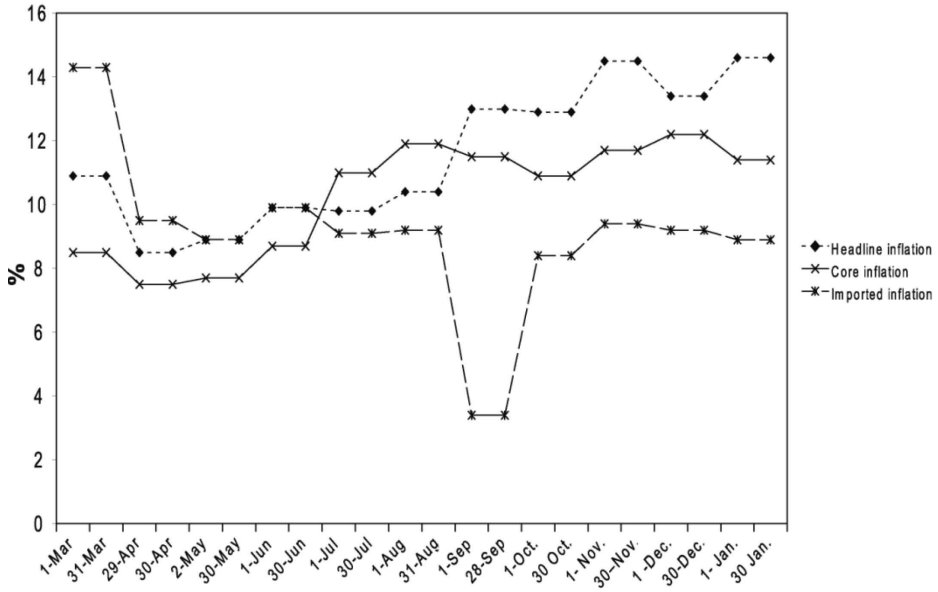


Table (5)
Descriptive statistics of exchange rate and inflation indices

	CORE	HEADLINE	IMPORTED	OFFICIAL	PARALLEL
Mean	10.27273	11.52727	9.109091	2.329095	2.649273
Median	11.00000	10.90000	9.200000	2.331400	2.660000
Maximum	12.20000	14.60000	14.30000	2.436300	2.750000
Minimum	7.500000	8.500000	3.400000	2.245000	2.490000
Std. Dev.	1.746338	2.164691	2.410475	0.059586	0.063974
Skewness	-0.540289	0.101974	-0.320177	0.288629	-0.960942
Kurtosis	1.589673	1.531791	5.287325	1.960345	4.093199
Jarque-Bera	2.893616	2.014129	5.171750	1.296268	4.481326
Probability	0.235320	0.365290	0.075330	0.523021	0.106388
Observations	22	22	22	22	22

The contradiction between imported inflation and the parallel exchange rate can also be interpreted from table (5), if the average inflation rate is double digits 10% (headline inflation), while the parallel rate is 2.64 exceeding the official rate 2.32 with 14% approximately, then how can we explain imported inflation (which is only 9%)?. Furthermore, the correlation between parallel rate and imported inflation is negative (-0.67) as depicted by table (7), while the correlation between core inflation[9] and the parallel rate is positive (+0.66), while there is a strong evidence of positive correlation between head inflation and the black market premium (+0.73), i.e. the divergence between the official rate and the parallel market rate generated further cost of importation that raised inflation by a considerable part reflected in headline inflation but not embodied in the imported inflation index mainly because many imported goods were poorly represented in the index.

Table (6)

Correlation matrix: parallel rate, official arte and black market premium versus inflation (core, headline and imported)

	BLACK	CORE	HEADLINE	IMPORTED	OFFICIAL	PARALLEL
BLACK	1.000000	0.485896	0.736399	-0.311730	-0.641612	0.663376
CORE	0.485896	1.000000	0.748701	-0.406049	-0.133206	0.634519
HEADLINE	0.736399	0.748701	1.000000	-0.260142	-0.635827	0.460371
IMPORTED	-0.311730	-0.406049	-0.260142	1.000000	-0.222285	-0.671374
OFFICIAL	-0.641612	-0.133206	-0.635827	-0.222285	1.000000	0.052833
PARALLEL	0.663376	0.634519	0.460371	-0.671374	0.052833	1.000000

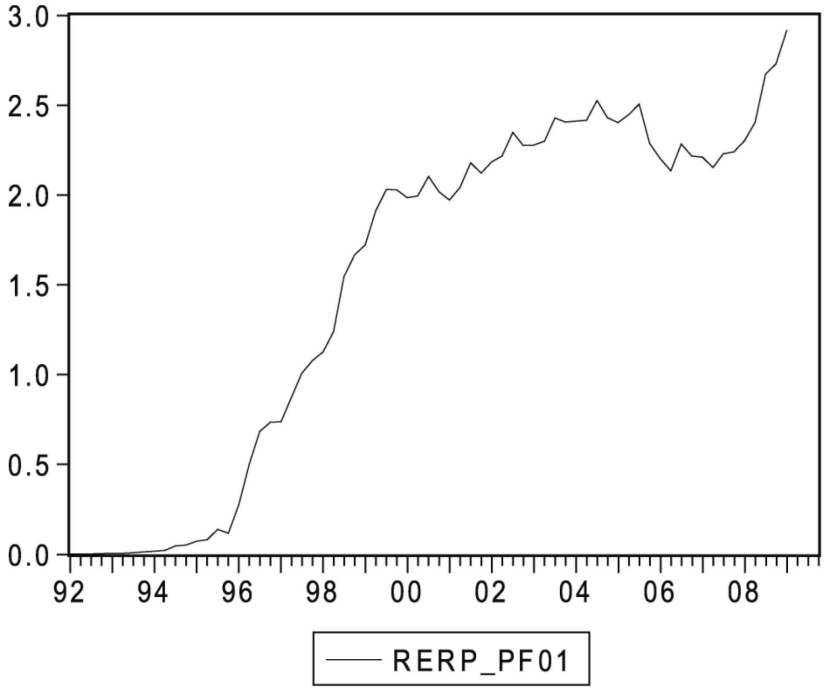
Based on the PPP the external real exchange rate can be measured by

[9] Core inflation is excluding food items which represent 50% of consumer basket of goods.

RER= n. p/p*…… (1)

The way we quote the exchange rate determines whether the domestic inflation will be located in the denominator or the nominator, applying this concept to Sudan data shows that the real exchange rate was depreciating over a long period of time mainly because of the nominal depreciation of the domestic currency and the high rates of domestic inflation exerted in 1990s as sketched by figure (5), however since early 2000s, the real exchange rate has shown slighter appreciation till early 2008, when the nominal exchange rate started to depreciate and the domestic inflation also reported double digits then the real exchange rate had revealed further depreciation as appeared in the graph.

Figure (5)
Sudan real exchange rate



One might argue that a real depreciation is useful for export promotion given the symptoms of the Dutch disease in the economy, although such an argument is beyond the task of investigating inflation dynamics, but empirical findings had shown that Sudanese exports were not encouraged by exchange rate devaluations, mainly because there are many structural rigidities responsible of reducing export profitability and competitiveness, which makes the devaluation policy impotent, moreover, Marshal Lerner (ML) condition might not be applicable to Sudan case, (ML) condition states that devaluation may encourage exports if and only if the elasticity of exports and imports were less than unity in absolute term. Furthermore, many Sudanese exports were dependent on imported inputs devaluation raises cost of importation of production inputs and raises cost of exportation, given the severe competition and low quality of Sudanese traditional exports and the dumping of African countries with products of emerging markets e.g. China & India makes our access to neighboring markets virtually weak. Therefore, containing inflation by further appreciating the exchange rate will make exportable goods more competitive in world markets, which in turn will lower inflation and positively affects the exchange rate performance.

