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4 January 2015

Online at <https://mpra.ub.uni-muenchen.de/83324/>  
MPRA Paper No. 83324, posted 20 Dec 2017 16:37 UTC

# **Exchange Rate Behaviour in the West African Monetary Zone: A GARCH Approach**

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## **Exchange Rate Behavior in the West African Monetary Zone –A GARCH Approach**

### **Abstract**

This study employs Generalized Autoregressive Conditional Heteroscedasticity (GARCH) to explore the level of exchange rate volatility in West African Monetary Zone for the period 1980-2014. Our empirical findings reveal that the Gambian dalasi experiences the least volatile official exchange rate while the Liberia dollar is the most volatile in the Zone. There is need for government of Gambia and Nigeria to control overshooting dynamics experienced by dalasi and naira. All the countries should exercise monetary and fiscal measures on time to put their exchange rate volatility under check.

Key words: Exchange rate Volatility, GARCH, West African Monetary Zone

JEL Classification: **C10, F02, F31**

### **1.0 Introduction**

Exchange rates and their rates of change, in the course of time, are often as reported in the literature to be inconsistent with equilibrium. Attempts to manage exchange rate volatility and its overshooting tendencies started after the failure of the Bretton Woods System in 1971 (Stockman, 1978).

The adoption of the floating exchange rate regime by countries in the West African Monetary Zone (WAMZ) started in the 80s. Unlike the period of fixed exchange rate regime where exchange rate was rigid, exchange rate under floating exchange rate regime is flexible as it moves freely with supply and demand of currency in the foreign exchange market. In other

word, scarcity or surplus of foreign currency does not build up for too long under floating exchange rate regime (Jhingan, 2003).

The exchange rate policy regimes employed by the nations that is made up of the WAMZ spans from fixed to peg to managed floating and to independently floating. The monetary zone being the second monetary zone in West Africa, was formed in 2000 with five countries (Gambia, Ghana, Guinea, Nigeria and Sierra Leone) while Liberia joined in 2010. In the Sub-Saharan Africa, among the countries that started to consider floating exchange rate system, after the Bretton Woods system broke down, are Ghana, Gambia and Nigeria followed by Guinea, Sierra Leone and Liberia (Sekkat and Varoudakis, 1998).

The outcome of the policy to move towards a more flexible exchange rate mechanism in the Non- Communauté Financière Africaine (CFA) is the rising real exchange rate volatility through the 1980s. This experience is obviously not in the best interest of the countries that is in the zone because they are largely import dependent. The country whose exchange rate volatility persists would be vulnerable to macroeconomic problems like instability in domestic prices of fully imported goods and goods with high level of import content (Sekkat and Varoudakis, 1998).

Attempts to address at least some of these macroeconomic issues causes the region to envision a full-blown monetary union which was expected to commence in 2003 but failed due to unsuccessful effectuation of the specified conversion criteria by member states. The zone then projected to introduce a common currency by 2015. The common currency, named 'eco', is projected to reduce volatility among WAMZ countries due to anticipated drop in transaction costs, overridden price uncertainty caused by differences in official exchange rate thus paving a way that could make stable inflation rate, and enhanced efficiency in allocation of capital accompanied by intra-regional trade (Yuen, 2000).

The need to maintain stability of exchange rate in the zone might also be related to the need to ensure stability in the national income of these countries because evidence has shown that WAMZ economy accounts for 73.3% of West Africa's GDP and 19.1% of Africa's GDP (ADF, 2010). For sustainable growth, exchange rate stability must be maintained in the zone so as to improve the success of business plans and economic integration.

Studies in this area are replete in the literature for advanced economies but in the WAMZ our review of literature uncovers that few studies have been done but not on all members of the WAMZ. For Nigeria we have- Olowe (2009), Adeoye and Atanda (2011), Bala and Asemota (2013). For Ghana- Mensah, Awunyo-Victor and Asare-Menako (2013), Insaah and Chiaraah (2013) based their studies on the effects of exchange rate volatility on some macroeconomic variables.

In anticipation of the introduction of the common currency "eco" in 2015, this study explores the behavior of exchange rate volatility in each of the six WAMZ countries (Gambia, Guinea, Liberia, Sierra Leone, Nigeria and Ghana) from the period of the adoption of floating exchange rate in the Zone to the year before 2015 (i.e. 1980 to 2014) using quarterly data. The rest of the paper is structured as follows; second section literature review, third section is on methodology, fourth section is on discussion of results, and fifth section takes care of conclusion.

