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An Examination of Foreign Exchange Reserve and Inflation Relationship of Four West African Countries: Evidence from ADRL Model

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Abstract

The objective is to provide the empirical evidence regarding the relationships between foreign exchange reserves and inflation for four West African countries namely Cote d'Ivoire, Senegal, Ghana and Nigeria. A comparison of empirical evidence is obtained from the Autoregressive distributive lag model (ARDL) proposed by Pesaran, Shin and Smith (2001) using annual data running the period of 1972 to 2014. The empirical result shows that the relationship between the change in foreign exchange reserves and inflation rate is positive for the countries cited above in long run but the overall short run estimation of our model is insignificant at the conventional level. This means that rise in foreign exchange reserves leads to increase the rate of inflation. Regarding our investigation results, the study suggests that governments of these countries cited above should pay more attention to foreign exchange system management by enlarging open market operations. Moreover, they can use sterilization or other policy instruments to reduce foreign exchange reserves to stabilize domestic economy. According our overall empirical results, we propose the following suggestions. First, the central bank expands the base money supply channels and offers a variety of sterilization methods. Second, reinforce coordination of monetary and fiscal policy, and adopt comprehensive measures to promote the international payments balance. As West African countries' economy is growing rapidly, exchange reserves will still growth and the inflation is an urgent issue too. Therefore, it's still very important for these countries to reduce the negative effect of the excessive foreign exchange reserves.

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1. Introduction

Since 1980s, exchange rate policy emerged as one of important instrument in developing countries with strong opposition to devaluation because most authorities of their countries fear of its inflationary impact, among other effects. So due to worldwide fluctuation of Inflation and exchange, policy maker considers that these two variables are important determinants of economic performance. This means that growth (output), demand conditions, the levels and monetary trends determine fiscal policy. Many African countries faced such a situation and there has been interest, therefore, in inflation performance and the role of exchange rate in the economy. Authorities have to pay more attention on different factors that may easily rise inflation and affect holding money, trade flows and investor confidence even when the inflation rate seems to be low.

In addition, regarding the nature and intensity of relationship between foreign exchange reserves and inflation rate is also a hot issue for researchers especially in those economies where above said variables have unequal and rapid fluctuations. In the modern research area, the factors like foreign exchange rate and foreign exchange reserves play important role in economic stability, especially in case of small open economy like ECOWAS[1] countries. The reason is that rapid variations in foreign exchange rate and in its level affect the profitability of entrepreneurs and multinational corporations directly and indirectly. And as a result fluctuation of goods and services supply play a significant role for inflation. In case of ECOWAS countries, experience of last few decades of currency devaluation or depreciation has affected their foreign exchange reserves significantly. And such variations in foreign exchange reserves also have an effect on the prices of goods and services. It means that foreign exchange reserves or its level adjusts quickly the inflation rate in these countries cited above. So moving in this background we have to investigate the nature and intensity of such connection between foreign exchange reserves and inflation rate. To address the direction of relationship between foreign exchange reserves and rate of inflation in these countries mentioned above, we directly regress the reduced form relationship equation through recent econometric technique known as ARDL approach and OLS method. To come back to the literature there are various studies concerning this area. Research undertaken by Ahmed and Ram (1991); Bilquees (1988); Hasan and A. H. Khan (1994); A. H. Khan and Qasim (1996) provide reliable evidence that the domestic price level reacts significantly but gradually to devaluation. Meiselman (1975) looks into the connection between international reserves and inflation and found the direct association between changes in international reserves and inflation. Heller (1976) investigates the association between international reserves and worldwide inflation and shows that change in international reserves positively affect the world wide inflation through change in monetary base and money supply. Genberg and Swoboda (1977); Parkin (1977) also demonstrate the correlation nature between above discussed variables and get the consistent results with Meiselman (1975) and Heller (1976). They conclude that the increase in national money supplies prompted by the international reserves enlargement ultimately have positive impact on national inflation. M. S. Khan (1979) finds that it was the growth in international reserves that augment the level of inflation. In other words we can say that M. S. Khan (1979) results were consistent with the quantity theory of money approach extended to the international economy. Utami and Inanga (2009) tested Fisher effect theory considering yearly and quarterly data on inflation, rate of interest and exchange rate of four countries for the period 2003-2008. They found that interest rate differential and changes in

[1] Economic Community of West African States

exchange rate are positively and significantly related. Prasertnukul, Kim and Kakinaka (2010) examined that inflation targeting caused a fall in exchange rate volatility in Asian countries.