It is useful to predict the behavior of inflation based on economic theory as postulated in the hypothesis or empirically test it with the models, however, the data behavior may reveal different story, and this is typically the arrangements made for coming part in this research. The next step is to estimate structural vector autoregressive

model (SVAR) and Vector Error Correction Model (VECM) as follows;

(2) Structural vector Autoregressive model (SVAR):

Inflation is a stochastic phenomenon, it's affected randomly by the main variables stated in the single equation model, but these variables are endogenously determined. In order to incorporate these variables into a dynamic model the present research employed a VAR system of equations as follows:

$f(yt, xt, \beta t) = \varepsilon t$ .....(1)

Where yt= vector of endogenous variables, xt= vector of exogenous variables, εt= vector of possibly serially correlated disturbances. The objective is to find values of the vector βt. Wojciech Maliszewski (2003) based on Bruno price equation maintained the following:

$Y_d = \alpha 1(m-p) + \alpha 2(e-p)$ .....(2)

$Y_d = Ys$ .....(3)

Assuming product market equilibrium substitute (2) into (3) and find p:

$p = \alpha 1/(\alpha 1+\alpha 2)\ m + \alpha 2/(\alpha 1+\alpha 2)e-1//(\alpha 1+\alpha 2)y$ .....(4)

Inflation determinants were to be examined then the system can be presented as follows:

$Yt = At\ Yt-1 + \ldots + Ap\ yt-p + \beta\ xt + \mu$ .....(5)

Where, Yt is k vector of endogenous variables, xt is vector of endogenous variables, A and β are matrix of coefficients to be estimated, μ is error term.

Table (7)

Sample(adjusted): 1972 2008
Included observations: 37 after adjusting endpoints
Trend assumption: Linear deterministic trend
Series: INF LNM2 LNY LNS
Lags interval (in first differences): 1 to 1
Unrestricted Cointegration Rank Test

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	5 Percent Critical Value	1 Percent Critical Value
None *	0.655817	51.67294	47.21	54.46
At most 1	0.209491	12.20937	29.68	35.65
At most 2	0.090359	3.511459	15.41	20.04
At most 3	0.000199	0.007369	3.76	6.65

*(**) denotes rejection of the hypothesis at the 5%(1%) level
Trace test indicates 1 cointegrating equation(s) at the 5% level
Trace test indicates no cointegration at the 1% level

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	5 Percent Critical Value	1 Percent Critical Value
None **	0.655817	39.46357	27.07	32.24
At most 1	0.209491	8.697911	20.97	25.52
At most 2	0.090359	3.504090	14.07	18.63
At most 3	0.000199	0.007369	3.76	6.65

*(**) denotes rejection of the hypothesis at the 5%(1%) level
Max-eigenvalue test indicates 1 cointegrating equation(s) at both 5% and 1% levels

Since the eigenvalues of P are numerically less than one, direct estimation of a VAR in levels is appropriate; based on the main variables (inf, m2, y, s, pf) which are the inflation rate, money supply, output, exchange rate, and foreign inflation, a simultaneous equation system is constructed to investigate the regression of these dependent variables on

lagged variables. A shock to the i-th variable not only directly affects the i-th variable but is also transmitted to all of the other endogenous variables through the dynamic lag structure of the VAR.

Structural vector autoregressive model excluding foreign inflation:

Table (8)

Date: 02/10/10 Time: 03:43
Sample(adjusted): 1972 2008
Included observations: 37 after adjusting endpoints
Standard errors & t-statistics in parentheses

	INF	LNM2	LNY	LNS
INF(-1)	0.716742	0.006872	0.003190	0.004653
	(0.25044)	(0.00141)	(0.00236)	(0.00279)
	(2.86198)	(4.88441)	(1.35386)	(1.66543)
INF(-2)	0.259407	-0.001130	0.002118	0.001504
	(0.15841)	(0.00089)	(0.00149)	(0.00177)
	(1.63761)	(-1.26947)	(1.42132)	(0.85144)
LNM2(-1)	23.94690	0.970888	0.590876	0.187943
	(32.9018)	(0.18484)	(0.30956)	(0.36702)
	(0.72783)	(5.25245)	(1.90877)	(0.51209)
LNM2(-2)	9.870777	0.006931	-0.333845	-0.131900
	(35.5292)	(0.19961)	(0.33428)	(0.39632)
	(0.27782)	(0.03472)	(-0.99870)	(-0.33281)
LNY(-1)	-63.36010	-0.434008	0.211419	-0.489965
	(24.5942)	(0.13817)	(0.23140)	(0.27435)
	(-2.57622)	(-3.14107)	(0.91367)	(-1.78594)
LNY(-2)	32.36932	0.472651	0.509051	0.524193
	(25.5799)	(0.14371)	(0.24067)	(0.28534)
	(1.26542)	(3.28892)	(2.11514)	(1.83708)
LNS(-1)	-7.136855	0.003194	0.223170	1.024965
	(18.0211)	(0.10124)	(0.16955)	(0.20102)
	(-0.39603)	(0.03155)	(1.31623)	(5.09875)
LNS(-2)	4.138862	-0.024329	-0.164627	-0.168518
	(19.5687)	(0.10994)	(0.18411)	(0.21829)
	(0.21150)	(-0.22129)	(-0.89416)	(-0.77200)

C	24.56075 (136.105) (0.18045)	-0.030690 (0.76465) (-0.04014)	0.963610 (1.28055) (0.75249)	-1.338607 (1.51824) (-0.88169)
R-squared	0.711413	0.999241	0.998081	0.993163
Adj. R-squared	0.628960	0.999025	0.997533	0.991210
Sum sq. resids	13840.52	0.436845	1.225176	1.722190
S.E. equation	22.23296	0.124906	0.209180	0.248006
F-statistic	8.628061	4609.619	1820.435	508.4435
Log likelihood	-162.1028	29.62252	10.54420	4.244717
Akaike AIC	9.248802	-1.114731	-0.083470	0.257042
Schwarz SC	9.640647	-0.722886	0.308375	0.648887
Mean dependent	38.24351	10.97373	12.48785	-2.366156
S.D. dependent	36.49948	3.999225	4.211324	2.645247
Determinant Residual Covariance		0.002408		
Log Likelihood		-98.46608		
Akaike Information Criteria		7.268437		
Schwarz Criteria		8.835816		

More than 71% of changes in inflation were explained by the model, the largest coefficient appeared to be (lny(-1)): -63 which is correctly signed, then comes Ln(M2(-1)): 23 which is also correctly signed, this coincides with the results of the equation of the exchange and the single equation model, but

indicating a longer period of effects of money than output. The exchange rate coefficient is Ln(S(-1)): -7, when foreign inflation entered to the model the estimation revealed no significant results because of the problem of multicollinearity, moreover, most of the model coefficients were statistically insignificant as expected, this is mainly due to randomness of the effects of the variables.