## **2.0 Literature review**

Exchange rate volatility has been modeled in the last thirty years using all variants of Generalized Autoregressive Conditional Heteroscedasticity (GARCH) modeling (called parametric estimation) and non-parametric estimators like realized volatility, bi-power and truncated power variation, etc. (Erdemlioglu, Laurent and Neely, 2012).

Olowe (2009), on Nigeria presented results separately for the period before and after deregulation, used different versions of GARCH model over the period 1970 to 2007. The results showed that volatility is persistent in Nigerian foreign exchange. Adeoye and Atanda (2011) with ARCH and GARCH models also discovered that there is presence and persistency of volatility shocks in the nominal and real exchange rates for naira vis-à-vis U.S dollar monthly time series between 1986 and 2008. Their coefficient of variation measure, under the real exchange rate, was the only measure that suggested overshooting volatility shocks. Bala and Asemota (2013) on the other hand examined exchange rate volatility for three major currencies in the Nigerian foreign exchange market with variants of GARCH models using monthly exchange rate return series from 1985 to 2011 for Naira/US dollar return and from 2004 to 2011 for Naira/British Pounds and Naira/Euro returns. They identified USD as the most volatile and BPS as the least volatile. They found significant evidence that all the asymmetric models they adopted rejected the existence of a leverage effect except for models of GARCH with volatility breaks.

Although there are no studies from other countries that examined the behavior of exchange rate volatility, here are studies on Ghana: Mensah et al. (2013) investigated how employment growth in Ghanaian manufacturing sector is affected by exchange rate volatility for the year 1990 to 2010 using ordinary least squares estimation technique. They found that exchange rate volatility has effect on employment growth within the manufacturing sector of Ghana. Insah and Chiaraah (2013) examined the sources of real exchange rate volatility in Ghana using autoregressive distributed lag model covering the period 1980 to 2012. The study established that government expenditure, domestic and external debts are major determinants of real exchange rate volatility in Ghana.

This study contributes to literature by considering the volatility behavior of exchange rates of all the six countries in the West African Monetary Zone in the period of their floating exchange rate regime i.e. 1980 to 2014.

### 3.0 Methodology

#### 3.1 Sources of Data and Model

Quarterly data of official exchange rate (local currency per US\$) for the six WAMZ countries were obtained from the International Monetary Fund’s (IMF) International Financial Statistics (IFS) CD-ROM. The countries’ respective local currencies are: the Gambia –dalasi, Ghana –cedi, Guinea –franc, Liberia –Liberian dollar, Nigeria –naira, and Sierra Leone – leone. The sample period covered by this study is from 1980 to 2014.

Our model is the GARCH econometric technique which is widely used in the literature for estimating volatility of exchange rate behavior (see: Baillie and Bollerslev, 1990; Doyle, 2001; Del Bo, 2009; Dukich et al, 2010; Vee et al, 2011).

$$y_{xt} = c_x + u_{xt} \quad (1)$$

From equation 1 above where  $y_{xt}$  is the relative change in exchange rate for country  $x$  at time  $t$ ,  $c_x$  is the constant and  $u_{xt}$  is the error term, we can obtain an ARCH model, shown in equation 2, which allows conditional variance to change over time as a function of past errors.

$$u_{xt}^2 = \alpha_0 + \alpha_1 u_{xt-1}^2 + \alpha_2 u_{xt-2}^2 + \dots + \alpha_p u_{xt-p}^2 \quad (2)$$

Bollerslev (1986) argues that a simple GARCH model provides a marginally better fit than an ARCH model with a relatively long lag. The GARCH process: equation 3 is the mean equation and equation 4 is the generalized variance specification i.e. the standard GARCH (p, q) specification. Of which ARCH (p + q) model is equivalent to GARCH (p, q).

$$y_{xt} = c_x + u_{xt} \quad (3)$$

$$\sigma^2_{xt} = \omega_x + \sum_{j=1}^p \alpha_j u^2_{xt-j} + \sum_{i=1}^q \beta_i \sigma^2_{xt-i} \quad (4)$$

Equation 4 has non-negative coefficients and would be applied to each country.

The ARCH term ( $\alpha_{ix}$ ) is the lag of the squared residual from the mean equation for each country. It will tell if volatility reacts to market movements i.e. it would test the hypothesis that there is volatility clustering or persistence, simply put if volatility from previous period affects volatility in current period. If there is volatility clustering it means large changes tend to be followed by large changes of either sign (+ or -) and small changes followed by small changes. The GARCH parameter ( $\beta_{ix}$ ) is the forecasted variance from the previous period for each country while  $\omega_x$  is the constant term.

