Modelling the effect of exchange rate on inflation in Ghana

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ABSTRACT

The paper examines the exchange rate-inflation nexus for Ghana during the period 1964 to 2013 using annual data. The analysis of the results performed by using the Johansen test (JH), Vector Error Correction (VECM) test, and the Ordinary least square test (OLS). The findings of the result based on the JH, and VECM tests indicate stable long run and short run link between exchange rates and inflation. The results of the OLS test indicate there is positive link between exchange rates and inflation. Policy makers should take into account the findings of the study in order to control inflation. Future studies should consider causality and structural break issues as well as panel study.

Keywords: Inflation, exchange rates, money supply, long run
Jel classification: E31, F31, 024, P24, P44

1 INTRODUCTION

Sustainable economic growth results from macroeconomic stability and this has attracted attention in research into macroeconomic linkages in recent years (Omotor, 2008; Nwosa & Oseni, 2012; Rehman & Aftab, 2015). Empirical examination of the linkages is very important for formulating various macroeconomic policies to ensure growth. Among the macroeconomic linkages is the link between inflation and exchange rate. Exchange rate and inflation are considered as key measures of economic health of various economies and that continue to attract empirical studies on the linkage between the two variables in the literature.

Examining the linkage between inflation and exchange rate in the current study and controlling for money supply in a trivariate modelling help avoid complexity in macroeconomic analysis as preferred by policy makers and economists. Policies on inflation control and exchange rate is very essential to understand the key forces behind the behaviour of these variables. In Ghana where exchange rate depreciation and high interest rate is a serious macroeconomic issue, empirical understanding of the way these variables affect each other is very important for robust policy formulation.

The findings of the empirical verification of the long run link between exchange rate on inflation are found in various works in the literature (Folawewo & Oshinubi, 2006; Ito & Sato, 2006; Okhira & Saliu, 2008; Omotor, 2008; Nwosa & Oseni, 2012; Rehman & Aftab, 2015). For example, Odusola and Akinlo (2001) analysed the effect of exchange rate on inflation in Nigeria for the period 1970 to 1995 using quarterly data by applying the restricted vector autoregressive (VAR) model. The variables in the model were real Gross Domestic Product (GDP), money supply (broad money), official exchange rate, parallel exchange rate, prices (consumer price index; CPI) and lending rates. The findings of the study provided evidence that official exchange rate influenced prices, money supply and parallel exchange rate.

Campa and Goldberg (2002) and Kara and Nelson (2002) used UK data to examined the link between exchange rate and inflation and reported that there is low correlation between

inflation and nominal exchange rate changes, whereas there is high correlation between 'import price inflation' and nominal exchange rate changes.

Lu and Zhang (2003) examined the exchange rate-inflation nexus for China and reported that exchange rates is positively associated with inflation in the short run in China. Devaluation is not good for China's economy.

Maswana (2005) examined the link between exchange rate, monetary growth, and the price for Congo during the period of high inflation. The findings indicated that there is stable long run link among the variables with exchange rate Granger causing inflation.

Folawewo and Oshinubi (2006) investigated the link among monetary policy, inflation, and exchange rate for Nigeria for the period 1880 to 2000 using quarterly data. The findings of the study indicate that inflation influence volatility of its own rate as well as the rate of real exchange.

Okhira and Saliu (2008) study the effect of exchange rate on inflation rate and reported that inflation and exchange rate are correlated. However, the findings of the study indicate no significant long run relationship between inflation and exchange rates. Short run link existed between inflation and exchange rate.

Omotor (2008) analysed the effect of exchange rate on inflation for Nigeria for the period 1970 to 2003. The findings of the study suggested that exchange positively influenced inflation in Nigeria for the study period. The analysis is of interest for using Johansen test that is appropriate for multivariate study. The vector error correction model (VEC) was also used which allows for the short run analysis. The study included money supply to assess its effect on inflation.