Furthermore, Bacchetta, Benhima and Kalantzis (2013) found that in a steady state it is optimal for the central bank to replicate the open economy, i.e. to issue debt financed by the accumulation of reserves so that the domestic interest rate equals the foreign rate. They also found that capital controls can still help reach the first best when the planner has more fiscal instruments. Emmanuel (2013) has investigated the effect that foreign exchange reserves exchange rates in Nigeria. In so doing, time series data for a period of 25 years were collated from Central Bank of Nigeria Statistical Bulletin. The results showed that inflation rate has positive relationship with foreign exchange reserves. This study has shown that accumulation of reserves is essential for the economy of Nigeria which tends to confirm finding of earlier researchers. Zhou (2014) examined the relationship between Foreign exchange reserves and inflation covering monthly data from Jan. 2008 to Dec. 2011 for People Republic of China. According the test results we can get that China's foreign exchange reserves growth will promote consumer price index increase, foreign exchange reserves will influence the monetary policy by increasing money supply. So that, the excessive foreign exchange reserves is the reason to CPI increase, also we find that the contribution degree of foreign exchange reserves to CPI is more that 20%, that means the influence of foreign exchange reserves is obvious. Krušković and Maričić (2015) analyzed the effect of the accumulation of foreign exchange reserves to economic growth in emerging countries. They utilized balanced panel data methodology for Brazil, China and Russia, for the period from 1993 to 2012. The empirical results in this paper suggest that the increase in foreign exchange reserves causes the growth of GDP, while in the opposite direction causality has not been proven. Exchange rate depreciation that occurs as a result of the accumulation of foreign exchange reserves is not inflationary because it is a one-time, non-persistent shock, unlike the sudden depreciation of the exchange rate that occurs as a result of maintaining an overvalued exchange rate in the long term and leads to currency crisis. Moreover, the accumulation of foreign exchange reserves does not lead to inflation if the rate of accumulation of foreign exchange reserves does not exceed the rate of economic growth. Lin and Wang (2005) studied the effect of foreign reserves on inflation in five East Asia Economies. They used the model developed by Kyaland and Prescott (1977) and arrived at the conclusion that when the foreign exchange reserves increase (or domestic currency depreciates), inflation will be rising while the exchange rate effect is stronger than monetary surprise effect. The inflation rate will be reduced when the monetary surprise effect is powerful and if the weight placed output stability is not large.

The main objective of this paper is to analyze the relationship between changes in level of foreign exchange reserves and inflation rate in four African countries namely Cote d'Ivoire, Senegal, Ghana and Nigeria through ARDL estimation technique. Another target of our research paper is to observe the behavior of inflation again fluctuations of foreign exchange reserves in one side two countries with fixed exchange rate (Cote d'Ivoire, Senegal) and other side two countries with floating exchange rate(Ghana, Nigeria).The remain part of the paper is organized as follows. Section 2 deals with the Model and the econometric methodology applied, Section 3 is based on empirical examination and analysis of results. And section 4 gives us conclusion and policy recommendations.

2. The Model, Econometric Methodology Applied and Data Sources

2.1. The Model Specification

To examine the Foreign Exchange Reserves - Inflation rate long run relationships in four African countries we base our analysis on the model employed by Chaudhry, Akhtar, Mahmood and Faridi (2011). Therefore, the following econometric model is specified as follow:

$$(GDPd)_t = \alpha_0 + \alpha_1 (FR)_t + \varepsilon_t \quad (1)$$

Where $(GDPd)$ is Gross Domestic Product Deflator (a proxy of inflation rate), and (FR) is stands for Foreign Exchange reserves, at a certain period of time t; α_0 is the constant; and ε_t is the stochastic disturbance term. The foreign exchange reserves and inflation rate correlation is determined by the size of alpha. To examine the relationships between focused variables, we utilize the autoregressive distributed lag model (ARDL) suggested by Pesaran *et al*. (2001), for cointegration investigation and error correction (short run) analysis. We use variables in natural logarithm form to assess the significance of foreign exchange reserves on inflation rate in our study Chaudhry *et al*. (2011). So the log transformation of model is formulated as follow:

$$Ln(GDPd)_t = \alpha_0 + \alpha_1 Ln(FR)_t + \varepsilon_t \quad (2)$$

2.2. Econometric Methodology Applied and Data Sources

2.2.1. Unit Roots

Prior to testing for cointegration, the time series properties of the variables need to be examined. Non-stationary time series data has often been regarded as a problem in empirical analysis. Working with non-stationary variables leads to spurious regression results from which further inference is meaningless when these variables are estimated in their levels. In order to overcome this problem there is a need for testing the stationarity of these economic variables. The unit root and cointegration test on relevant economic variables are performed in order to determine time series characteristics. In general, economic variables which are stationary are called *I*(0) series and those which are to be differenced once in order to achieve a stationary value are called *I*(1) series. In testing for stationarity, the standard Augmented Dickey and Fuller (1979), and Phillips and Perron (1988) are performed to test the existence of unit root in order to establish the properties of individual series. The Augmented Dickey-Fuller (ADF) test for unit rootregression is estimated by equation (3) as follow:

$$\Delta Y_t = \alpha_0 + \beta Y_{t-1} + \gamma_1 \Delta Y_{t-1} + \gamma_2 \Delta Y_{t-2} + ... + \gamma_k \Delta Y_{t-k} + \varepsilon_t \quad (3)$$

Where Δ is the difference operator, Y_t the series to being tested, k is the number of lagged differences, and ε_t an error term. The standard augmented Dickey-Fuller (1979) test for a unit autoregressive root tests the null hypothesis $H_0 : \delta = 0$ against the one side alternative, $H_1 : \delta \langle 0$ in the regression. Under the null hypothesis Y_t has a stochastic trend; under the alternative hypothesis Y_t is stationary. The ADF statistic is the OLS $t - statistc$ testing $t - statistc\ \delta = 0$. The lag length *k* can be estimated using the BIC or AIC (Stock & Watson, 2003, P.464).

2.2.2. ARDL Approach to Co-Integration

To examine the long run relationships between foreign exchange reserves and inflation rate in four West African countries, this study uses recent co-integration analysis approach, known as autoregressive-distributed lag (ARDL) model Pesaran *et al*. (2001). To begin with, we test for the null hypothesis of no co-integration against the existence of a long run relationship. All other techniques require the same level of stationarity of variables for further process. But the ARDL model provides a substitute test for examining a long run relationship regardless of whether the underlying variables are *I*(0), *I*(1), or fractionally integrated. This approach has the following econometric advantages in comparison to other Co-integration procedures.

1) The long and short-run parameters of the model in question are estimated simultaneously;
2) The ARDL approach for testing the existence of long-run relationship between the variables in levels is applicable irrespective of whether the underlying regressors are purely *I*(0),

purely *I*(1), or fractionally integrated;

3) The small sample properties of the bounds testing approach are far superior to that of multivariate co-integration. The bounds testing approach of Pesaran *et al.* (2001) is employed to test the existence of a co-integration relationship among the variables.

4) The Pesaran *et al.* procedure involves investigating the existence of a long-run relationship in the form of the unrestricted error correction model for each variable. According to ARDL procedure the unrestricted model of our concerned function is depicted as follow:

$$\Delta Ln(GDPd)_t = \lambda_0 + \sum_{i=1}^{n} \lambda_i \Delta Ln(GDPd)_{t-i} + \sum_{i=0}^{n} \lambda_i \Delta Ln(FE)_{t-i} + \alpha_1 Ln(GDPd)_{t-1} + \alpha_2 Ln(FE)_{t-1} + \nu_{it} \quad (4)$$