The sum of the ARCH and GARCH term, although often observed under high frequency data, will inform us if volatility shocks are persistent. If the sum is less than unity the shocks would die out slowly if not it would die out quickly (Bollerslev and Wooldridge, 1990).

$$\varpi_x = \frac{\omega_x}{1 - \alpha_x - \beta_x} \quad (5)$$

Equation 5,  $\varpi_x$  is the unconditional variance for each country, which would measure the long run volatility. There is stationarity in variance if  $\alpha_x + \beta_x < 1$ . There would be non-stationarity in variance if  $\alpha_x + \beta_x > 1$  while  $\alpha_x + \beta_x = 1$  is termed unit root in variance. If  $\varpi_x$  is squared we obtain the unconditional standard deviation. The result of this would identify which of the WAMZ countries has the highest level of volatility in its exchange rate.

### 3.2 Estimation Procedure

The raw data was transformed such that the analysis of this study employs the relative change in official exchange rate. We provide descriptive analysis of the data and proceed to estimate



its stationarity by employing the Dickey and Fuller (1979) and Phillips and Perron (1988) unit root tests, specifying the intercept as expressed in equations 6 and 7 below.

$$\Delta Z_{xt} = \beta_1 + \delta Z_{xt-1} + \sum_{i=1}^m \alpha_i \Delta Z_{xt-i} + \varepsilon_{xt} \quad (6)$$

$$\Delta Z_{xt} = \beta_1 + \delta Z_{xt-1} + \varepsilon_{xt} \quad (7)$$

These tests will determine if the null hypothesis of  $\delta = 0$  (not stationary) or the alternative hypothesis of  $\delta < 0$  (stationary) exist in WAMZ countries official exchange rate. The lag length used was based on Akaike info and Schwarz information criterion.

To empirically determine the level of volatility and if there is time varying variance in our data, we used the Generalized Autoregressive Conditional Heteroscedasticity (GARCH) test. To know if there is any misspecification and if there is any consequent ARCH effects present we conducted the ARCH –LM residual test (Baillie and Bollerslev, 1990).

#### 4.0 Discussion of Findings

The results of the unit root test in Table 1 (see appendix) shows that all the series of the countries are integrated of order one and significant at 1%.

GARCH (1,1) was used for all the countries. Liberia has an ARCH term ( $\alpha$ ) of 0.4495 and a GARCH term ( $\beta$ ) of 0.4829 (see Table 2, appendix). Both of the terms are statistically significant at 5% and 1%, respectively. The ARCH term implies that there is volatility clustering. ( $\alpha+\beta$ ) is 0.9324, which is lower than one as such there is stationarity in variance. This implies that volatility shocks to conditional variance in Liberia’s official exchange rate are persistent in future periods and they would die out slowly. The computed square root of the unconditional variance ( $\sqrt{\omega}$ ) (is used to measure the level of volatility) is the highest

among the countries which means the Liberian dollar has the most volatile official exchange rate among the countries of study.

In the case of Ghana, the results reveal that the ARCH term is significant at 1%. However, the GARCH term is not significant. The ARCH term has volatility clustering but its coefficient does not conform to the a priori expectation of non-negativity. Due to this, one could infer that a positive shock on Ghana's official exchange rate could result to a higher next period conditional variance than a negative shock (Brooks, 2008). The sum of the terms is 0.565. This fulfills the stationary condition in variance and depicts that volatility shocks are barely persistent in the official exchange rate of Ghanaian cedi. The square root of the unconditional variance allows us to rank the official exchange of Ghana's cedi as the second most volatile in the West African Monetary Zone.

Results on Sierra Leone reveal that the ARCH term and GARCH term are significant at 5% and 1%, respectively. That is there is volatility clustering. The addition of the terms is 0.9918 which implies that volatility is persistent in Sierra Leone's official exchange rate. The square root of the unconditional variance shows that the currency leone is not as volatile as Liberian dollar and Ghanaian cedi.

The ARCH and GARCH term for Nigeria are statistically significant at 5% and 10%, respectively. There is volatility clustering. The addition of the terms is 1.0171. This implies there is no stationarity in variance thus shocks would not die out slowly. Thus, one can infer from Dornbusch (1976) that volatility in naira could be explained by overshooting dynamics. That is, the effect of shocks on naira in the short run makes the buying and selling rates of naira in the foreign exchange market to move far beyond the Central Bank of Nigeria's buying and selling rates. The square root of the unconditional variance shows that Nigerian

naira is more volatile than Guinean franc and Gambian dalasi while it is less volatile than Liberian dollar, Ghanaian cedi and Sierra Leonean leone.