If we want to include foreign inflation in the model then the exchange rate may be removed from the model, simply because foreign inflation affects domestic inflation through the exchange rate, thus, the model was reestimated based on the specification of excluding the exchange rate to encounter the effects of foreign inflation on domestic inflation and the following results were obtained:

Structural vector autoregressive model excluding the exchange rate:

Table (9)

Vector Autoregression Estimates
Date: 02/10/10 Time: 10:22
Sample(adjusted): 1974 2008
Included observations: 35 after adjusting endpoints
Standard errors in ( ) & t-statistics in [ ]

	INF	LNM2	LNY	INFF
INF(-1)	0.821636	0.006977	-0.000807	-0.087705
	(0.43288)	(0.00247)	(0.00422)	(0.10022)
	[1.89808]	[2.82504]	[-0.19122]	[-0.87517]
INF(-2)	0.132805	-0.001573	0.001556	0.079587
	(0.18081)	(0.00103)	(0.00176)	(0.04186)
	[0.73451]	[-1.52516]	[0.88266]	[1.90131]
LNM2(-1)	-14.30522	0.924590	1.472029	22.63991
	(91.6831)	(0.52305)	(0.89363)	(21.2255)
	[-0.15603]	[1.76770]	[1.64724]	[1.06664]
LNM2(-2)	70.27285	0.102722	-1.130599	-11.41431
	(95.0144)	(0.54205)	(0.92610)	(21.9968)

	[0.73960]	[0.18951]	[-1.22081]	[-0.51891]
LNY(-1)	-45.01419	-0.435353	-0.198537	-13.14391
	(52.7812)	(0.30111)	(0.51446)	(12.2194)
	[-0.85285]	[-1.44581]	[-0.38592]	[-1.07566]
LNY(-2)	-11.78798	0.402883	0.862467	1.945151
	(57.1344)	(0.32595)	(0.55689)	(13.2272)
	[-0.20632]	[1.23603]	[1.54873]	[0.14706]
INFF(-1)	-1.729121	-0.001420	0.032126	1.210248
	(3.04841)	(0.01739)	(0.02971)	(0.70574)
	[-0.56722]	[-0.08166]	[1.08122]	[1.71487]
INFF(-2)	2.231494	0.003429	-0.025525	-0.193127
	(2.83676)	(0.01618)	(0.02765)	(0.65674)
	[0.78664]	[0.21188]	[-0.92316]	[-0.29407]
C	93.19867	0.298560	0.323201	13.55405
	(34.7158)	(0.19805)	(0.33837)	(8.03705)
	[2.68462]	[1.50749]	[0.95516]	[1.68645]
R-squared	0.730312	0.999179	0.997867	0.955553
Adj. R-squared	0.647331	0.998927	0.997211	0.941877
Sum sq. resids	12747.14	0.414873	1.211020	683.2053
S.E. equation	22.14214	0.126320	0.215819	5.126122
F-statistic	8.800958	3957.448	1520.761	69.87060
Log likelihood	-152.8728	27.95194	9.205138	-101.6632
Akaike AIC	9.249877	-1.082968	-0.011722	6.323610
Schwarz SC	9.649823	-0.683021	0.388224	6.723557
Mean dependent	39.24486	11.30290	12.81799	49.76180
S.D. dependent	37.28515	3.856225	4.086850	21.26250
Determinant Residual Covariance		0.293711		
Log Likelihood (d.f. adjusted)		-177.2111		
Akaike Information Criteria		12.18349		
Schwarz Criteria		13.78328		

The results confirm that foreign inflation play a marginal role in determination of domestic inflation, the coefficient is very low (-1.7) compared to money supply (-14.3) and output (-45), Akaike AIC: 9.249, Schwarz SC: 9.649, indicating no significant changes happened to the model specification if we

exclude the exchange rate and introduce foreign inflation. i.e. no more lagged variables deemed necessary for model estimation, therefore, if we exclude foreign inflation and entered the exchange rate the model fitness and perdition is more appropriate as indicated in table (9).

This is to conclude that the factors determined inflation may be ranked as follows: output, money, and exchange rate. The impulse responses were brought in table (10), while variance decomposition in table (11) respectively:

Table (10)
SVAR variance decomposition

Variance Decomposition of INF: Period	S.E.	INF	LNM2	LNY	LNS
1	19.34084	100.0000	0.000000	0.000000	0.000000
2	23.25460	80.95852	1.760617	16.92338	0.357485
3	26.30575	76.16439	2.283568	18.53166	3.020385
4	28.35526	66.83455	4.532691	23.88929	4.743468
5	29.96551	60.60728	6.163028	26.72426	6.505428
6	31.33904	55.44191	7.678275	28.98144	7.898375
7	32.31187	52.42946	8.699779	29.77019	9.100570
8	33.09190	50.92690	9.380193	29.83857	9.854344
9	33.63830	50.50915	9.714423	29.45534	10.32108
10	34.04951	50.75924	9.812751	28.90863	10.51938

For a period of 10 years the variance decomposition revealed that past inflation has a long lasting effect (50%), while output (28%), in the long run it seems that the exchange rate is the major cause behind inflation (10%), and then comes monetary expansion (9.8%).

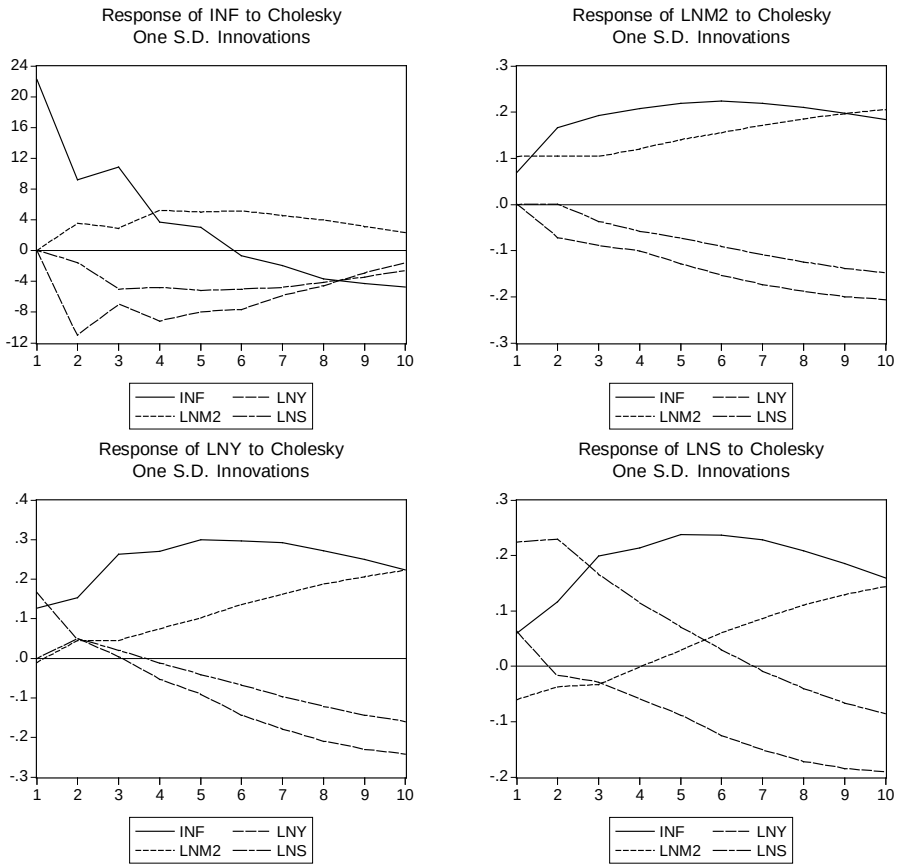
Table (11)
SVAR Impulse responses

Response of INF: Period	INF	LNM2	LNY	LNS
1	19.34084	0.000000	0.000000	0.000000
	(2.24833)	(0.00000)	(0.00000)	(0.00000)
2	7.983514	3.085613	-9.566487	-1.390394
	(3.49996)	(3.05443)	(3.10663)	(3.05843)
3	9.447076	2.506216	-6.059708	-4.355186
	(3.39583)	(2.38729)	(3.00183)	(3.13301)
4	3.211209	4.543310	-7.989817	-4.151823
	(3.42245)	(2.48527)	(3.28662)	(3.47299)
5	2.616902	4.346952	-6.920312	-4.502868
	(3.63592)	(2.53326)	(3.46708)	(3.89382)
6	-0.550127	4.480099	-6.683665	-4.377036
	(3.59945)	(2.53670)	(3.60137)	(4.05755)
7	-1.696744	3.926781	-5.116720	-4.176412
	(3.67694)	(2.48806)	(3.62207)	(4.16752)
8	-3.208340	3.448094	-3.992051	-3.591263
	(3.53391)	(2.35251)	(3.58358)	(4.09104)
9	-3.720461	2.683672	-2.557990	-2.978984
	(3.41015)	(2.20846)	(3.48133)	(3.93110)
10	-4.118034	1.960588	-1.363872	-2.274168
	(3.23052)	(2.05445)	(3.33400)	(3.68637)

Figure (6) SVAR Impulse responses:
An impulse response function traces an effect of one time shock e.g. broad money expansion or currency depreciation, to innovations of current and future values of the other variables that include (e.g. Inflation), here we confine our

selves with the innovations in inflation, as its clear innovations are highly correlated.