Where $Ln(GDPd)$ the natural logarithm of Gross domestic product deflator is, $Ln(FE)$ is the natural logarithm of foreign exchange reserves, Δ is the difference operator and ν_{it} is the *i.i.d* stochastic error term. In order to investigate the long run relationship with restriction of coefficients α_1 and α_2. Hence, the null hypothesis in long run can be written as follow:

$$H_0 = \alpha_1 = \alpha_2 = 0$$

The F-test is used to test the existence of long-run relationships. Thus, the Pesaran *et al*. (2001) approach compute two sets of critical values for a given significance level. One set assumes that all variables are *I*(0) and the other set assumes they are all *I*(1). If the computed F-statistic exceeds the upper critical bounds value, then the H_0 (null hypothesis) is rejected. If the F-statistic falls into the bounds, then the test becomes inconclusive. Lastly, if the F-statistic is below the lower critical bounds value, it implies no co-integration. When long-run relationship exists, the F-test indicates which variable should be normalized. Moreover, when the order of integration of the variables is known and if all the variables are *I*(1), then the decision is based on the upper bound value. Similarly, if all the variables are *I*(0), then the decision is based on the lower bound.

However, for policy reasons, the short-run adjustment of inflation to changes in its determinants is necessary. To capture the speed of adjustment we estimate the following dynamic error correction model depicted by the equation bellow:

$$\Delta Ln(GDPd)_t = \alpha_0 + \sum_{i=1}^{n} \lambda_i \Delta Ln(GDPd)_{t-1} + \sum_{i=0}^{n} \lambda_i \Delta Ln(FE)_{t-1} + (ECM)_{t-1} \quad (5)$$

Where Δ represents first difference operator and ECM_{t-1} is the one period lag error correction term estimated from equation (5). The error correction term coefficient got after estimation measures the speeds of adjustment to obtain equilibrium in the event of shocks to the system. After estimation of long run relationship by employing the selected ARDL model, there are varieties of diagnostic and stability tests to verify the goodness of the fit of the model. These diagnostic tests refer to the serial correlation, functional form, normality and heteroscedasticity associated with the model. The stability test of the regression parameters is undertaken using the Brown, Durbin and Evans (1975) stability testing technique, also known as cumulative sum of recursive residuals (CUSUM) and the cumulative sum squares of recursive residuals (CUSUMSQ).

2.2.3. Data Sources

The annual data utilized for our study will be selected from the World Development Indicators published by the World Bank covering the whole period 1972 to 2014. Where gross domestic product deflator (GDPD) is used here as proxy of inflation and (FR) is stands for Foreign Exchange reserves. We used logarithm transformation of both variables for econometric estimation.

3. Empirical Results and Interpretation

3.1. Unit Root Problem and Co-Integration Analysis

In this section, we first perform the Augmented Dickey and Fuller (1979) (*ADF*), and Phillips and Perron (1988) test, which tests the series' stationarity. The *ADF* statistic is the *t* statistic for the lagged dependant variable. If the *ADF* statistical value is smaller than the critical value then we reject the null hypothesis of a unit roots and conclude that Y_t is a stationary process. However the result is presented in table 1.

Table 1. Unit roots test at level and first difference

	Test Variables	ADF Statistics		PP Statistics	
		Trend	No Trend	Trend	No Trend
Cote d'Ivoire	**Level**				
	$Ln(GDPd)$	3.847	-2.181	2.732	-2.050
	$Ln(FE)$	0.183	1.210	-0.135	-1.128
	First Difference				
	$\Delta Ln(GDPd)$	-3.500***	3.617***	-3.617***	-4.732***
	$\Delta Ln(FE)$	-6.786***	-0.743***	6.784***	6.743***

	Test Variables	ADF Statistics		PP Statistics	
		Trend	No Trend	Trend	No Trend
Senegal	**Level**				
	$Ln(GDPd)$	4.900	-2.646	3.625	-2.429
	$Ln(FE)$	-0.237	-1.331	0.228	-0.945
	First Difference				
	$\Delta Ln(GDPd)$	-0.022***	-4..404***	-2.912	-4..404
	$\Delta Ln(FE)$	-7.456***	-7.432***	8.022***	-11.326***

	Test Variables	ADF Statistics		PP Statistics	
		Trend	No Trend	Trend	No Trend
Ghana	**Level**				
	$Ln(GDPd)$	1.246	-0.009	-0.775	-1.491
	$Ln(FE)$	0.918	1.724	1.714	1.641
	First Difference				
	$\Delta Ln(GDPd)$	0.739***	-5.030***	1.560***	5.144***
	$\Delta Ln(FE)$	-7.331***	-7.621***	7.340***	7.620***

	Test Variables	ADF Statistics		PP Statistics	
		Trend	No Trend	Trend	No Trend
Nigeria	**Level**				
	$Ln(GDPd)$	1.246	-0.009	1.967	-0.070
	$Ln(FE)$	0.941	1.788	1.455	-1.697
	First Difference				
	$\Delta Ln(GDPd)$	2.73***	4.866***	2.562***	4.851***
	$\Delta Ln(FE)$	-5.304***	-5.572***	5.981***	-7.178***

(i) McKinnon (1980) critical values are used for rejection of the null unit root.

