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Modeling Exchange Rate Volatility in Selected WAMZ Countries[1]: Evidence from Symmetric and Asymmetric GARCH Models

Perekunah .B. Eregha[a], Festus .O. Egwaikhide[b] and Emeka Osuji[c]

[a]Department of Economics, SMSS, Pan-Atlantic University, Lagos, Nigeria.
Email: peregha@pau.edu.ng
[b]Department of Economics, University of Ibadan, Nigeria.
Email: fegwas@yahoo.com
[c]Department of Economics, SMSS, Pan-Atlantic University, Lagos, Nigeria.
Email: eosuji@pau.edu.ng

Abstract

Exchange rate is one of the macroeconomic indicators that gives concern to policy makers and investors as its movements are mostly unpredictable and tend to affect both trade and capital flows. Hence, this study analyzes exchange rate volatility clustering among selected WAMZ countries for the period 1980-2016. The univariate symmetric and asymmetric ARCH/GARCH modeling approach is employed with the Maximum Likelihood Estimation Technique and the results show exchange rate volatility clustering and the existence of leverage effect in all the countries. Therefore, it is imperative for policy makers in these countries to ensure adequate policy coordination based on current realities to boost investors' confidence and create needed automatic adjustment mechanism.

JEL Codes: E3, F30, F31
Keywords: Exchange Rate, Exchange Rate Volatility, Symmetric GARCH Models, Asymmetric GARCH Model, Leverage Effect.

1. Introduction

Prior to the collapse of the Bretton-Woods System in the early 1970s, exchange rate movements had been stable in most countries. However, the collapse of the system has caused both nominal and real exchange rates to be volatile overtime in most countries (Stockman, 1983; Stancik, 2007; Ajao and Igbekoyi, 2013; Onanuga and Onanuga, 2015). This ignited widespread interest in managing and predicting stable exchange rates. It also partly explained the increasing trend of countries joining economic and monetary unions (Stancik, 2007). This is because sudden movement of exchange rate creates serious macroeconomic imbalances and thus, affects trade and investment.

[1]Liberia was excluded because it joined in 2010 but for Ghana, it was due to data inconsistency.

The West African Monetary Zone (WAMZ) was formed in 2000 with the Gambia, Ghana, Guinea, Nigeria and Sierra-Leone as pioneer members and Liberia becoming a member in 2010. The main thrust was to address exchange rate uncertainty so as to promote trade and investment in the zone. Sekkat and Varoudakis (1998) and Onanuga and Onanuga (2015) showed that exchange rate regimes adopted by member countries spanned from fixed to managed floating, to independent floating regimes, and the floating policy regime dates back to the 1980s. Meese and Rogoff (1983) opined that exchange rate movements have been largely unpredictable, while Haussmann et al. (2006) found that low income countries, into which the WAMZ countries fall, have more exchange rate volatility experiences. However, as net importers, rising exchange rate volatility is detrimental to these economies. The question then is, what has been responsible for exchange rate volatility in these countries?

Although, several studies exist in the literature analyzing the volatility of exchange rate and its determinants (Devereux and Lane, 2003; Calderon, 2004; Morana, 2004;Stancik, 2007; Russ 2012), for WAMZ countries (see, Ogunleye, 2008; Olowo, 2009; Adeoye and Atanda, 2011; Ajao and Igbekoyi, 2013; Onanuga and Onanuga, 2015), the literature delved more into the analysis of the volatility clustering without examining the factors responsible for the volatility. Besides, most of the studies in WAMZ countries used the symmetric GARCH modeling approach that failed to analyze asymmetric (leverage) effect on exchange rate volatility. Engle (1982) and Bollerslev (1986) developed the ARCH/GARCH symmetric volatility modeling approach which most of the studies, especially the WAMZ countries-based, studies used. But these models (Engle, 1982 and Bollerslev, 1986) could not account for leverage effect in volatility clustering hence, the extension by Nelson (1991) and Glosten, Jagannathan and Ruknle (1993) called the EGARCH/TGARCH models accounting for asymmetric effect.

Consequently, this study focuses not only on exchange rate volatility modeling but also accounting for its determinants with the symmetric and asymmetric GARCH models. This study is not only understandable but imperative for the selected WAMZ countries as they propose to have a common currency, with exchange rate stability as one of the criteria. Therefore, gauging what explains exchange rate volatility among them will inform and improve policy in this regard.

The remainder of the study is organized as follows. Section two presents the review of empirical issues. Section three describes the key features of our dataset, and model specification, while Section four discusses the main results of the empirical analysis. Section five presents the concluding remarks.

2. Background to the Study (Stylized Facts)

2.1 Brief Overview of Exchange Rate Policies and Monetary Policy Framework in WAMZ

Exchange rate policies are broadly categorized into three: fixed (pegged), intermediate and flexible (free floating) policy regimes. Before 1971, most countries operated under fixed exchange rate regime known as the Bretton-Woods System, and under this system, countries fixed their currencies against the US dollar, which was worth a fixed amount of gold. Consequently, all participating countries pegged their currencies to gold. This system could not go beyond 1971 as it failed but the fixed exchange rate system continued in many countries.

The main thrust for the fixed exchange rate regime is the belief that exchange rate stability is necessary to facilitate trade and investment, curb price distortions and control uncertainty.

However, some economies, especially the industrialized ones, moved away from the fixed rate system to the flexible rate system where a domestic currency depreciates when the demand for foreign currency increases and appreciates when the demand for foreign currency falls. However, in the WAMZ and even other Sub-Saharan African countries, the fixed exchange rate was in practice until the introduction of the Structural Adjustment Programmes (SAP) in these countries. This made them liberalize their economies and exchange rates due to misalignment effect. So, the policy of devaluation came with SAP. The implication is that WAMZ countries never practiced flexible exchange rate system, as government intervention is very visible, but allows devaluation for the purpose of competitiveness of the export sector and for correction of external imbalances.