Nwosa and Oseni (2012) examined the long run and the short run nexus among monetary policy, exchange rate and inflation rate for the period 1986 to 2010 for Nigeria. The findings of the study supported significant long run and short run link among the variables in the model. The findings suggested bidirectional causality between inflation and exchange rate.

Rehman and Aftab (2015) examined the long run link between exchange rate and inflation for the economy of Southeast Asia, Malaysia for the period 1990 to 2011 using annual time series data. The study is of interest for the use of the autoregressive distributed lags (ARDL) approach to co-integration and vector error correction model (VECM) since the ARDL is robust in small sample studies and the VECM allows for the examination of the short run link. The study introduced interest rate as a control variable that also helps to produce robust results. The findings of the study suggest significant long run link between is present between inflation and exchange rate. Inflation negatively influences exchange rate in the study with causality running from inflation to exchange rates.

The conclusion from the review is that devaluations of the domestic currency is associated with increase in inflation in an economy that has subsequent deleterious effect on the economy resulting from inflationary pressures. However, few studies have been conducted in Ghana for the period 1960 to 2013 using the OLS, JH, and the VECM. The aim of the study is therefore to examine the long run and short run relationship between inflation and exchange rate to contribute to the body of knowledge in literature on the determination of inflation using the OLS, JH, and VECM.

The paper is based on research question such as what is the nature of the link between exchange rate and inflation in the long run and short run. The hypothesis underlying the paper is that there is significant long run and short run relationship between exchange rate and inflation. The paper uses secondary data and as such, challenges of using secondary data may influence the results of the study. The findings are also limited by the criticisms of the estimation methodologies (ADF, JH, and VECM).

The rest of the paper is organised as follows. The econometric methodology is given in section 2. The empirical results are discussed in section 3. Section 4 concludes the study.

2 METHODOLOGY

2.1 Estimation methodology

The current paper is based on quantitative research design using time series data. The relationship between inflation and exchange rates is quantitatively examined and explained in the current study. The empirical model is as specified in equation (1). The dependent variable in the model is inflation (INF), whereas the independent variable is exchange rates. The estimation methods for the study are Johansen method (JH), the error correction model (VECM), and the Ordinary least squared (OLS). The Johansen test is use to examine the stable long run relationship between inflation and exchange rates. The error correction model (ECM) is use to investigate the short run link between inflation and exchange rates. The Augmented Dickey-Fuller (ADF) test is use to examined the stationarity properties of the variables.

$$INF_t = \alpha_0 + \beta_i EXR_t + MS_t + \varepsilon_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where INF= is inflation (proxied by consumer price index); EXR= exchange rates; MS= money supply; and ε_t = error term.

2.2 Data

The data for the empirical verification of the effect of exchange rates on inflation is based on annual secondary data for Ghana for the period 1964 to 2013. The source of the data is the World development indicators (WDI). The sample size for the study is 50.

Table 1 Data Description, Proxies and Sources

Data Description	Source
Exchange Rates (EXR)	WDI
Inflation (INF)	WDI
Money Supply (MS)	WDI

3 EMPIRICAL RESULTS

3.1 Descriptive Statistics

Table 2 shows of the summary statistics of the data in the model estimated. The mean is a measure of the central tendencies of the data, and the values of the mean indicate a good fit for inflation and money supply and not for exchange rate. The spread of the data set is measure by comparing the minimum and maximum values of the data set. The inflation is more spread (132.4637), followed by money supply (22.8032), and then money supply (1.954).

The coefficients of variation (C.V) measure the volatility of the data set. The higher the value the more volatile the data and the lower the value the less volatile the data set. The results indicate that inflation is more volatile followed by exchange rates, and then money supply. The standard deviation measures the dispersion of the data set from their mean values. The more spread apart the data, the higher the deviation and the higher the value of the standard deviation. The results show that inflation is more spread followed by money supply, and then exchange rates.

The coefficient of skewness is a measure of the nature of distribution of the data set (the nature of normality). The results indicate all the data set are positively skewed. The coefficient of kurtosis measures the nature of peakness of the data distribution. The values for the data set are in absolute terms larger than zero. These indicate more peaked-topped distribution with inflation been more peaked followed by exchange rate. The values of the kurtosis and skewness show that the data set are not normally distributed.