(ii) I(0) = The variable is stationary at level, I(1) = A variable is integrated of order one.

(iii) Critical value for ADF: *1% and ***10% are -3.7343 and -2.6348 respectively.

The standard augmented Dickey and Fuller (1979), and Phillips and Perron (1988) which test the stationarity of the individual variables shows that we fail to reject the stationary null hypothesis base on *ADF* and *PP* tests at level. In another words the tests indicate that all variables contains a unit root at level while they are all first difference stationary equation (4). Thus, according the empirical foundation, we found that all variables follow the $I(1)$ process.

3.2. Long Run and Short Run Dynamics Behaviors

After ensure that our variables are stationary at first difference, we perform the ARDL (Autoregressive Distributive Lag Model) method to investigate the existence of cointegration both in long and short run. The results are depicted in table 2 below:

Table 2. Critical value bounds of the statistic: intercept and no trend with $k = 2$

	F-Statistics	876.00	
Cote d'Ivoire (CIV)	Critical Value	Lower *I*(0)	Upper *I*(1)
	1%	3.88	5.30
	5%	2.72	3.83
	10%	2.17	3.19

	F-Statistics	2149.56	
Senegal	Critical Value	Lower *I*(0)	Upper *I*(1)
	1%	3.88	5.30
	5%	2.72	3.83
	10%	2.17	3.19

	Calculated F-Statistics	76.66	
Ghana	Critical Value	Lower *I*(0)	Upper *I*(1)
	1%	3.88	5.30
	5%	2.72	3.83
	10%	2.17	3.19

	F-Statistics	71.30	
Nigeria	Critical Value	Lower *I*(0)	Upper *I*(1)
	1%	3.88	5.30
	5%	2.72	3.83
	10%	2.17	3.19

Source: Own calculation using data from regression analysis.

Notes: critical values are extracted from Narayan (2004a, b, 2005a) *k* is the number of regressors.

The F-statistics calculated for all four (4) countries selected are bigger than the upper bounds values; hence we reject the null hypothesis of alternative hypothesis and conclude that there is strong cointegration relationship between our variables. These results link with other economies that foreign exchange reserves affect inflations rate. Having found a long run relationship between inflation and foreign exchange reserve, we now estimate the long-run elasticities based on the ARDL model specified by equation (5) above then, we estimate equation (2) for each economy respectively. Table 3 displays the results of four countries selected.

Table 3. Estimated long run elasticities using the ARDL approach

	Dependent Variable $Lndgdp_t$			
	Explanatory Variable	**Coefficients**	**Standard Error**	**T-Statistics**
Cote d'Ivoire	$Lnfe_t$	0.16	0.04	3.38
	Constant	3.38	0.21	15.96
	R^2	0.27		
	$\overline{R}^2$	0.26		
	DW	0.08		
	F-(Statistics)	15.04		
	F(Prob)	0.0004		
	N	42		

	Dependent Variable $Lndgdp_t$			
	Explanatory Variable	**Coefficients**	**Standard Error**	**T-Statistics**
Senegal	$Lnfe_t$	0.18	0.25	7.21***
	Constant	3.41	0.116	28.86***
	R^2	0.56		
	$\overline{R}^2$	0.55		
	DW	0.27		
	F-(Statistics)	51.93		
	F(Prob)	0.000		
	N	42		

	Dependent Variable $Lndgdp_t$			
	Explanatory Variable	**Coefficients**	**Standard Error**	**T-Statistics**
Ghana	$Lnfe_t$	2.26	0.22	12.34***
	Constant	-15.92	1.34	12.34***
	R^2	0.79		
	$\overline{R}^2$	0.78		
	Dw	0.71		
	F-(Statistics)	152.16		
	F(Prob)	0.000		
	N	42		