Using available classifications, in this case, the IMF classification[2] as also used by Abbott et al., (2012),which is based on the members' actual, de facto arrangement classifying the arrangement primarily on the degree to which the rate is determined by the market rather than by official action, the study discuss exchange rate policies in these countries. Market determined rate here is basically flexible rate. Table 1 shows that the IMF classification distinguishes between four major categories: hard pegs with two categories, soft pegs with five sub categories, floating regimes with two categories and the residual classification, which is termed as other managed arrangements as used by countries (IMF, 2012 & 2014). Therefore, the WAMZ countries can be classified into the following three exchange rate policy regimes; the fixed exchange rate regime, the intermediate and the flexible (free floating). Following the IMF approach, this study classified any arrangement that allows government intervention, even when the rate is determined by the market, as intermediate. Consequently, any floating arrangement that allows the intervention of government is classified as intermediate.

Table 1: Classification of Exchange Rate Arrangement and Monetary Policy Framework.

	IMF Classifications					Monetary Policy Framework		
	Hard Pegs	Soft Pegs	Floating regimes	Residual	Countries	Exchange Rate Targeting	Monetary Target	Inflation Targeting
Categories	Arrangement with no separate legal tender	Conventional peg	Floating	Other Managed arrangement	Gambia	No	1980-2016	No
	Currency board arrangement	Pegged within horizontal bands	Free floating		Ghana	No	1980-2001	2002-2016
		Stabilized arrangement			Guinea	No	1980-2014	No
		Crawling peg			Nigeria	Till 1974	1975-2010	2011-2016
		Crawl-like arrangement			Sierra-Leone	No	1980-2016	No

Sources: IMF Various Exchange Arrangement Reports online and Tarawalie et al., (2013).

This study covers the period 1980-2016 based on data availability and the classification is done with respect to this study period. By this classification, any exchange rate policy that is not determined by demand and supply in the market, but allows monetary authority

[2] Details can be found in the various IMF Annual Reports on Exchange Arrangements and Exchange Restrictions; there are other classifications such Ghosh et al. (2002) that base their classifications on official exchange rate declarations; Reinhart and Rogoff (2004) that examined the volatility of the relevant exchange rate and sometimes the parallel rate and Levy-Yeyati and Sturzenegger (2005) that studied the volatility of official exchange rate and currency reserves.

interventions to limit exchange rate movement is seen as intermediate regime but periods where the rate is not allowed to float at all is classified as fixed regime.

On a careful consideration of the IMF reports[3], it is evident that Gambia only moved away from the fixed exchange rate policy in 1986 after the introduction of the Structural Adjustment Programme, as the economy was becoming more uncompetitive, coupled with serious economic imbalances. In 1985, the Gambian dalasi was exchanging for the US$ at 3.89. Five years after, in 1990, after the liberalization policy that allowed devaluation of the dalasi, the currency was devalued and it depreciated by about 102% to 7.87 dalasi to the US$. Thereafter, it deprecated further to 12.8 to the dollar in 2000 and to 28.6 in 2005 (See, Table A1 in appendix A).

Inflation rate for the same period was 18.3% in 1985 but reduced to 12.2% after five years in 1990 within the liberalization period and to 6.98% and 4.95% in 1995 and 2005 respectively (Figure 3). FDI flows to the country also moved from negative $0.5 million in 1985 to $14.12 million in 1990, and later increased again to $43.5 million and $87.1 million in 2000 and 2005 respectively. It fell to $20.4 million in 2010 (Table A1). This might not be unconnected with the current account imbalance as Gambia export fell drastically in 2005, with peanut and groundnuts as the country's major export commodities. The export share of GDP in 2005 fell to 7% from 48% in 2000 (Table A1), which explains a downward trend in foreign exchange reserves as the country tried to manage the exchange rate (Figure 2). However, the primary concern of monetary policy in Gambia has been price stability and as well to maintain stability in the local currency. Hence, the monetary policy framework of the Gambia has always been Monetary-Targeting Policy Framework (MTF) and monetary policy decision making is exercised through the Monetary Policy Committee (MPC), which meets twice a month to review developments in the economy. The Central Bank of Gambia uses Open Market Operations to manage liquidity and intervenes in the foreign exchange market to smoothen short term fluctuations (Tarawalie et al., 2013).

Ghana moved away from fixed peg regime in 1983. As at 1983, the Ghanaian economy was facing serious economic woes ranging from high inflation to widening current account imbalances and fiscal deficits. The alarming rate of inflation continued to erode the value of the cedi and the national income, which undermined confidence in the economy, coupled with overvalued currency that made the export sector uncompetitive (Kwakye, 2012). In 1983, the government introduced the Economic Recovery Programme (ERP) followed by the Structural Adjustment Progreamme (SAP) alongside the Financial Structural Adjustment Programme (FINSAP) to restore financial and monetary discipline and all price controls were removed (Kwakye, 2012). Consequently, the government started the devaluation of the cedi which resulted in the floating of the cedi in 1990. During this period, the value was determined in the interbank market but the Bank of Ghana still provided foreign exchange to meet part of the demand, which gave the Bank the position to influence the exchange rate making it a managed float policy and not independent float. Ghana's exchange rate as at 1985 was 0.01 to the US$ but increased to 0.12 to the US$ in 1995 and to 0.54 and 0.91 in 2000 and 2005 respectively (see Table A1). The Ghana cedi continued depreciating due to widening current account imbalance (see, Figure 1) and shortage of foreign exchange, while inflation remained alarming as it was 50.1% in 1980. However, after the economic recovery programme and liberalization of the economy, it fell to 10.3% in 1985 and increased again to 37.2% and 59.3% in 1990 and 1995 respectively (Figure 3). In 2005, the inflation rate was