Figure (6)



The first panel explains how domestic inflation responded to various innovations, it's clear that there is a positive responses of inflation to exchange rate and money changes that last for a longer period of time than output changes which revealed negative responses.

(3) Error Correction Model (ECM):

Before estimating the model, we have to test the data upon stationarity. The test revealed that all variables were non stationary in levels but when transformed into differences the existence of the unit root can not be rejected, i.e. the data is non stationary in levels but stationary in differences .

Table (12)
ADF, PP tests of staionarity :

Variables	PP	Critical values	ADF –t	Critical values
s	-4.512818	-3.6171 (1%)	-2.83262	-2.6105 (10%)
M2	-3.606055	-2.9422 (5%)	-2.61557	-2.6105 (10%)
INF	-8.83813	-3.6228 (1%)	-5.4223	-3.6228 (1%)
y	-5.101949	-3.6171 (1%)	-2.87225	-2.6105 (10%)
INF*	-5.978355	-3.6171 (1%)	-5.2055	-3.6228 (1%)

$$\Delta Y_t = \beta_0 + \sum_{j=1}^{k} \beta_j \Delta X_{1t-j} + \sum_{j=1}^{h} \alpha_j \Delta Y_{t-j} + \xi_t \quad \text{.....(6)}$$

Where ξt has zero mean given ΔY_{t-1}, …, ΔY_{t-h}, ΔX_t, ΔX_{t-1}, …, ΔX_{t-k}. If Y and X are cointegrated, then the obtained estimated error term must be stationary, i.e., I(0). Now if we include the lagged estimated error term as

$$\Delta Y_t = \beta_0 + \sum_{j=1}^{k} \beta_j \Delta X_{1t-j} + \sum_{j=1}^{h} \alpha_j \Delta Y_{t-j} + \delta\, Z_{t-1} + \xi_t \quad \text{.....(7)}$$

Where $Z_t = \hat{e}_t = Y_t - \hat{\beta}_0 - \sum_{j=1}^{k} \hat{\beta}_j \Delta X_{1t-j} - \sum_{j=1}^{h} \hat{\alpha}_j \Delta Y_{t-j}$ is the one-period lagged value of The estimated error of the cointegrating regression obtained from OLS estimation, this term is called the (ECT). The long run equilibrium might exist, in the short run, however, there may be disequilibrium. With the error correction mechanism, a proportion of the disequilibrium is corrected in the next period. The error correction process is thus a means to reconcile short-run and long run behavior.

Therefore, in the error correction model, the right hand side contains the short-run dynamic coefficients (i.e., α_i, β_i) as well as the long-run coefficient (i.e., δ). The absolute value of δ decides how quickly the equilibrium is restored.

After testing of non stationarity problem, then the cointegration test revealed an equilibrium relationship between the determinants of inflation, a VAR system can be transformed into an ECM as follows;

$$xt = \sum_{j=1}^{k-1} \prod j \Delta xt - j + \alpha B' xt - 1 + \gamma Dt + \varepsilon t \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

Where x is vector of endogenous variables and D is vector of exogenous variables, the rank of $B'x$ determines the number of co integrating vectors, the first component is adjustment matrix coefficients of α, the second component is long run coefficients B, the standard errors are presented in parenthesis .
using an error correction model the following results were obtained:

Table (13)
ECM results:

Sample(adjusted): 1973 2008
Included observations: 36 after adjusting endpoints
Standard errors & t-statistics in parentheses

Cointegrating Eq:	CointEq1			
INF(-1)	1.000000			
LNM2(-1)	-15.18017			
	(8.61810)			
	(-1.76143)			
LNY(-1)	15.20804			
	(9.75273)			
	(1.55936)			
LNS(-1)	0.832335			
	(7.24675)			
	(0.11486)			
C	-60.08052			
Error Correction:	D(INF)	D(LNM2)	D(LNY)	D(LNS)
CointEq1	-0.319189	0.004182	0.007438	0.002137
	(0.40181)	(0.00216)	(0.00394)	(0.00427)
	(-0.79438)	(1.93812)	(1.88827)	(0.50008)
D(INF(-1))	-0.062576	0.002174	-0.003507	0.001259
	(0.32622)	(0.00175)	(0.00320)	(0.00347)
	(-0.19182)	(1.24064)	(-1.09660)	(0.36280)
D(INF(-2))	-0.246000	-0.000489	-0.000551	-0.004205
	(0.18315)	(0.00098)	(0.00180)	(0.00195)
	(-1.34313)	(-0.49746)	(-0.30695)	(-2.15913)
D(LNM2(-1))	61.71580	0.168814	0.634145	0.888259
	(40.2686)	(0.21627)	(0.39474)	(0.42820)
	(1.53260)	(0.78058)	(1.60648)	(2.07440)
D(LNM2(-2))	47.59445	0.083385	0.301036	0.256656
	(35.9755)	(0.19321)	(0.35266)	(0.38255)
	(1.32297)	(0.43158)	(0.85362)	(0.67091)
D(LNY(-1))	-54.94854	-0.446811	-0.889481	-0.678280

	(29.1359)	(0.15648)	(0.28561)	(0.30982)
	(-1.88594)	(-2.85542)	(-3.11432)	(-2.18927)
D(LNY(-2))	16.63905	0.181419	-0.394358	0.246220
	(33.8340)	(0.18171)	(0.33167)	(0.35978)
	(0.49178)	(0.99840)	(-1.18903)	(0.68437)
D(LNS(-1))	1.735469	0.042936	0.190970	0.176740
	(18.9246)	(0.10164)	(0.18551)	(0.20124)
	(0.09170)	(0.42245)	(1.02942)	(0.87827)
D(LNS(-2))	-16.95643	-0.144279	0.077036	0.065756
	(19.5286)	(0.10488)	(0.19143)	(0.20766)
	(-0.86829)	(-1.37565)	(0.40242)	(0.31665)
C	-20.59456	0.352045	0.397743	-0.097099
	(26.0413)	(0.13986)	(0.25528)	(0.27691)
	(-0.79084)	(2.51716)	(1.55809)	(-0.35065)
R-squared	0.461440	0.634657	0.540298	0.470098
Adj. R-quared	0.275015	0.508192	0.381170	0.286670
Sum q.resides	14109.81	0.406977	1.355855	1.595448
S.E. equation	23.29560	0.125112	0.228360	0.247716
F-statistic	2.475207	5.018435	3.395371	2.562852
Loglikelihood	-158.5617	29.60352	7.941778	5.012771
Akaike AIC	9.364539	-1.089084	0.114346	0.277068
Schwarz SC	9.804405	-0.649218	0.554212	0.716935
Mean ependent	0.005000	0.328881	0.332955	0.181859
S.D.dependent	27.35958	0.178402	0.290291	0.293298
Determinant Residual covariance		0.001989		
Log Likelihood		-92.36447		
Akaike Information criteri		7.575804		
Schwarz Criteria		9.511216		