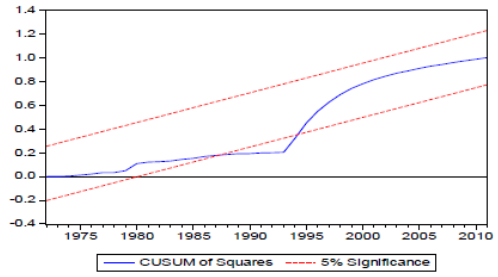
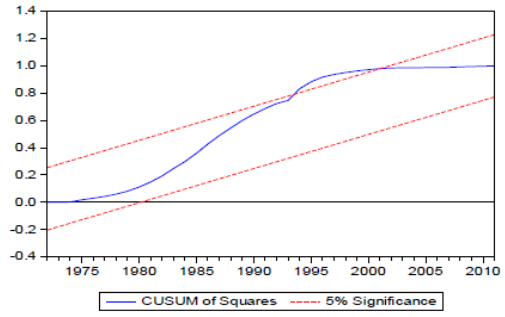
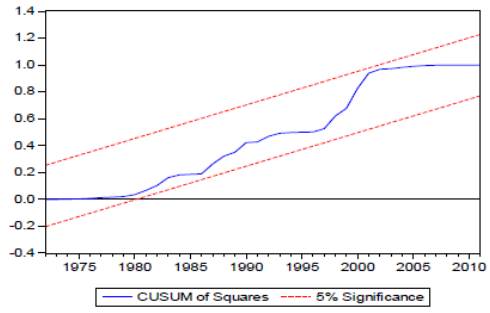
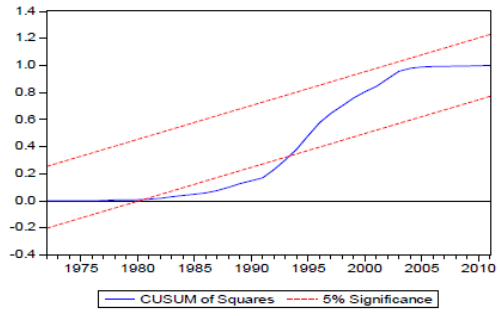
	Dependent Variable $Lndgdp_t$			
	Explanatory Variable	**Coefficients**	**Standard Error**	**T-Statistics**
Nigeria	$Lnfe_t$	0.15	0.156	7.57
	Constant	-7.64	1.316	5.803
	R^2	0.59		
	$\overline{R}^2$	0.58		
	DW	0.30		
	F-(Statistics)	57.253		
	F(Prob)	0.000		
	N	42		

Source: Own calculation using data from regression analysis.

Notes: The asterisks ***, ** and * implies statistically significant at 1%, 5% and at 10% level respectively.

As we see our selected variables such as foreign exchange reserves and inflation rate display the long run connection between one and other. To analyze the intensity of such relationships we regressed the equation (5) specified above. The results given in table 3 show long run coefficient in other word the table describes the long run elasticity because all variables are in logarithm form. The estimation analysis demonstrates that Foreign Exchange reserves (FE) has positive and significant effect on rate of inflation for Cote d'Ivoire, Senegal, Ghana and Nigeria in long run. The elasticity of inflation with respect to change in levels of foreign exchange reserves for all four (4) countries selected is very higher and very fit because the overall T-statistics are significant at the conventional level 1%, 5% and 10% but also has zero probability of acceptance of null hypothesis of no long run relationship between foreign exchange reserves and inflation excepted Cote d'Ivoire which has a bit low R-squared (R^2 =0.27) with probability (Prob=0.0004) among all countries cited above. In addition we continued our study by testing the model utilizing a battery of diagnostic tests. For that we conducted the autoregressive conditional heteroscedasticity test (ARCH), measure of goodness of fit, Adjusted R square, Durbin Watson statistics, F tests of autocorrelation, the general heteroscedasticity test (White) and the Lagrange multiplier test (LM) developed by Breusch (1978) and Godfrey (1978). In order to verify the stability of our models coefficients, we performed the $CUSUMQ$ square Brown *et al*. (1975) to test the parameters reliability. The diagnostic test results are shown in table 4 bellow.