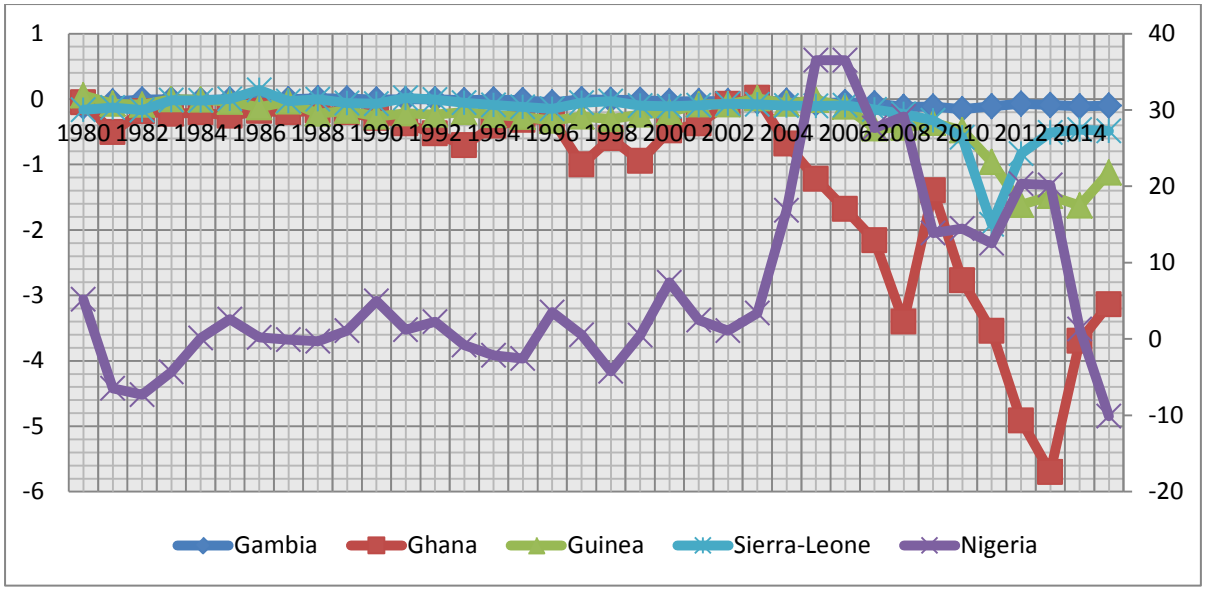
[3] Details can be found the various IMF reports and classifications of the arrangements. This study is not intend to provide the details.

still high though the economy started recovering by responding to these recovery programmes.

In 2007, the Bank of Ghana introduced a new cedi, with the redenomination policy of the cedi. The objective was to eliminate 4-digits in the cedi. As a result, 10,000 cedi became 1 new cedi. By this new cedi, the Ghanaian currency became the highest denominated currency unit issued in Africa. In 2010 the exchange rate was 1.4 cedi to a US$, which is supposed to be 14,000 cedi to a dollar (Table A1) and consequently, inflation plunged to 6.1% in 2010 (Figure 3). FDI flow within this period also experienced an increasing trend as FDI inflow to the Ghanaian economy increased to $14.8 million in 1990, from the previous $5.6 million in 1985. It grew significantly to $106.5 million and to $144.9 million in 1995 and 2000 respectively, and thereafter maintained the upward trend (Table A1).

The monetary policy goal of the Bank of Ghana during this period was price stability and specifically to maintain low inflation and support growth and employment in the economy. Consequently, its Monetary Policy Framework was Monetary-Targeting (MTFW) up till 2001. However, due to limited success in achieving inflation target and weakness between monetary aggregate and inflation, the Bank of Ghana switched to Inflation-Targeting Monetary Policy Framework (ITFW) in 2002 (Tarawalie et al., 2013). Accordingly, a target of below 10% was desired in terms of annual rate of inflation, based on Consumer Price Index (CPI). The Bank of Ghana uses multiple instruments in achieving its policy objectives ranging from Monetary Policy Rate (MPR) to Cash Reserve Requirement (CCR) to open market operations. And in conducting monetary policy, the Monetary Policy Committee (MPC) of the Bank meets twice a month to review developments in the economy (Tarawalie et al., 2013). The main export product dominating Ghana's is gold, which accounts for 29.6% of export, followed by cocoa accounting for 26.8% (UNCTAD, 2014).

Figure 1: Trend of Current Account Balance



Source: IMF World Economic Outlook, 2016

Guinea on the other hand had, used different currencies ranging from the Guinea franc to CFA franc and later to Syli but reverted to the Guinea franc in 1985 at par with the Syli. The country operated a fixed exchange rate regime up till 1993 before shifting to the floating regime due to macroeconomic imbalances and uncompetitive export sector regime in 1994, though with intervention from its Central Bank. Within these periods, the exchange rate of

the Guinea Syli to the US$ was around 92 francs to the US$ in 1980. The Guinea franc depreciated about 112% to 195 franc to the dollar five years after in 1985 and further depreciation of about 238% to 660 franc to the dollar in 1990 (Table A1). Inflation rate however, fell from 39% in 1980 to 19% in 1985 and later to 25% in 1990 (Figure 3). This is not unconnected with the fact that the Guinea export sector is well diversified with different minerals exports, and tree crops and minerals resources with which the country is endowed, such as bauxite, gold, diamond and oil and as well as coffee.

The country possesses a quarter of the world's proven reserves of bauxite, having more than 1.8 billion metric tons of high grade iron ore, hence the fall in the rate of the franc never had any much effect on inflation instead it facilitated more exports. This is further supported with the trade balance statistics as export share of GDP was 38% as against 34% of import as ratio of GDP in 1980, the export ratio to GDP fell to 33% in 1985 but import ratio reduced by more than 50% to a value of 15% of GDP. By 1990, the export ratio increased significantly to 44% of GDP and import ratio declined to 8% (Table A1). This explained the controlled inflation rate during the fall in the franc rate, which prevented imported inflation due to better trade performances in boosting foreign exchange earnings. The intuition is that the fall in franc actually made the export products more competitive. However, foreign exchange earnings were improperly managed with fiscal indiscipline resulting from uncontrolled expansionary fiscal policy, leading to fiscal deterioration and external imbalances coupled with falling minerals exploitation and serious capital outflows. The franc depreciated further (Table A1). In this period, FDI flow was US$0.56 million in 1980 which increased to US$17.86 million in 1990 but due to these problems it fell drastically to almost 15 years ago low figure of US$0.77 million in 1995. It increased after the further depreciation through the economic recovery programmes of IMF in 1994 to US$9.94 million in 2000 and to US$105 million in 2005 and maintain that trend further to 2014 (Table A1). Monetary policy main concern of the Bank of Guinea is to ensure price stability in facilitating growth. The country operates the Monetary-Targeting Policy framework (MTFW). Monetary policy decisions are made through the Monetary Policy Committee (MPC) that has only the central bank officials as members. In the MPC pursues low inflation target and broad money supply growth as its intermediate target, the reserve money adjustment is seen as key to achieving these goals (Tarawalie et al., 2013).