Table 2 Summary Statistics

Summary Statistics, using the observations 1964 - 2013				
Variable	Mean	Median	Minimum	Maximum
INF	21.0950	1.4159	0.0013	132.4650
EXR	0.3416	0.0236	0.0001	1.9541
MS	22.5727	22.0781	11.3050	34.1082
Variable	Std. Dev.	C.V.	Skewness	Ex. kurtosis
INF	35.7199	1.6933	1.7618	1.9505
EXR	0.5422	1.5872	1.5060	1.1020
MS	5.9316	0.2628	0.0399	-0.8390

Source: Author's calculation, March 2017

3.2 Unit Test Results

The unit root properties of the data set were examined using the time series plots and the ADF test.

3.2.1 Time Series Plots

Figure 1 to figure 6 show the time series plot results of the data set. The figures indicate the data set are unit root in levels (figure 1 to figure 3) and attained stationarity after differencing (figure 4 to figure 6). The stationarity properties are further investigated by employing the ADF test. Table 3 report the ADF test results.

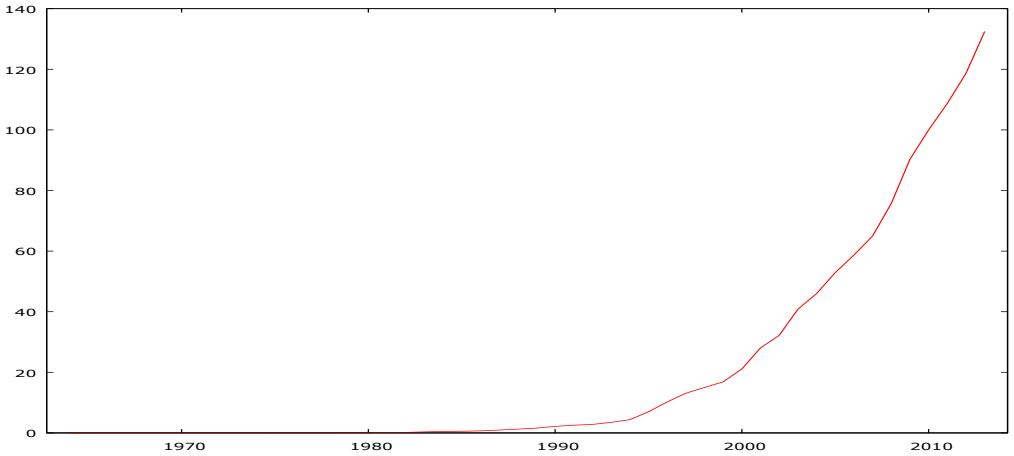

Figure 1 Plots of Inflation (levels)

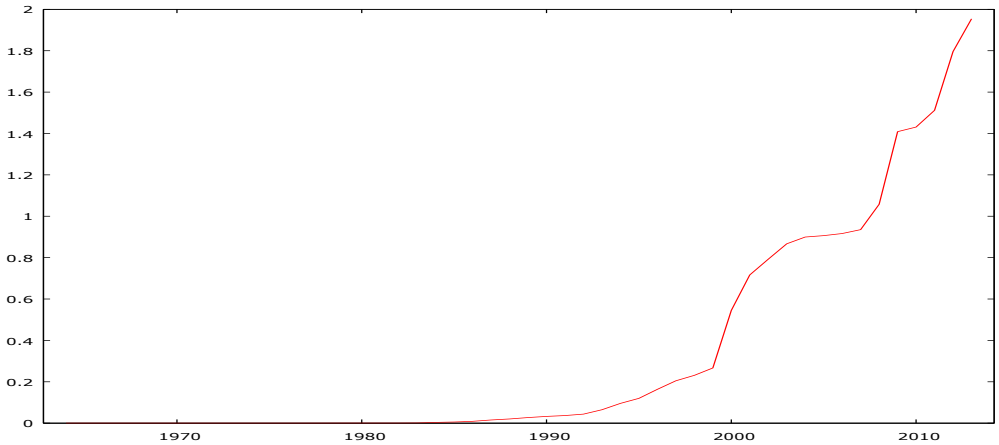

Figure 2 Plots of Exchange Rates (levels)