Estimating the VECM had revealed the following results; only 46% of the total variations in inflation were explained by the model, Surprisingly, the long run effect of money supply and output were quite the same (-15) and (15) respectively, while the exchange rate revealed less influence

on inflation in the long run (0.83), about 31% of the disequilibrium in inflation will be corrected within the first year if foreign shock is observed in the national economy, i.e. it requires more than 3 years to retain the equilibrium inflation rate. In the short run the most influential factor is money supply (61), output (-54), then comes the exchange rate lagged two terms (-16), i.e. the exchange rate effect more likely takes much more time to influence inflation than money growth, this is also evident if we consider the impulse responses and variance decomposition provided in table (14), table (15) and figure (7). about 31% of disequilibrium will be corrected annually indicating that a shock (drop of oil prices caused by financial crisis) will prevail for more than three years.

Table (14)
ECM-Impulse responses:

Response of INF:

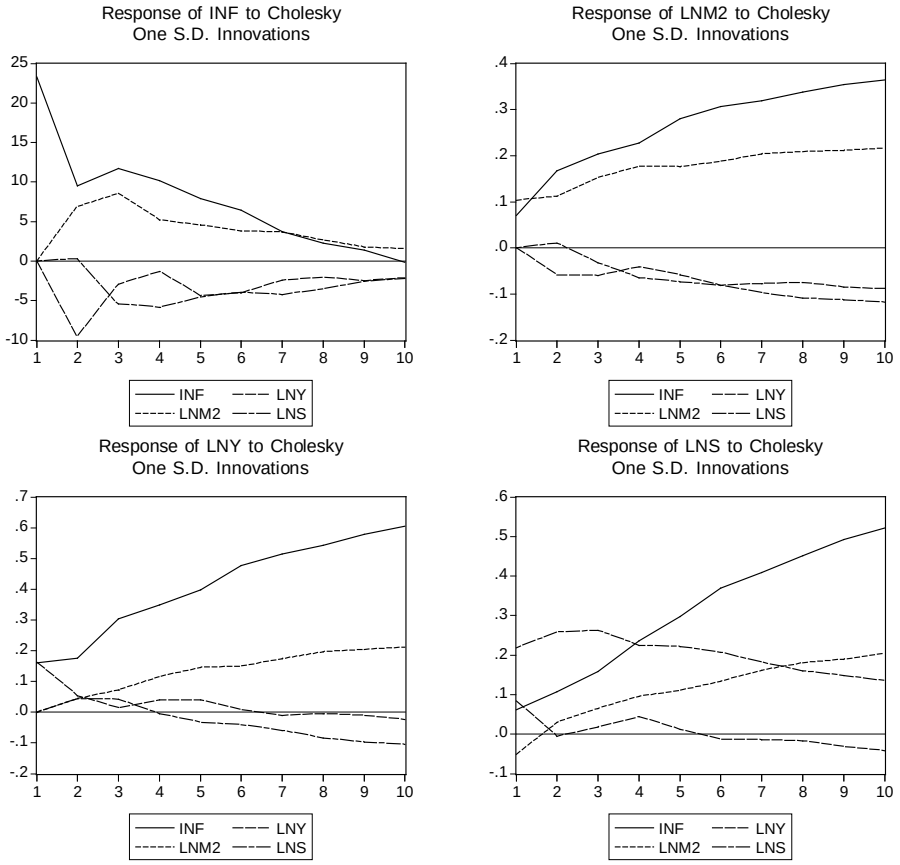
Period	INF	LNM2	LNY	LNS
1	19.79745	0.000000	0.000000	0.000000
2	8.108649	5.831431	-8.124903	0.273534
3	9.967481	7.292694	-2.478785	-4.606470
4	8.653982	4.434336	-1.148736	-4.978702
5	6.695484	3.852211	-3.749432	-3.872621
6	5.495276	3.239397	-3.441352	-3.363668
7	3.194221	3.090848	-2.029114	-3.623656
8	1.901428	2.262692	-1.756195	-2.985031
9	1.187568	1.479547	-2.098715	-2.173240
10	-0.135569	1.330359	-1.813874	-1.846038

Table (15)
ECM- Variance decomposition:

Variance Decomposition of INF: Period	S.E.	INF	LNM2	LNY	LNS
1	19.79745	100.0000	0.000000	0.000000	0.000000
2	23.61745	82.05497	6.096553	11.83506	0.013414
3	27.16030	75.51224	11.81932	9.781781	2.886663
4	29.29750	73.62220	12.44866	8.560443	5.368697
5	30.77447	71.45853	12.84932	9.242868	6.449278
6	31.79492	69.93245	13.07580	9.830595	7.161154
7	32.37162	68.43661	13.52571	9.876356	8.161317
8	32.69023	67.44739	13.74243	9.973382	8.836803
9	32.88432	66.78401	13.78312	10.26332	9.169556
10	33.01310	66.26568	13.83819	10.48529	9.410843

Unlike the results obtained in variance decomposition of the SVAR model the monetary growth effect on inflation is superior to exchange rate changes, (13.8) compared to (9.4), the explanation for that is the estimation method while SVARS uses regression analysis, the ECM employs cointegration techniques, therefore, lagged terms of exchange rate might have more influence than money growth.

Figure (7)
ECM- Impulse responses:



A granger causality test is carried to examine the relationship between inflation and the main determinants, statistically insignificant tests were removed, and there is a strong relationship between inflation and the main determinants money growth, output and the exchange rate:

Table (16)
Pairwise Granger Causality Tests

Sample: 1970 2008
Lags: 2

Null Hypothesis:	Obs	F-Statistic	Probability
INF does not Granger Cause LNM2		5.54645	0.00855
LNY does not Granger Cause INF	37	4.14015	0.02517
INF does not Granger Cause LNY		13.9986	4.3E-05
INFF does not Granger Cause INF	35	2.80142	0.07666
INF does not Granger Cause INFF		9.79631	0.00053
INF does not Granger Cause LNS		5.07819	0.01215
LNM2 does not Granger Cause LNY		10.9778	0.00023
LNM2 does not Granger Cause INFF		4.74835	0.01616
LNM2 does not Granger Cause LNS		4.46802	0.01944
LNS does not Granger Cause LNY	37	2.43227	0.10391
LNS does not Granger Cause INFF	35	2.83225	0.07469
INFF does not Granger Cause LNS		2.43052	0.10513

Granger causality test is adopted to investigate the causal relationship between inflation and the main determinants, only significant causal relationships were provided, it appeared that inflation causes further monetary expansion (one way causality), but foreign inflation produced two way causalities, from an economic point of view this is nonsense, one way direction is acceptable that is domestic inflation is generated by foreign inflation, but it seems unlikely to presume that foreign inflation is caused by domestic inflation or domestic money growth. The most reliable findings are the two direction relationship from domestic inflation to the exchange rate, this typically confirms the validity of the purchasing power parity, that is depreciation in local currency raises inflation and inflation accelerates

currency depreciation, this also support the central thesis in this research that the exchange rate is the major cause behind inflation in Sudan economy.

(4) Fiscal dominance model:

To test the second hypothesis the research also employed fiscal dominance model based on Jean-Claude Nachega (2005), the main issue is to investigate whether deficit financing through printing money (seignorage) may also represent a major cause behind inflation.