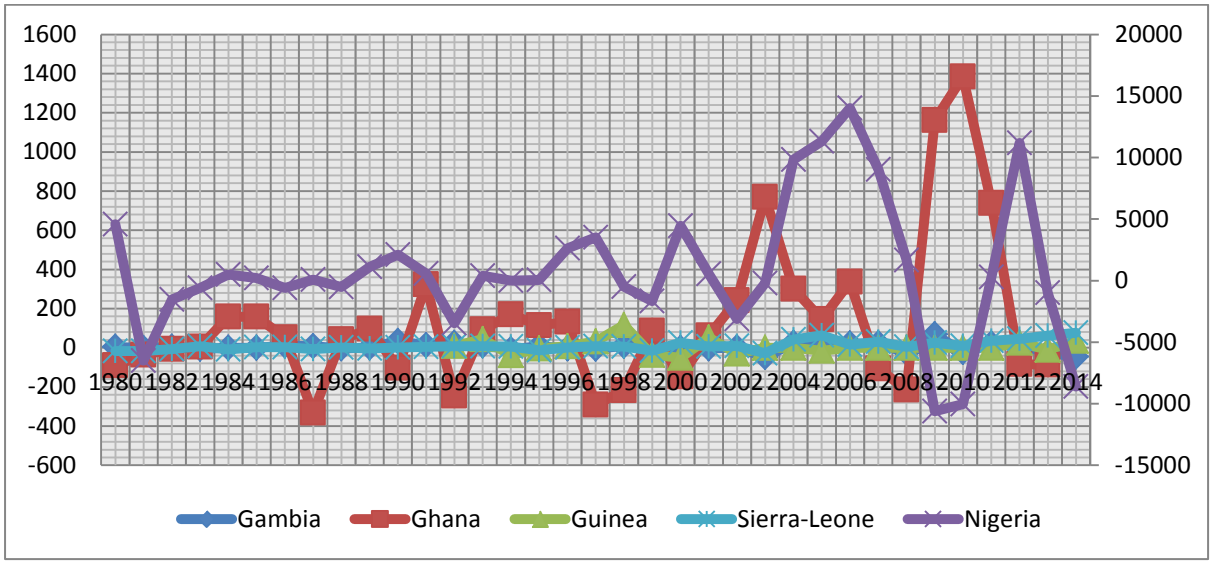
In an attempt to manage the nation's foreign exchange earnings, Central Bank of Nigeria (CBN) as a matter of policy transited the country from one policy regime to another. The country operated the fixed exchange rate policy regime up till 1985 after the collapse of the Bretton-Wood system in 1971. However, the fixed exchange rate could not achieve the expected major policy goals as the currency was seriously overvalued due to external imbalance and widening fiscal deficit as a result of the early 80s oil price shock and increasing debt profile. As the country is plunged with serious economic woes, in 1986 Nigeria introduced the Structural Adjustment Programmes which made the country to move away from the fixed exchange rate regime to floating regime through the liberalization policy of SAP. The floating exchange rate system operated with allowance for intervention by the monetary authority up till 1993 then a temporary halt to deregulation came in 1994 when the rate was fixed and by 1995 the country revert back to the floating policy with deregulation of the foreign exchange market through exchange rate liberalization and the institution of a dual exchange rate system.

Following the adoption of the structural adjustment programme, the naira depreciated almost 802% from 0.89 naira to the US$ in 1980 to 8.03 naira to the US$ in 1990 and continued in that trend (Table A1). The naira depreciated further to about 40% from the 1995 value to 101.7 naira to the dollar in 2000 and experienced consistent fall. This is due to heavy reliance

on crude oil as the main export product such that any shock to international crude oil price greatly affected the current account position (see, Figure 1) as the country is a net importer in both consumables and capital goods. This translates into higher inflation rate in the country as inflation rate as at 1985 moved from 3.2% to 72.7% in 1995 within 10 years but plunged back to a 6.9% in 2000 which is as a result of oil price boom that boasted export earning in facilitating foreign reserve (Figure 2). FDI flows within this period however were on upward swing as FDI to Nigeria are mainly resource seeking specifically to the oil sector. In 1985, the FDI flows in Nigeria stood at US$485.5 million but increased to US$1271 million in 1995 and maintained steady increase up till 2010 but fell due to crude oil price plunge recently (Table A1).

The monetary policy objective of the CBN is to maintain optimal liquidity supply so as to sustain price stability and non-inflationary growth (Tarawalie et al., 2013). Consequently, the CBN has used contractionary monetary policy instruments over the years to curb inflationary expectations and reduce pressure on the exchange rate due to foreign exchange demand. Monetary Policy decisions are taken by the CBN Monetary Policy Committee (MPC) and recently, due to so much pressure on the currency as a result of falling oil price, the CBN introduced a number foreign exchange restrictions such as refusal to make withdrawals with naira dominated debit cards and refusal to accept deposit in domiciliary accounts and others, including restrictions of access to foreign exchange from the official market for 41 imported items. Prior to the year 2010, the CBN operated the Monetary-Targeting Monetary Policy Framework (MTF) but switched to the Inflation-targeting Monetary Policy Framework (ITF) in 2011.