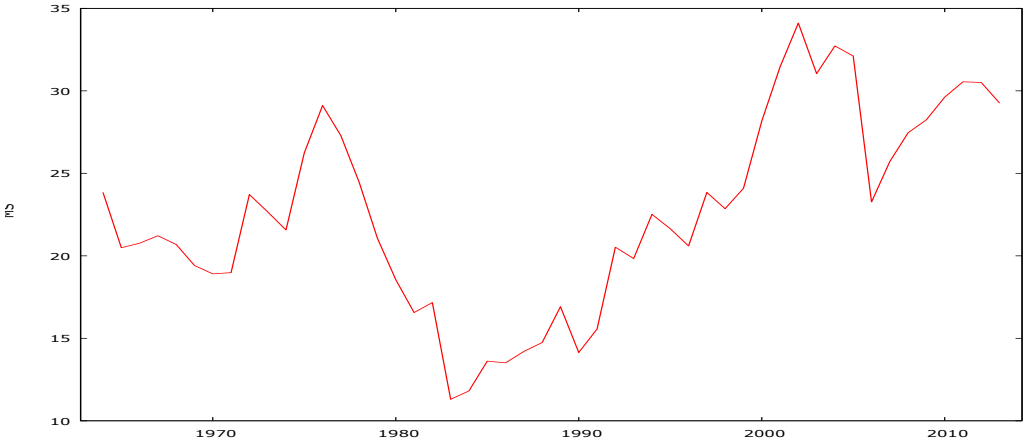

Figure 3 Plots of Money Supply (levels)

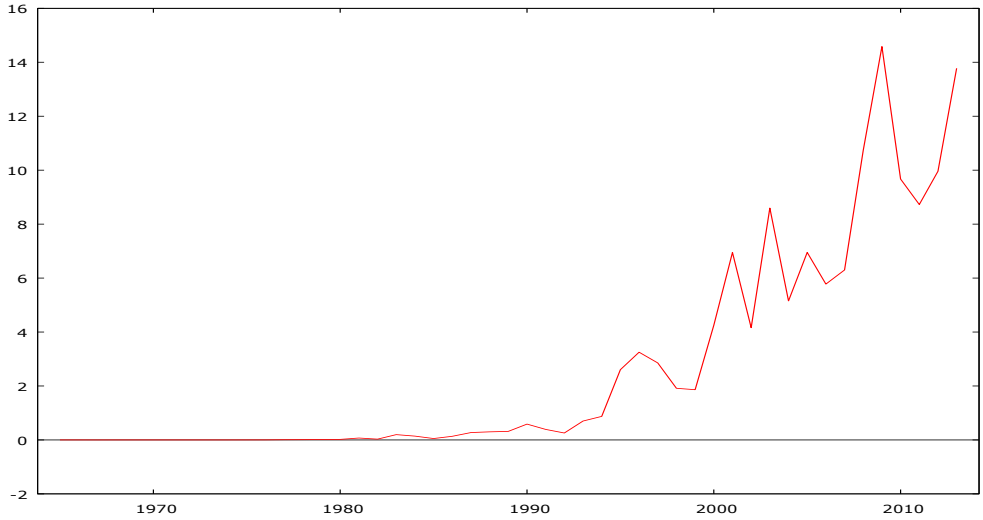

Figure 4 Plots of Inflation (1st difference)