Jean-Claude Nachega (2005) using VAR system of equations and cointegration tests for inflation fiscal dominance, the results confirmed the validity of the central thesis that inflation is caused by fiscal dominance in D.R. of Congo.

The present research also adopted three system of equations that include z1,t=(ΔPt,ΔM1t, DEFYt); z2,t=(ΔPt, ΔM0t, DEFYt); and z3,t=(ΔPt ΔM3t, DEFYt). The first system encompasses the benchmark of inflation, money and deficit financing, while substituting for M0 and M3 for the second and third systems respectively. the research tested two properties for the system, test of non stationarity and cointegration.

z1,t = (x1t, x2t, x3t)…… ……(1)

where x1t = ΔPt ; x2t = ΔM1t and x3t = DEFYt.

Charles T. Carlstrom and Timothy S. Fuerst (1999) pointed out that both forms of theory

The research adopted VEC model to establish the causal long–term or equilibrium relationship among these variables, Ignacio Lozano (2008) provided the description of the model, the close relationship between the

VEC model and the cointegration relations can be checked by reordering any Δxi equation as follows:

$\alpha(x1,t\text{-}1 - B\,1x2,t\text{-}1 - B\,2x3,t\text{-}1\ )$.....(2)

$\Delta\, xi,t - \gamma i1\Delta\, x1,t\text{-}1 - \gamma i2\Delta\, x2,t\text{-}1 - \gamma i3\Delta\, x3,t\text{-}1 - \mu\, i,t$.....(3)

The model is generalized to include the lag number of Δz which is expanded up to period t-ρ+1 and, moreover, a deterministic term εt is included10, the final ECM specification is:

$\Delta zt = \prod zt\text{-}1 + \Gamma\Delta zt\text{-}1 + ...+ \Gamma p\text{-}1zt\text{-}p+1 + \varepsilon 0 + \mu t$ .....(4)

The fiscal theory of the price level explains inflation on the basis of fiscal dominance; the main idea is that if fiscal policy derives inflation the monetary authorities will stay idle, even if money growth is enacted fiscal policy affects inflation in the strong version of the theory, thus inflation targeting become impossible. The weak version of the theory still considers inflation as a monetary phenomenon but money growth is dictated by fiscal authorities (fiscal dominance), the mechanism as follows:

> *"The central bank creates money by exchanging dollar bills for government bonds. Money creation increases revenues by decreasing the liabilities of the fiscal authority, and also decreases the liabilities of the Treasury by increasing prices, thus lowering the real value of government debt. Both enable the fiscal authority to tax less or to increase government spending".*

[10] see more details in Ignacio Lozano (2008) p: 15

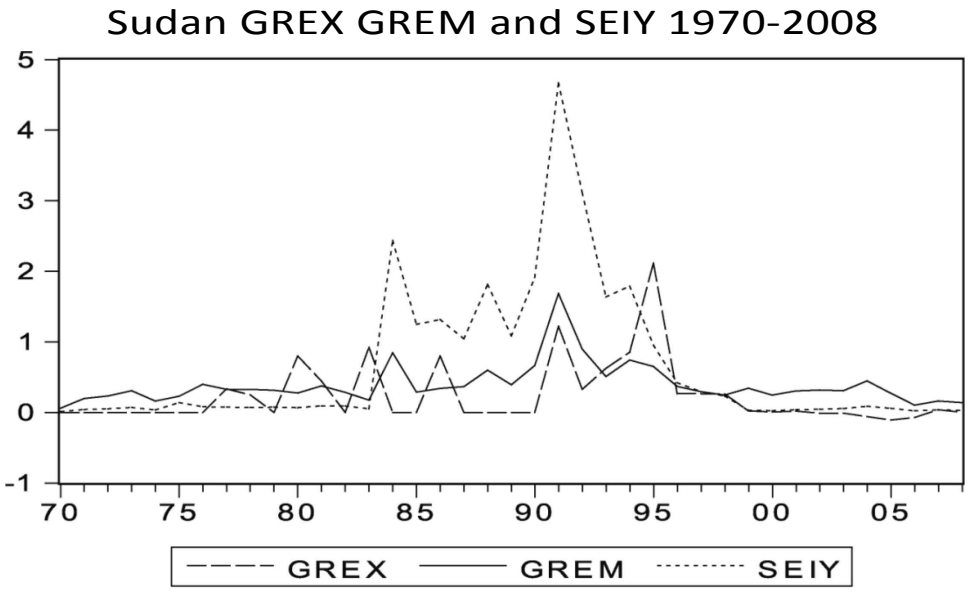
Charles T. Carlstrom and Timothy S. Fuerst (1999)P: 2

Domenico Fanizza and Ludvig Söderling (2006) argued that a sound fiscal position constitutes a necessary condition for macroeconomic stability whereas "sound" monetary policy is neither sufficient nor necessary; their results had brought increasing concerns over the role of fiscal policy in economic stability. In spite of the fact that we disagree with the notion that monetary policy is impotent, we still believe that fiscal dominance represented a major cause behind inflation pressure, monetary expansion also exacerbated the effects of fiscal dominance in Sudan economy.

$$INF = f(DEFY, X) \quad \ldots\ldots(1)$$

where INF: inflation, DEFY: percentage of deficit to GDP, x: vector of conditional factors such as velocity= VELO, real GDP growth= GRY, seignorage =SEIY, money growth rate=GRM, exchange rate changes= GREX, the equation (1) represents the response of inflation to its determinants based on Wallace fiscal dominance model.

Figure (8)
Exchange rate variations, money growth and seignorage



The model is estimated based on ARCH and GARCH specification of conditional mean and conditional variance as follows:

The GARCH (1, 1) Model

In the standard GARCH(1,1) specification:

$$Y_t = \gamma_0 + \gamma_1 X_{1t} + ... + \gamma_k X_{kt} + e_t \quad (2)$$

$$\sigma_t^2 = \omega + \alpha\ e_{t-1}^2 + \beta\ \sigma_{t-1}^2 \quad (3)$$

Table (17)

Fiscal dominance model :

Dependent Variable: INF
Method: ML – ARCH
Sample: 1970 2008
Included observations: 39
Convergence achieved after 65 iterations

	Coefficient	Std. Error	z-Statistic	Prob.
C	12.24252	4.032522	3.035947	0.0024
DEFY	1.672815	0.505909	3.306554	0.0009
GREX	36.17348	6.372634	5.676378	0.0000
GRY	0.471223	0.360040	1.308807	0.1906
SEIY	20.97825	1.703863	12.31218	0.0000
Variance Equation				
C	10.20021	26.81603	0.380377	0.7037
ARCH(1)	1.295785	0.751993	1.723134	0.0849
GARCH(1)	0.131250	0.131534	0.997839	0.3184

R-squared	0.527669	Mean dependent var	36.56590
Adjusted R-squared	0.421013	S.D. dependent var	36.28535
S.E. of regression	27.60996	Akaike info criterion	8.722602
Sum squared resid	23631.60	Schwarz criterion	9.063846
Log likelihood	-162.0907	F-statistic	4.947411
Durbin-Watson stat	2.165669	Prob(F-statistic)	0.000768

In spite of the fact that only 52% of total changes in inflation were explained by the model, the model seems mode valid, because DW: 2.1 reveals no serial correlation problem, the most influential variable in inflation determination is exchange rate depreciation proxied by GREX with the coefficient 36 correctly signed and statistically significant at 1% level, then comes seignorage effect with the coefficient

seiy =20, which is also statistically significant at 1%, followed by government budget deficit DEFY= 1.67, which is also statistically significant at 1% level, the only insignificant variable is the output effect proxied by GRY= 0.47, which is the lowest coefficient, the coefficients of ARCH (1) and GARCH(1), (α+β) are close to 1 , indicating persistence of inflation volatility in Sudan economy over the period 1970-2008, therefore, it seems that currency depreciation and deficit financing by printing money are the main determinants of inflation .