Figure 2: Changes in Foreign Exchange Reserves

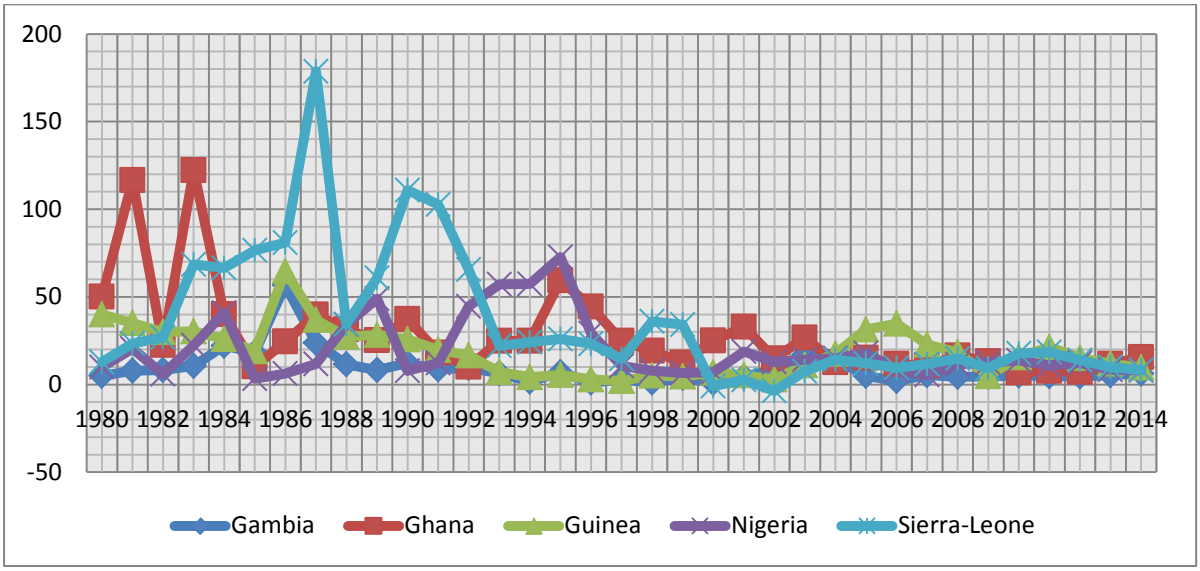


Source: IMF World Economic Outlook, 2016

Sierra-Loene operated under the fixed exchange rate up till 1989 when the Structural Adjustment Programme was introduced in 1990 and the economy was liberalized. From 1978 to 1982, the currency was linked to IMF Special Drawing Rights and from 1982 to 1989, the Sierra-Loene currency was pegged to the US dollar. However, in 1990 the country abandoned the fixed exchange rate regime and switched to the floating exchange rate arrangement due to a number of macroeconomic imbalances. Available statistics showes that the currency exchanged for a dollar by 1.05 Loene in 1980 but after SAP, the currency depreciated to a significant value of 151.5 Loene in 1990 (see, Table A1). The depletion of

the reserve during the OAU meetings in the 80s led to the introduction of the two tier system to attract more foreign exchange to beef up the reserves. Commercial market rates were determined at fortnight auctions held by the Central Bank.

Figure 3: Trend of Annual CPI Inflation Rate



Source: IMF World Economic Outlook, 2016

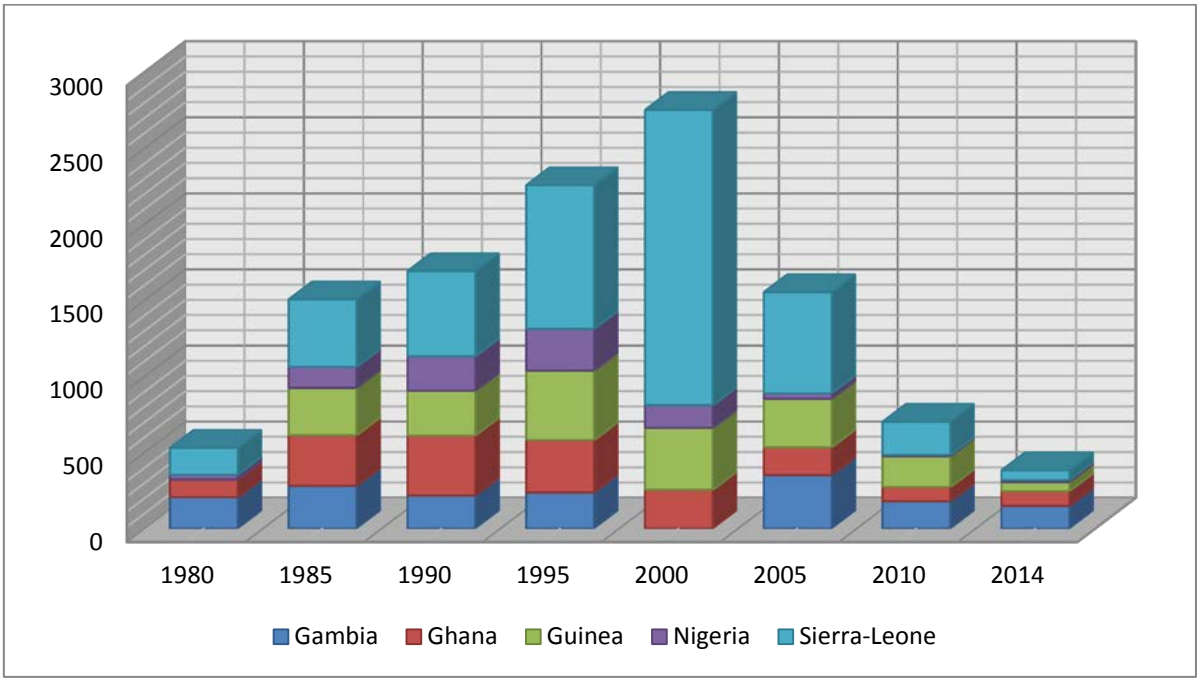
During this period, CPI inflation surged from 12.9% to 110.9% (figure 3). This is not unconnected with the fact that the country's trade balance was deteriorating at the time. (Figure 1) and foreign exchange was in short supply. This was against the demand for import as the country is a net importer. Mineral exports remain Sierra Leone's major source of foreign exchange earnings. The country is a major producer of gem-quality diamonds. Though rich in this resource; the country has historically struggled to manage its exploitation and export. Her trade balance is also affected mainly by FDI oriented imports. For instance, within the same period export as a ratio of GDP plunged from 23% in 1980 to 9% in 1990 and thereafter to a non-significant increase of 11% and 10% in 1995 and 2000 respectively (Table A1) and the currency depreciated further to 755 Leone to the US dollar and consistently depreciated further as the macroeconomic indicators could not sustain the currency. FDI flow was to the tune of US$32.4 million in 1990 but fell drastically to US$7.28 million in 1995 before taking an upward trend in the year 2000 to US$38.9 million and continued in this trend up till 2014 (Table A1). The main policy thrust of the Bank of Sierra Leone is to ensure price stability and also enhance financial sector stability and growth through strengthened supervision and vigorous regulatory agenda (Tarawalie et. al., 2013). The Bank operates the Monetary-Targeting Monetary Policy Framework by making use of reserve money as the operating target and broad money as the intermediate target.