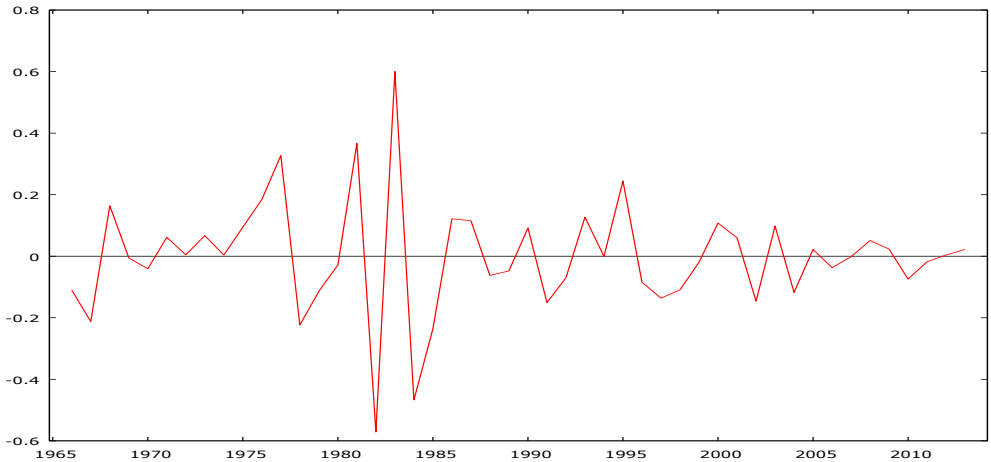

Figure 5 Plots of Inflation (2nd difference)

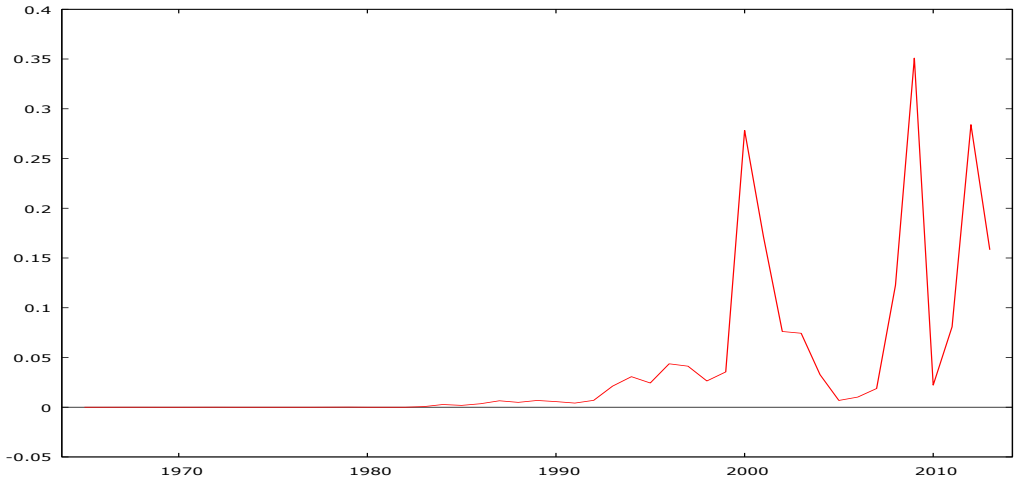

Figure 6 Plots of Exchange Rate (1st difference)