Table (18)
ARCH Test:

F-statistic	0.245303	Probability	0.623412
Obs*R-squared	0.257179	Probability	0.612065

Test Equation:
Dependent Variable: STD_RESID^2
Method: Least Squares
Sample(adjusted): 1971 2008
Included observations: 38 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.102803	0.244772	4.505431	0.0001
STD_RESID^2(-1)	-0.081829	0.165218	-0.495281	0.6234

R-squared	0.006768	Mean dependent var	1.022577
Adjusted R-quared	-0.020822	S.D. dependent var	1.119632
S.E. of egression	1.131228	Akaike info criterion	3.135681
Sum squared resid	46.06840	Schwarz criterion	3.221870
Log likelihood	-57.57795	F-statistic	0.245303
Durbin-Watson tat	1.987164	Prob(F-statistic)	0.623412

Table (18) indicates that there is no ARCH effect left in the residuals both F-statistics and obs*R-squared are statistically insignificant. To estimate an error correction

model first we checked the staionarity of the data using ADF, the whole variables found to be non stationary in level but stationary in first difference at 1% level:

Table (19)

ADF, PP tests of stationarity of fiscal dominance model:

Variable	ADF –t	Critical values
DEFY	-5.465674	-3.6228
GRY	-5.952167	-3.6228
GREX	-7.565475	-3.626784
SEIY	-5.740661	-3.6228

After elimination of GREM and DEFY from the model based on the justification that money growth and deficit financing will be represented by Seignorage, to reduce the number of the variables to suit the number of observations, the model is estimated and the following results were obtained:

Table (20)

Fiscal dominance ECM:

Date: 02/11/10 Time: 05:28
Sample(adjusted): 1973 2008
Included observations: 36 after adjusting endpoints
Standard errors & t-statistics in parentheses

Cointegrating Eq:	CointEq1
INF(-1)	1.000000
SEIY(-1)	47.61901
	(19.3331)
	(-2.46309)
GREX(-1)	45.90337
	(70.8376)
	(0.64801)

GRY(-1)	7.321154			
	(6.40844)			
	(1.14242)			
C	-50.05279			
Error Correction:	D(INF)	D(SEIY)	D(GREX)	D(GRY)
ECT	-0.271607	-0.002732	-0.006006	-0.047600
	(0.08459)	(0.00372)	(0.00203)	(0.02308)
	(-3.21105)	(-0.73425)	(-2.95483)	(-2.06216)
D(INF(-1))	-0.463419	-0.004785	0.005022	-0.007917
	(0.16315)	(0.00718)	(0.00392)	(0.04452)
	(-2.84041)	(-0.66687)	(1.28082)	(-0.17783)
D(INF(-2))	-0.220760	-0.008666	0.000381	-0.021953
	(0.15309)	(0.00673)	(0.00368)	(0.04178)
	(-1.44206)	(-1.28707)	(0.10357)	(-0.52549)
D(SEIY(-1))	-2.050602	-0.236517	-0.315919	-1.309656
	(5.94042)	(0.26127)	(0.14275)	(1.62108)
	(-0.34519)	(-0.90526)	(-2.21303)	(-0.80789)
D(SEIY(-2))	-3.048427	-0.121761	-0.211574	-0.799895
	(5.52347)	(0.24293)	(0.13273)	(1.50730)
	(-0.55190)	(-0.50122)	(-1.59397)	(-0.53068)
D(GREX(-1))	34.08275	0.202630	-0.573699	3.541433
	(6.77432)	(0.29794)	(0.16279)	(1.84865)
	(5.03117)	(0.68009)	(-3.52409)	(1.91569)
D(GREX(-2))	14.97141	-0.116799	-0.294451	0.672124
	(7.39200)	(0.32511)	(0.17764)	(2.01721)
	(2.02535)	(-0.35926)	(-1.65760)	(0.33320)
D(GRY(-1))	1.657100	-0.002259	-0.004748	-0.277414
	(0.88198)	(0.03879)	(0.02119)	(0.24068)
	(1.87885)	(-0.05823)	(-0.22400)	(-1.15261)
D(GRY(-2))	2.678186	0.044743	-0.007491	0.091769
	(0.78440)	(0.03450)	(0.01885)	(0.21405)
	(3.41432)	(1.29694)	(-0.39740)	(0.42872)
C	-1.030884	-0.009436	0.003306	0.221929
	(3.04849)	(0.13408)	(0.07326)	(0.83190)
	(-0.33816)	(-0.07037)	(0.04512)	(0.26677)
R-squared	0.672606	0.256306	0.575327	0.442378
Adj. R-squared	0.559277	-0.001127	0.428325	0.249355

Sum sq.resides	8577.443	16.59194	4.953366	638.7543
S.E. equation	18.16319	0.798844	0.436479	4.956558
F-statistic	5.934996	0.995624	3.913733	2.291844
Log likelihood	-149.6025	-37.13895	-15.37966	-102.8498
Akaike AIC	8.866805	2.618831	1.409981	6.269433
Schwarz SC	9.306671	3.058697	1.849847	6.709300
Mean dependent	0.005000	-0.000595	0.000133	0.169444
S.D. dependent	27.35958	0.798394	0.577283	5.720883

Determinant Residualcovarianc	174.4134
Log Likelihood	-297.2329
Akaike Information Criteria	18.95738
Schwarz Criteria	20.89279

The test of the relationship between inflation and deficit financing by printing money is attained, in the long run seignorage is the major determinate of inflation (the coefficient is 47), followed by the exchange rate effect (the coefficient is 45), some model coefficients were statistically insignificant because of the randomness effect of the variables in the ECM representation, in the short run the exchange rate changes in the first and second lags were very high (the coefficients are 34 and 14 respectively), while seignorage has a marginal effect in the first and second lags (the coefficients are -2 and -3 respectively), this actually coincides with economic theory because deficit financing and seignorage always take lengthier time than exchange rate movements.

Testing for impulse response had shown convergence of the main variables to the equilibrium level after three years from the first shock, It appeared that error correction term is correctly signed -0.27 and statistically significant, this indicates that the model presume that almost one third of the shock to the disequilibrium will be corrected in the same year, i.e. it requires about 3 years to retain the equilibrium

rate of inflation if a foreign shock occurred to the national economy. This typically coincides with the results obtained in the previous ECM, although the effects of the variables are generally random, most of the confidents were statistically significant. And 67% of the changes in inflation were explained by the model, these results confirms the validity of the argument that exchange rate depreciation and deficit financing were the major causes of inflation in Sudan economy over the period 1970-2008, according to the results obtained in the long run deficit financing is more influential causing inflation rather than exchange rate movements, while in the short run exchange rate depreciation seemed to more influence on inflation than deficit financing.