2.2 Debt Stock and GDP Growth in WAMZ

Debt stock is one of the key indicators, which serve as a measure of risk to investors, and most of these countries have high debt profile with heavy debt burden over the years, as a result of debt payment and servicing. The reason is not farfetched as they are mainly import dependent economies with very narrow export bases, which is mainly facilitated by a primary product export that is pruned to external shock due to commodity price movements that are not under their control. Consequently, any slump in commodity prices exposes them to increasing budget deficit that is primarily financed through either domestic or external debt. Foreign exchange is needed for servicing foreign loans and the only supply to the foreign

reserve is through this narrow based export sector that dwindles due to dwindling commodity prices and from capital inflows. It is therefore imperative that debt stock as percentage of export earnings as a trend is followed by experts and stakeholders. This will help to avoid sovereign debt crises resulting from low foreign reserve and this indicator is a measure of debt overhang or debt burden.

Figure 5: Debt Stock as Share of Export



Source: World Bank WDI Online, 2015

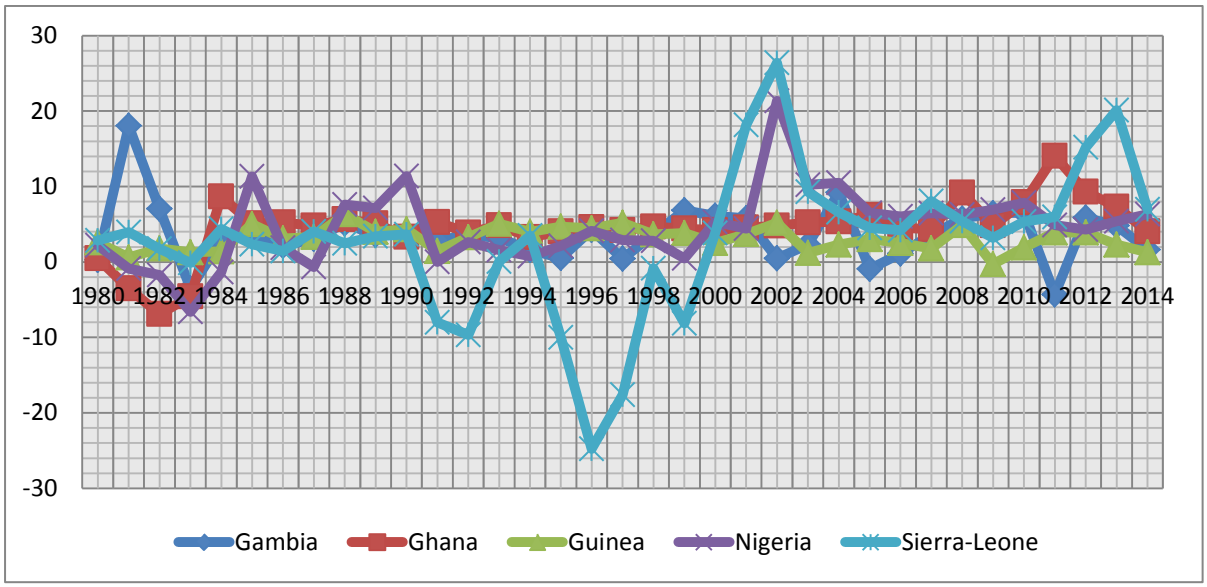
An examinations of the statistics in the WAMZ shows that most of these countries' debts as percentage of export are as high as over 200% of export earning, in most cases except for Nigeria. This is not unconnected with the fact that there seems to be so much export earnings from crude oil export as a leading exporter in Africa, and also due to oil price boom (Figure 5). This is also partly connected with the net export values in these countries, which are pronounced from the differences between import and export shares in GDP (Table A1). This explains some of the reasons for exchange rate movement and instability experienced in these countries due to their exposure to global shocks. For instance, for Gambia, debt stock as percentage of GDP from figure 5 was as high as twice to thrice of export earnings of the country having a value of 206.5%, 280.9% and to a much higher value of 351% in 1980, 1985 and 2005 respectively. Recently, it dropped to 179.8% and 149.2% in 2010 and 2014 respectively, as a result of recent surge in commodity prices. However, with the 2015 slump in commodity prices, the figure will revert to its former trend. This can be explained in terms of what accounts for unstable exchange rate movement and the effect of global shocks.

For Gambia, Ghana and Sierra-Leone, the trend was not different as their debt stock took more than twice or three times of their export earnings in most cases which is due to higher negative trade balances, as shown earlier by the import and export shares. For instance, in Ghana, it was as high as 331.8%, 393.6% and 334.4% in 1985, 1990 and 1995 respectively. It was only in 2010 and 2014 that it fell to 92.8% and 96% respectively (Figure 5 & Table A1). This could be explained by the same recent commodity price surge and the fact that Ghana has recently joined the league of oil producers. For Guinea, the trend was not different with values as high as 456.5% and 406.8% respectively in 1995 and 2000, dropping slightly to 319.5% in 2005 and to 201.9% respectively. It declined later to 60.1% in 2010 and 2014

respectively, explained by the surge in commodity prices. Also, the fact that Guinea is a major exporter of various mineral resources and tree crops contributed.

The trend was the same for Sierra-Leone but the figures increased to as high as 559.3%, 945.2% and 1941% in 1990, 1995 and 2000 respectively, which is very risky signal to investors and domestic businesses as well.

Figure 6: Trend Real GDP Growth Rate



Source: UN Statistical Database Online, 2015

The case of Nigeria was at variance with these other countries as the value was only very high to 274% in 1995 but averaged less than 100% of export earnings. In fact, as a result of the recent surge in oil price coupled with debt forgiveness, the value dropped to as low as 35.8%, 8.79% and 14% in 2005, 2010 and 2014 respectively. This was partly supported by the trade balance as shown by the import and export shares. But Nigeria's experience is not too different because these countries are all prone to global shocks through budgetary deficits caused by dwindling commodity prices, huge import dependence and serious mismanagement. This is supported by their growth statistics, which do not significantly differ, even with relatively better trade balances and lower debt-export ratios experienced by Nigeria. A cursory look at the growth statistics over the years shows that the growth trajectories in these countries are similar (see, Figure 6). They all experienced growth rates as low as 2% to 3% except during the commodity price surge that they maintained the growth path around 5%. Only during the last commodity price increase that African countries grew at an average of 6% for almost a decade. The implication is that any external shock can affect this growth path due to their narrow production and export bases.