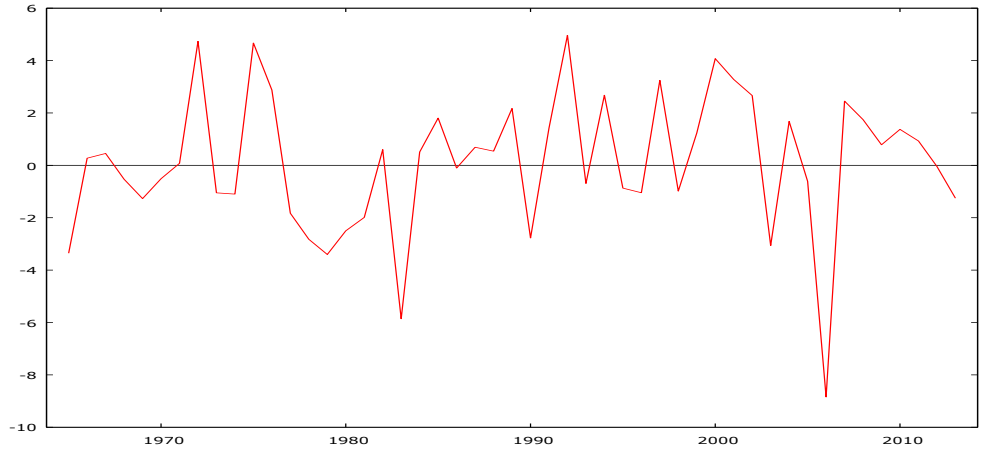

Figure 7 Plots of Money Supply (1st difference)

3.3 Unit Root Test Results

The results of the ADF test for stationarity are reported in Table 3. The ADF test is based on the null assumption that the data set are unit root (not stationary) in levels. The data set are integrated of order one, I(1). The ADF test statistic is a negative number. The more negative it is, the stronger the rejection of the null hypothesis that there is a unit root at the levels of confidence (1%, 5%, and 10%). The results show the variables (INF, EXR, and MS) are non-stationary in levels using the ADF test. However, the data attained stationarity on first differenced. The results indicate shock to the data set are permanent and not temporary.

Table 3 ADF Stationarity Test Results with a Constant, Time Trend, and Trend Squared

Variables	T-statistic	Results	Max Lag
INF-level	1.2858	Unit root	1
INF-1st diff.	-5.5208	No unit root	1
EXR-levels	-1.4654	Unit root	1
EXR-1st diff.	-5.7424	No unit root	1
MS-level	-2.0390	Unit root	1
MS-1st diff.	-6.5850	No unit root	1
Critical values	-4.04(1%) -3.45(5%) -3.15(10%)		

Source: Author's calculation, March 2017

3.4 Ordinary Least Squared Test Results (OLS)

Table 4 reports the OLS test results on the relationship between exchange rate and inflation. The results show that there is significant positive link between exchange rate and inflation at 1% level of significance. There is also significant negative link between money supply and inflation at 5% level of significance. The results indicate that 1% increase in exchange rate leads to about 105.6% increase in inflation, whereas 1% increase in money supply leads to about 119.6% decrease in inflation.

Table 4 OLS Regression Results

OLS, using observations 1964-2013 (T = 50) **Dependent variable: lnINF**					
	Coefficient	**Std. Error**	**t-ratio**	**p-value**	
const	8.0258	1.7704	4.5334	0.0000	***
lnEXR	1.0564	0.0476	22.1793	<0.0000	***
lnMS	-1.1958	0.5415	-2.2084	0.0321	**

Mean dependent var	-0.4585	S.D. dependent var	4.0417
Sum squared resid	25.9856	S.E. of regression	0.7436
R-squared	0.9675	Adjusted R-squared	0.9662
F(2, 47)	263.5740	P-value(F)	0.0000
Log-likelihood	-54.5849	Akaike criterion	115.1698
Schwarz criterion	120.9058	Hannan-Quinn	117.3541
Rho	0.8993	Durbin-Watson	0.1789

Source: Author's calculation, March 2017

3.5 The Diagnostic Test Results

The diagnostic test results are reported in Table 5. The test results are on parameter stability, model specification, heteroskedasticity, normality of the errors, and autocorrelation. The estimated model passed the stability test as shown in Table 5 and figure 8. The test did not pass the CUSUMSQ test as shown in figure 9. The estimated model did not pass the rest of the tests such as model specification, heteroskedasticity, normality of the errors, and autocorrelation.