Guinea's ARCH and GARCH term are statistically significant at 1% and 5%, respectively. The ARCH term does not comply with the non-negative a priori. There is volatility clustering. The addition of the coefficients of both terms ( $\alpha+\beta$ ) is -4.3489. Although this is less than unity, it does not comply with the a priori expectation of non-negativity. The square root of the unconditional variance shows that Guinean franc is not as volatile as Liberian dollar, Ghanaian cedi, Sierra Leone leone, and Nigerian naira.

We found that the Gambia's ARCH term ( $\alpha$ ) and GARCH term ( $\beta$ ) are both significant at 1%. This implies that there is volatility clustering. ( $\alpha+\beta$ ) is 1.7626. This implies no stationarity in variance thus shocks. The Gambian dalasi, just like Nigerian naira, experiences overshooting in the short run when there is change in exogenous variables. The square root of the unconditional variance shows that dalasi is not as volatile as other currencies in the WAMZ.

#### **4.4 Diagnostic test**

The ARCH-LM test (table 2), under each country, has F-statistics that are not significant. This proves that there are no further ARCH effects in the specified variance equation at all levels of significance.

#### **5.0 Conclusion**

Empirical evidence analyzed in this paper suggests that all the WAMZ countries' currencies experience exchange rate volatility clustering though not of the same level. Perhaps the reasons for the differences in the degree of volatility in official exchange rate could be as a result of unstable source(s) of foreign earnings in the domestic economy and/or rising level of

appetite for imported goods in the respective nations among others. The need for government to reduce the level of exchange rate volatility and control overshooting dynamics (in Nigeria and Gambia) becomes pertinent because of its risk import to international trade returns and cost of financial transactions. This is not desirable for a zone that is predominantly poor. Thus, for government to ensure stability in the exchange rate of the respective nations it must intervene in good time through monetary and fiscal measures, as this would improve economic integration of the zone.

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## Appendix

Table 1: Results of unit root test

	LOG (GMBER)	LOG (SLEER)	LOG (NGAER)	LOG (GINER)	LOG (LBRER)	LOG (GHAER)
ADF t-statistic	-11.458	-8.769	-10.823	-11.554	-12.582	-11.847
Remark	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***
PP t-statistic	-11.478	-9.044	-10.821	-11.554	-12.604	-11.847
Remark	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***
Critical Values						
10%	-2.599					
5%	-2.921					
1%	-3.568					

Significant at 1% means \*\*\*

LOG(GMBER) means log of Gambia's exchange rate; LOG(SLEER) means log of Sierra Leone's exchange rate; LOG(NGAER) means log of Nigeria's exchange rate; LOG(GINER) means log of Guinea's exchange rate; LOG(LBRER) means log of Liberia's exchange rate; and LOG(GHAER) means log of Ghana's exchange rate

Source: Computed by authors.

Table 2: Results of Generalized Autoregressive Conditional Heteroscedasticity (GARCH)

	Gambia	Sierra Leone	Nigeria	Guinea	Liberia	Ghana
Mean Equation						
C	0.0155***	0.0390**	4.8765***	8.2874***	8.8838	-0.0064
Variance Equation						
C	-3.1E-5	0.0014***	4.61E-5	0.0007***	7.8656***	0.2914

$\alpha$ (ARCH(-1))	1.1846***	0.2144**	0.8224**	-4.419***	0.4495**	-0.0079***
$\beta$ (GARCH(-1))	0.5780***	0.7774***	0.1947*	0.0697**	0.4829***	0.5729
$\alpha+\beta$	1.7626	0.9918	1.0171	-4.3489	0.9324	0.565
$\varpi$	4.07E-5	0.1707	-0.0027	-0.00021	116.355	0.6699
$\sqrt{\varpi}$	0.00638	0.4132	0.0520	0.0145	10.7868	0.8185
Ranking	6th	3rd	4th	5th	1st	2 <sup>nd</sup>
Diagnostic:						
ARCH Test						
F-statistic	0.8739	0.0631	1.1009	0.0536	0.0134	9.93E-6
Probability	0.5406	0.8025	0.3512	0.9946	0.9979	0.9975

Significant at 1% means \*\*\*, 5% means \*\*, and 10% means \*

Source: Computed by authors.