3. Empirical Literature

Several factors have been identified in the literature explaining exchange rate volatility. For instance, Devereux and Lane (2003) developed a theoretical model of bilateral exchange rate volatility and empirically analyzed the model using a standard deviation approach to generate the volatility measure for the period 1995-2000 on monthly series. The study showed that for developing countries, weak financial system negatively affected exchange rate volatility and for developed countries optimum currency area variable and trade interdependence appear more important in explaining exchange rate volatility. External debt was found not to be

significant. However, business cycle asymmetric and country size were positive and significant in exchange rate volatility. The study further showed that financial development increases volatility for industrial countries but reduces it in developing countries.

Calderon (2004) analyzed the determinants of exchange rate volatility for a sample of industrial and developing countries for the period 1974-2003 and obtained a measure of volatility through the standard deviation approach over a five years' window. The study included as determinants in the model, output volatility, money growth volatility, exchange rate regime and financial openness, and employed the GMM techniques for the analysis. The study found that real exchange rate volatility and shifts in the fundamentals are more volatile in developing countries than the industrial countries and that exchange rate in developing countries are four times as volatile as in industrial economies. The study further showed that the more flexible the exchange rate regime, the more volatile are real exchange rate fluctuations. But exchange rate among countries with flexible regimes were twice more volatile than among countries with hard pegs. Also, exchange rates among developing countries with flexible regimes are more volatile, in fact, three times as volatile as those with either hard pegs or fixed regimes. The differences in patterns of output growth as well as term of trade and changes in government expenditure were found to be negligible. The study also showed that output volatility, money growth volatility, term of trade and government spending had positive and significant effects on exchange rate volatility. The results were found to be higher among industrial countries than developing ones but the reverse was the case for the degree of openness variable effect.

Canales-Kriljenko and Habermeier (2004) analyzed factors affecting exchange rate volatility with specific emphasis on the foreign exchange regime. The analysis was based on a broad cross section of 85 developing and transition economies in 2001. The variables captured in the study were inflation, fiscal deficit, real GDP growth, adequacy of reserve, exchange rate regime, acceptance of article 8 obligations and degree of openness. The study found exchange rate volatility to be higher in countries with higher inflation and higher fiscal deficits, and lower in countries with faster real GDP growth and more openness. Higher reserves were found to correlate negatively with exchange rate volatility and money market interest rates showed strong correlations with exchange rate volatility. However, exchange rate regimes and acceptance of article 8 obligations were also found to have effect on volatility of exchange rate. The study employed the simple regression analysis.

Morana (2007) examined the macroeconomic determinants of exchange rate volatility for the period 1980-2006 on monthly series for five industrial countries. The macroeconomic variables analyzed were CPI inflation volatility, nominal money growth volatility and the nominal short term interest rate volatility. The study employed Fractional Integrated Factor Vector Autoregressive (FI-F-VAR) model and found that among the macroeconomic variables, output growth rates were more volatile followed by money growth, inflation and short term interest rates. However, macroeconomic volatility tends to be lower than exchange rate volatility. The analysis showed evidence of significant long-term linkages and trade-offs between the macroeconomic volatility and exchange rate volatility specifically with output and inflation but money growth volatility was found to have a lower effect. There was also evidence of bidirectional causality but linkages are found to be stronger from macroeconomic volatility to exchange rate volatility than the reverse.

Stancik (2007) analyzed the determinants of exchange rate volatility for new EU members and focused on exchange rate between euro and the domestic currencies of five different countries. The study employed the Threshold Autoregressive Conditional Heterosckedaticity model to generate the exchange rate volatility measure and used the OLS approach to

estimate the determinants model. The study covered the period 1999-2004 on daily data series and showed that exchange rate volatility is statistically and significantly affected by unpredictable circumstance except for Slovenia. A lower conditional variance in the case of a negative shock was found for Hungary, Poland and Slovakia while a higher conditional variance was found for the Czech Republic. However, a simple ARCH-M model was estimated and news was found to have a large effect on exchange rate volatility in Hungary, Slovakia and Slovenia. The degree of openness variable was found to have significantly explained the volatility of exchange rate for Slovenia but the reverse was the case for the other countries. However, for the regime dummy, only key changes in exchange rate regimes had significant effect on exchange rate volatility while minor changes never reflected on volatility at all.

Amor and Sarkar (2008) investigated the effect of financial integration on real exchange rate volatility for 10 South and South-East Asian countries for the period 1975-2004. The study employed the standard deviation approach on real exchange rate to obtain the volatility measure over a five-year period and adopted the dynamic panel data modeling approach; specifically, the Generalized Method of Moments (GMM) estimation techniques on the model. Among variables include in the model are output growth, investment, government spending, money, term of trade and financial openness. It found output growth, investment, financial openness and government spending to significantly explain exchange rate volatility in these countries while money and term of trade were not significant in explaining volatility of exchange rate. However, trade openness was found to have a negative and significant effect on exchange rate volatility in these countries.

Davis and Pomerantz (2009) analyzed the impact of EMU on real exchange rate volatility for EU countries for a monthly series from 1980 to 2007. The study used both conditional and unconditional measures of volatility which are GARCH (1, 1) and standard deviation on exchange rate respectively. Other variables included in the study were inflation, level of short-term real interest rates and the size of the current account balances. The panel data fixed effect model was estimated and the study found higher current account deficit to increase exchange rate volatility in Finland, France, Germany, Austria and Spain but the revise was the case for Belgium. However, higher real interest rate was found to increase volatility in Belgium, Finland, Italy and the UK and that the advent of EMU was accompanied by a reduction in real exchange rate volatility.