Table 5 Diagnostic Test Results of the OLS Regression

Tests	**Results**
CUSUM test for parameter stability Null hypothesis: no change in parameters Test statistic: Harvey-Collier t(46) = 0.0980 P-value = P(t(46) > 0.0980419) = 0.9223	There is no change in parameter stability
RESET test for specification Null hypothesis: specification is adequate Test statistic: F(2, 45) = 28.1167 P-value = P(F(2, 45) > 28.1167) = 0.0000***	Specification is not adequate
White's test for heteroskedasticity Null hypothesis: heteroskedasticity not present Test statistic: LM = 22.1294 P-value = P(Chi-square(5) > 22.1294) = 0.0005***	Heteroskedasticity is present

Test for normality of residual Null hypothesis: error is normally distributed Test statistic: Chi-square(2) = 14.5644 P-value = 0.0007***	Error is not normally distributed
LM test for autocorrelation up to order 1 Null hypothesis: no autocorrelation Test statistic: LMF = 251.769 P-value = P(F(1,46) > 251.769) = 0.0000***	There is autocorrelation

Source: Author's calculation, March 2017

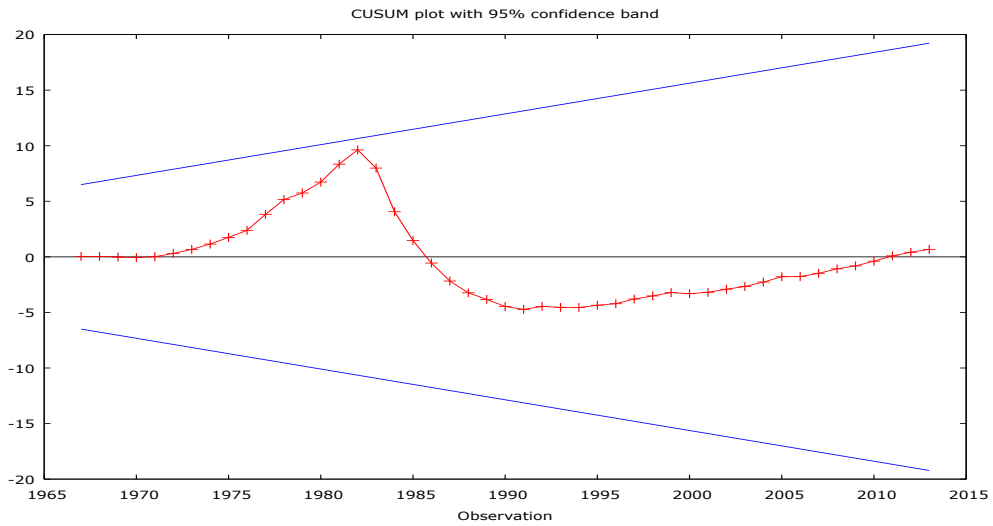

Figure 8 Plots of CUSUM

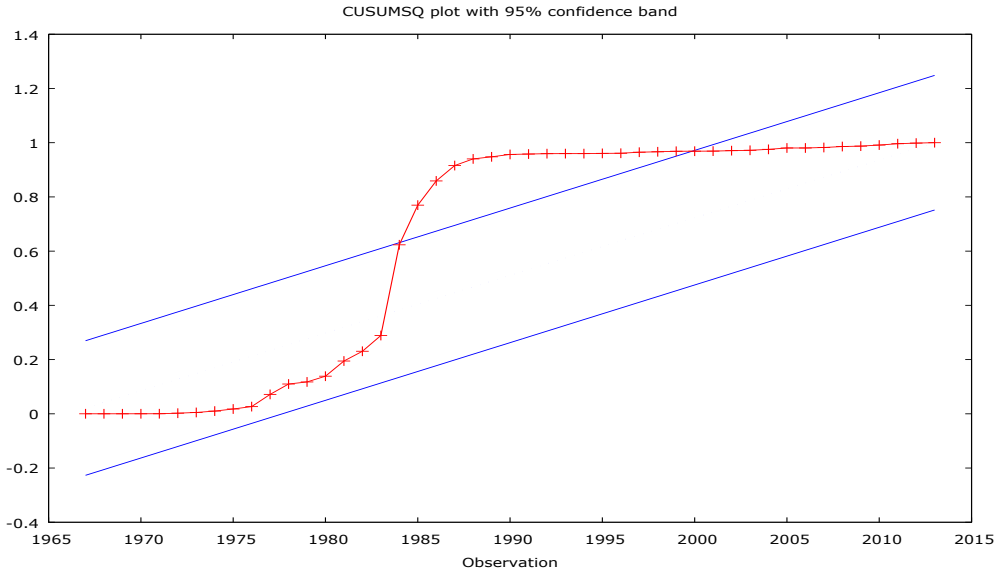

Figure 9 Plots of CUSUMSQ

3.6 Johansen Cointegration Test Result for the long run link between exchange rate and inflation

The results on the investigation of the stable long run relationship between exchange rates and inflation are reported in Table 6. The results show that there is significant long run relationship between exchange rates and inflation using the Johansen method, since both the trace test and the maximum Eigen value test passed the test of stability. There is at least one cointegration rank between exchange rates and inflation at 1% level of significance.

Table 6 Long run relationship between exchange rates and Inflation

Johansen test: Lag order = 1 Estimation period: 1965 - 2013 (T = 49)			
Rank	**Eigenvalue**	**Trace test/p-value**	**Lmax test p-value**
0	0.9010	124.4800[0.0000***]	113.3300[0.0000***]
1	0.1673	11.1570[0.2051]	8.9736[0.2951]
2	0.0436	2.1832[0.1395]	2.1832[0.1395]

Source: Author's calculation, March 2017

Note *** and ** denote significance at 1% and 5% levels of significance

3.7 The short run link between exchange rates and inflation