Table 4. Diagnostics tests

COTE D'IVOIRE	**ARCH(2)** F-statistic: 161.92(0.0000) **Jarque-Bera** F-statistic: 12.014(0.0017) **RAMSEY** F-statistic:47.04 (0.000) **LM-Test** F-statistic: 75.02(0.000) **WHITE** F-statistic 7.736(0.0015) R^2 0.27 $\overline{R}^2$ 0.26 DW: 0.08 N=42	
SENEGAL	**ARCH(2)** F-statistic: 39.28(0.000) **Jarque-Bera** F-statistic:12.74(0.000) **RAMSEY** F-statistic: 2.926(0.095) **LM-Test** F-statistic: 32.60(0.000) **WHITE** F-statistic 5.315(0.0091) R^2 0.56 $\overline{R}^2$ 0.55 DW: 0.71 N=42	
GHANA	**ARCH(2)** F-statistic: 10.97(0.000) **Jarque-Bera** F-statistic: 0.288(0.866) **RAMSEY** F-statistic 0.569(0.455) **LM-Test** F-statistic 14.39(0.000) **WHITE** F-statistic 5.316(0.0091) R^2 0.79 $\overline{R}^2$ 0.78 DW: 0.71 N=42	
NIGERIA	**ARCH(2)** F-statistic: 22.75(0.000) **Jarque-Bera** F-statistic: 2.87(0.238) **RAMSEY** F-statistic:0.801(0.376) **LM-Test** F-statistic: 52.49(0.000) WHITE F-statistic 5.391(0.0015) R^2 *0.59* $\overline{R}^2$ *0.58* DW: 0.30 N=42	

Source: Own computation using the data from the regression

The Ramsey's Reset Ramsey (1969) statistics revealed no serious misspecification of variables. Our model also passed the Jarque and Bera (1987) test for normality without any serious pain. LM & F tests results indicate the no presence of autocorrelation and heteroscedasticity. Coefficients of

determination of all countries selected are quite acceptable with significant *F* ratio excepted Cote d'Ivoire less than 50%. The computed D.W. statistics is meaningless in the presence of lagged values of dependent variable as explanatory variable but it will be compensated by diagnostic test of serial correlation. So we conclude that foreign exchange reserves affect significantly the inflation rate in long run. In the regression analysis, the stability of coefficients is considered to be essential for policy purposes. In order to verify the stability of our models coefficients, we performed the *CUSUM* square Brown *et al*. (1975) to test the parameters stability of the regress model. Table 4 above displays the cumulative sum of residuals plot. We have applied CUSMUS of Square (Brown *et al*., 1975) tests and recursive coefficients to check the stability of the inflation function. The overall model appears stable and correctly specified given the CUSMUS of Squares test statistics exceed the bounds of the 5 per cent level of significance (see table 4 above) excepted Nigeria with a bit unstable inflation rate. So we strongly conclude that long run relationship exist between inflation and foreign exchange level in the four West African countries namely Cote d'Ivoire, Senegal, Ghana and Nigeria during study period.

Finally we utilized the vector error correction model (VECM) version of modified ARDL to examine the short run dynamic relationships. An important advantage of VECM approach is to provide the adjustment speed of correction if the dependent variable deviates from its steady state path due to uneven fluctuation of explanatory variables formulated by equation (5) above. Since our data base are integrated in *I*(1) process, we regressed the lagged value of inflation rate on lagged value of our explanatory variable foreign exchange reserves (*FE)* with error correction variable at first difference as follow. Table 5(a & b) bellow reports the results of VECM formulation.

Table 5a: Estimated short run elasticities using the ARDL approach (Cote d'Ivoire and Senegal)

	Dependent Variable $DLndgdp_t$			
	Variables	**Coefficients**	**Standard Error**	**T-Statistics**
Cote d'Ivoire	C	4.492	0.044	102.54
	$DLnFe_{(-1)}$	-0.061	0.038	-1.605
	ECM_{t-1}	-0.161	0.039	-4.080
	$R^2 = 0.91$ $\overline{R}^2 = 0.79$ $DW = 1.172$	*F-(Statistics)* = 1.36 *F(Prob)* = 0.307 N = 42		