Table (21)
Fiscal dominance impulse responses:

Response of INF: Period	INF	SEIY	GREX	GRY
1	15.43575	0.000000	0.000000	0.000000
2	6.914667	8.338306	7.926047	-1.259908
3	7.123181	6.880432	-3.571226	-1.847773
4	9.239117	13.97552	-4.730880	-7.975639
5	10.92261	15.25380	-1.852139	-3.930435
6	9.440876	15.13296	-2.343352	-5.940688
7	8.329587	12.52205	-4.074309	-3.816568
8	9.706186	13.99320	-2.676069	-4.967679
9	9.482009	13.71374	-2.389585	-4.615953
10	8.974914	13.06712	-2.869303	-4.386834

Table (22)

Fiscal dominance: inflation variance decomposition

Variance Decomposition of INF: Period	S.E.	INF	SEIY	GREX	GRY
1	15.435747	100	0	0	0
2	20.494191	68.111151	16.5536638	14.9572501	0.37793440
3	23.114061	63.04322	21.874691	14.145903	0.93618043
4	30.015466	46.860104	34.651234	10.8729092	7.61575224
5	35.662149	42.57619	42.8421111	7.972040594	6.6096486
6	40.382034	38.67088	47.45592004	6.55413334	7.31906028
7	43.451797	37.07466	49.2924090	6.53998811	7.09293322
8	47.009761	35.9380	50.9738138	5.91153990	7.17658334
9	50.148878	35.15473	52.2701036	5.42167619	7.1534806
10	52.855330	34.52997	53.1661653	5.17535545	7.1285004

Conclusion and policy recommendations:

The research adopted empirical methods to investigate the main determinants of inflation in Sudan economy over the period (1970-2008), a single equation model was estimated, taking into consideration the problems of autocorrelation, model stability, multicolinearity, and heteroskedasticity, the findings revealed that the exchange rate is the major cause behind inflation in the short run, while in the long run both exchange rate and money growth represent main determinants of inflation, while foreign inflation played a minor role in inflation dynamics.

Adopting SVARS and ECM models also confirmed the main results obtained by the single equation model, lagged values of both the exchange rate and money growth played significant role in inflation dynamics, it appeared that only 31% of the disequilibrium will be corrected within the year,

i.e. it requires more than three years to correct the shock[11] in the system.

The fiscal dominance model also revealed correct signs and significant results indicating non plausible argument that deficit financing through printing money (seiognorage) also play crucial role in inflation determination.

Based on the results obtained the following recommendations can be made:

1. Its critically important to stabilize the exchange rate in order to curb inflation, further studies may be carried forward to strengthen the exchange rate system to be more resilient to the flux of the foreign crisis as well as the domestic shocks. This does not necessarily mean further appreciation of the national currency without deep concern about the possible impact of such policy on export competitiveness, or the requirements of defending the national currency with sufficient reserves, however, since devaluation seemed to be in appropriate to encourage exports, its recommended to maintain exchange rate stability to reduce inflation which in turn will improve export competitiveness[12]. Since inflation taxes poor and represents a major source of economic instability, the central bank may adopt a monetary policy that targets inflation. In other words, adopting a new monetary policy strategy based on inflation and the exchange rate as anchors. To curb inflation, it is critically important to adopt further measures that

[11] A shock can be external or internal such as the financial crisis or a sharp decline in oil proceeds.

[12] The idea is simply the structure of the national economy had changed tremendously, more than 95% of Sudanese exports are oil proceeds, traditional exports face structural rigidities that make devaluation ineffective in encouraging exports.

may strengthen and stabilize the exchange rate system and shield the domestic economy from foreign and domestic shocks.

2. There is need to develop hedging and coverage to reduce foreign exchange risks. To achieve that, a forward rate could be introduced as a mechanism that importers and foreign exchange /users/dealers could employ. This could reduce the demand for foreign exchange for speculative and coverage purposes in addition to eliminating uncertainty in foreign exchange markets, however, legal and legislative considerations must be taken into our consideration based on Islamic Shariaa .
3. Since money growth is a key determinant of domestic inflation, it is necessary to reduce government deficit that will eliminate money printing in addition to securitizing government owned-institutions. These measures can help reduce inflation in the long run. However, caution must be exercised to ensure that money markets are stable and sustainable. Such measures could include but not limited to precise and accurate issuance of government certificates based on the market mechanism, profit and loss sharing among security holders. Its recommended to reduce government deficit financing by printing money to a narrow level, securitization of government owned institutions must be economically managed to raise finance for various projects, reducing government budget deficit eliminates inflation in the long run, a crucial adjustments in the fiscal policy is critically important with specific coordinated arrangements in the monetary policy which in turn will play a vital

role in controlling inflation. Privatization of government owned enterprises may continue to limit losses and make the economy efficiently allocate resources. It's recommended to continue adopting conctractionary fiscal policy and rationing the government expenditure according to the priorities. More precisely, a tightened monetary policy is required to reduce inflation.

4. Immediate review of the current monetary policy should be implemented with objective of targeting lower money growth in order to prevent the current inflation surge.
5. Since financial crisis usually gives rise to public debt, it is important that the authorities design an appropriate public debt relief strategy.
6. To reduce inflation, other policy measures that aim at reducing the cost of finance in the economy should be urgently implemented, e.g. returns on certificates (Shahama, Sarah and Shihab).
7. Since inflation taxes poor and represents a major source of economic instability, the central bank may adopt a monetary policy that target inflation with some requirements of maintaining independence of the central bank and adopting flexible exchange rate system.
8. The central bureau of statistics is encouraged to revise the data about imported inflation to reflect the effect of exchange rate variations on imported goods, other indices are also crucially important to calculate such as; P^T = price of traded goods, P^N = price of non

traded goods, P_x = price of exports, P_m = price of imported goods , and TOT[13]= $P_x \setminus P_m$.

9. It's advisable to activate the open market operations to strengthen the central bank effectiveness in liquidity management in the short run, LRR as a tool could also be manipulated for monetary targeting in a shorter periods (monthly or quarterly) foreign exchange market interventions, and appropriate profit margins (reducing cost of finance in the economy) can also be used frequently.

[13] TOT= terms of trade

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Appendix : Matrix of policy measures required to contain inflation

Fiscal policy	Monetary policy	Exchange rate policies	Central bureau of statistics
(1) Reducing deficit financing from the banking system	(1) Raising the LRR	(1) Appreciation of the national currency to reduce cost of importation from abroad.	(1) Revising imported inflation to reflect the effects of exchange rate changes on imported goods
(2) Reducing tariffs on necessary imported goods	(2) Developing tools of the central bank in liquidity management given the technological advances in RTGS .	(2) Eliminating speculative demand for foreign currency	(2) Calculating indices of P_x = price of exports, and P_m = price of imported goods
(3) Reducing indirect taxes on necessary goods	(3) Cease money injection to commercial banks.	(3) Developing hedging and coverage in the foreign exchange market.	(3) Calculating terms of trade TOT= $P_x \setminus P_m$
(4) Reducing cost of finance in the economy (returns on certificates)	(4) Activation of open market operations (OMO)	(4) Using foreign exchange interventions to reduce monetary growth and sterilize the effects of external imbalance.	(4) Estimation of output on monthly or quarterly basis.
(5) Stimulating growth in the	(5) Developing auction system in primary	(5) Directing official foreign exchange	(5)Estimation of P^T= price of traded goods ,

real sector through public investments in leading economic sectors.	market operations to reduce cost of finance	resources to importation of basic goods.	P^N= Price of nontraded goods , Internal Real Exchange Rate= P^T/ P^N
(6) Attracting FDI and foreign portfolios to the productive sectors to accelerate output growth.	(6) Manipulating the factors that influence monetary growth (NDA, NIR claims on Banks, claims on government etc.) to reduce monetary expansion.	(6) Adopting basket of currencies to reduce the US dollar volatility on domestic currency.	(6) Sectoral decomposition of real output on monthly or quarterly basis (industry, agriculture, oil, services etc.)
(7) Reducing local and transportation duties on locally produced goods.	(7) Adopting a long run strategy to resolving public debt in the economy.	(7) Realignment of the exchange rate and elimination of the parallel market.	(7) coordination between central bureau of statistics, ministry of finance and central bank of Sudan in developing these indices