The error correction test (ECM) used to examine the short run relationship between exchange rates and inflation indicate that there is still disequilibrium in the short run since the error correction term (ECM-1= -0.0301; p=0.0000) is significant at 1% level of significance. The value have the expected a priori theoretical sign of negative. The value indicate that about 3% of errors generated in the previous period is corrected in the estimated model moving from the short run to the long run. The value did not indicate a very rapid correction in moving from the short run to the long run. The value of the adjusted R-squared (0.8714) indicate that in the short run model estimated about 87.14% of the changes in the estimated model is explained by exchange rate.

Table 7 Short run relationship between exchange rates and Inflation

VECM system, lag order 1 Maximum likelihood estimates, observations 1965-2013 (T = 49) Cointegration rank = 1				
	Coefficient	**std. error**	**t-ratio**	**p-value**
const	0.4436	0.2402	1.847	0.0711*
EC-1	-0.0301	0.0017	-18.06	0.0000 ***
Mean dependent var	2.7033	S.D. dependent var	4.0024	
Sum squared resid	96.8147	S.E. of regression	1.4352	
R-squared	0.8741	Adjusted R-squared	0.8714	
rho	0.2019	Durbin-Watson	1.5952	

Source: Author's calculation, March 2017

4 CONCLUSIONS

The aim of the current paper is to examine the effect of exchange rate on inflation for Ghana for the period 1964 to 2013 using the ADF test (for stationarity), Johansen test (for long run), and VECM test (for short run), and the OLS test (for degree of association). The results

overwhelmingly indicate that exchange rate have both long run and short run link with inflation.

The findings are in line with previous studies that reported of significant effect of exchange rate on inflation in the long run and short run such as Campa and Goldberg (2002) and Kara and Nelson (2002) for UK; Lu and Zhang (2003) for China; Maswana (2005) for Congo; Folawewo and Oshinubi (2006) for Nigeria; Okhira and Saliu (2008) for Nigeria; Omotor (2008) for Nigeria; Nwosa and Oseni (2012) for Nigeria; Rehman and Aftab (2015) for Malaysi.

The empirical findings of significant long run relationship between inflation and exchange rates support the theories on the effect of devaluation on inflation that devaluation may lead to increase in inflation. Policy makers in order to control inflation in inflation targeting economies should take into consideration the findings of the current studies to ensure stable exchange rates.

Consideration of the direction of causality and structural breaks in unit root and long run relationship in future studies are not out of place since the current study did not consider these issues. Panel study is worth doing in future studies to allow for discussions that are more flexible. Other exchange rate such as parallel exchange rate and nominal exchange rate should also be considered in further studies.

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