	Dependent Variable $DLndgdp_t$			
	Variables	**Coefficients**	**Standard Error**	**T-Statistics**
Senegal	C	0.22	0.033	0.681
	$DLnFe_{(-1)}$	0.011	0.013	0.86
	ECM_{t-1}	0.014	0.014	0.982
	$R^2 = 0.25$ $\overline{R}^2 = 0.77$ $DW = 1.168$	*F-(Statistics)* = 7.465 *F(Prob)* = 0.00092 N = 42		

Source: own computation using the data from the regression

Table 5b. Estimated short run elasticities using the ARDL approach (Ghana and Nigeria)

	Dependent Variable $DLndgdp_t$			
	Variables	**Coefficients**	**Standard Error**	**T-Statistics**
Ghana	*C*	0.14	0.070	2.026
	$DLnFe_{(-1)}$	-0.106	0.056	-1.843
	ECM_{t-1}	-0.033	0.020	-1.682
	$R^2 = 0.649$ $\overline{R}^2 = 0.172$ $DW = 2.37$	*F-(Statistics)* = 1.36 *F(Prob)* = 0.307 N = 42		

	Dependent Variable $DLndgdp_t$			
	Variables	**Coefficients**	**Standard Error**	**T-Statistics**
Nigeria	*C*	0.222	0.366	-0.608
	$DLnFe_{(-1)}$	-0.241	0.084	-2.840
	ECM_{t-1}	-0.097	0.071	-1.360
	$R^2 = 0.719$ $\overline{R}^2 = 0.336$ $DW = 2.51$	*F-(Statistics)* = 1.878 *F(Prob)* = 0.148 N = 42		

Source: own computation using the data from the regression

The error-correction term (ECT) coefficient term is estimated of back adjustment speed to the long-run equilibrium relationship. The (ECT) should have a negative sign and significantly different from zero. The negative sign of (ECT) means that the deviation event between actual and long-run equilibrium level would be adjusted back to the long-run relationship in the current periods to clear this discrepancy. Since all the variables in the above model follow *I*(1) process, statistical inference base on standard (*t*) and F-test is valid. Thus we can find the preferred model by removing all parsimonious insignificant regressors and test whether this diminution is supported by F-test. Therefore we can find the preferred model and test whether this diminution is supported by F-test. Hence, by using the Akaike Information criterion (AIC) and the Schwarz Bayesian Criterion (SBC) we find that the maximum lag length for our model is $k = 14$. Finally, the resultant model can be checked by performing diagnostic tests on the residuals. The equilibrium correction coefficients estimated value is -0.133 (for Ghana), which is statically insignificant and has correct sign also imply a fairly 13.3 % per annum speed of correction if economy suffered with unexpected inflation due to uneven variations in foreign exchange reserves. In other words 13.3 % disequilibrium (in inflation) from the previous year shock (in foreign exchange reserves) converges back to the long run equilibrium in the current year. Some short run coefficients of determination are also quite satisfactory but all estimators obtained are not robust at the conventional level 1%, 5% and 10%.

4. Conclusion

The main objective of this paper was to analyze the linkage between foreign exchange reserve and

inflation through most recently reliable "ARDL" econometric technique. As we know theoretically, through the operations in the foreign exchange market by central bank, we are then able to analyze the relation between foreign exchange reserves and inflation rate. The empirical result shows that the relationship between change in foreign exchange reserves and inflation rate is positive for Cote d'Ivoire, Ghana, Nigeria and Senegal long run. The overall short run estimation of our model is insignificant at the conventional level. Our founding mixes with the earlier studies and consistent with our hypothesis because most researches show positive relationship between foreign exchange and inflation. Hence, the increase of foreign exchange reserves will lead the price level sustained growth. Then, once inflation occurs, it will push prices continually rise, so it is much more difficult to control the inflation after it start. As suggestion, government of these countries cited above should pay more attention to foreign exchange system management by enlarging open market operations. Moreover, they can use sterilization or other policy instruments to reduce foreign exchange reserves to stabilize domestic economy. Regarding our overall empirical results, we propose the following suggestion. First, the central bank expands the base money supply channels and offers a variety of sterilization methods. Second, reinforce coordination of monetary and fiscal policy, and adopt comprehensive measures to promote the international payments balance. As West African countries' exchange reserves still growth and the inflation is an urgent issue too. Therefore, it's still very important to reduce the negative effect of the excessive foreign exchange reserves.

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