Rodriguez and Humala (2009) studied the effect of foreign intervention on exchange rate volatility in Peru for the period 1994-2007 using daily, weekly and monthly series. The study employed the Markov-Switching (2)-VAR (1) model for the analysis. Intervention in the study was measured by net purchases, purchases and sales of foreign currency by the Central Bank and other variable included in the model was interest rate spread. It was found that official intervention in exchange rate was consistent with the goal of reducing excess volatility in the foreign exchange rate. However, evidence was mixed with respect to the interest rate spread variable as it was found to be non-significant in the entire sample but found significant after the monetary policy change period.

Russ (2012) investigated the dynamic linkages between exchange rate volatility and FDI inflows for 28 OECD countries for the period 1980-2005. The study employed panel data analysis using the OLS, FGLS and GMM techniques. The results showed that depending on whether home or foreign interest volatility both impact on exchange rate risk having different effects on entry by new and veteran foreign firms. Interest rate volatility both from host or source country had a non-negative correlation with exchange rate volatility.

For Africa-based studies, Ogunleye (2008) studied the dynamic link between exchange rate volatility and Foreign Direct Investment inflow in Nigeria and South Africa, using the Two Stage Least Square (2SLS) approach. The study obtained exchange rate volatility measure with the GARCH (1, 1) model and found FDI inflow to negatively and significantly impact exchange rate volatility but inflation, nominal interest rate and foreign reserves shocks contributed immensely to exchange rate volatility in both countries. Olowo (2009) also examined exchange rate volatility in Nigeria with monthly series for the period 1970-2007 using symmetric GARCH models. The study presented results for pre- and post-deregulation periods. It showed evidence of exchange rate volatility in Nigeria. Adeoye and Atanda (2011) also analyzed the existence of exchange rate volatility in Nigeria with monthly series covering 1986-2008 with symmetric GARCH models. The study found evidence of volatility of Nigerian naira/dollar exchange rate for both nominal and real exchange rates. In a recent study, Ajao and Igbekoyi (2013) examined the determinants of exchange rate volatility in Nigeria for the period 1981-2008 and used the GARCH (1,1) model to obtain the exchange rate volatility measurement from the naira/dollar exchange rate data. The study then employed the error correction model to examine the determinants of exchange rate volatility which included government expenditure, money supply, productivity index, degree of openness and real interest rate. It found that government expenditure had positive and significant effect on exchange rate volatility while degree of openness and real interest rate explained the volatility of exchange rate in Nigeria negatively. Money supply and productivity index were found to be insignificant in explaining exchange rate volatility. Bala and Asemota (2013) analyzed exchange rate volatility in Nigeria for the period 2004-2011 with monthly series of the naira against the British Pounds, the US dollar and the Euro. They employed GARCH model for the analysis and found the naira/dollar exchange rate to be the most volatile rate and that of naira/pounds to be the least volatile rate.

4. Data and Methodology

Devereux and Lane (2003), Calderon (2004), Canales-Kriljenko and Habermeier (2004), Morana (2007), Stancik (2007), Davis and Pomerantz (2009), Rodriguiz and Humala (2009) and recently Russ (2012) have analyzed and identified a number of factors explaining exchange rate volatility in different countries and regions both among developing and developed countries. Prominent among these factors that this present study considered for the selected WAMZ countries are output volatility, money supply and inflation volatility. The choice is informed by data availability and consistency for the selected countries.

The unconditional volatility measures (ARCH/GARCH) introduced by Engle (1982) and Bollerslev (1986) facilitated several researches analyzing volatility clustering in economic and financial variables (Aliyu, 2012). However, these models failed to account for the presence of leverage effect in volatility modeling. Consequently, this study followed the approach of Asteriou and Price (2001) in analyzing volatility clustering with both symmetric and asymmetric GARCH models thus:

$$EXR_t = \alpha + \sum_{i=1}^{p} \varphi_i \, EXR_{t-i} + v_t; \; v_t \sim IID(0, \delta^2) \tag{1}$$

Where, v_t is model as;

$$\hat{v}_t^2 = \alpha + \sum_{i=1}^{p} \beta_i \hat{v}_{t-i}^2 \, \forall ARCH(p) effect \tag{2}$$

$$Ho: \beta_{i=}0 \; (NoARCH)$$

$$\sigma_t^2 = \vartheta_0 + \sum_{i=1}^{p} \vartheta_i \, v_{t-i}^2 + \sum_{j=1}^{q} \omega_j \, \sigma_{t-j}^2 \quad (3)$$

The above is the symmetric ARCH/GARCH process but to account for the asymmetric effect, the EGARCH process was introduced thus;

$$\log(\sigma_t^2) = \omega + \sum_{i=1}^{p} \gamma_i \left| \frac{v_{t-i}}{\sqrt{\sigma_{t-i}}} \right| + \sum_{j=1}^{q} \omega_j \log(\sigma_{t-j}^2) + \sum_{i=1}^{m} \vartheta_i \frac{v_{t-i}}{\sqrt{\sigma_{t-i}}} \quad (4)$$

The leverage effects are captured by ϑ_i that accounts for the asymmetry in the model. If $\vartheta_i = 0$; it means no asymmetry effects, if $\vartheta_i > 0$ indicates that positive shocks (good news) lead to higher volatility of exchange rate than negative shock (bad news) else the reverse is the case.

Glosten, Jagannathan and Ruknle (1993) also introduced the TGARCH to capture leverage effect thus;

$$\sigma_t^2 = \theta + \sum_{i=1}^{p} \gamma_i \, v_{t-i}^2 + \sum_{j=1}^{q} \beta_j \, \sigma_{t-j}^2 + \sum_{i=1}^{p} \varphi_i v_{t-i}^2 \, I_{t-i} \quad (5)$$

Where, $I_{t-i} = \begin{cases} 1, & v_{t-i} > 0 \\ 0, & otherwise \end{cases}$

If $\varphi_i = 0$ implies no asymmetry effect. If $\varphi_i > 0$ indicates that negative shocks (bad news) lead to higher volatility than positive shocks (good news) else the reverse is the case.

To analyze the effects of the identified variables on exchange rate volatility, Asteriou and Price (2001) approach was followed where the variables are included in both the mean and variance equations. The data for the study were monthly series extracted from the IMF statistical database covering 1980-2016 and the Maximum Likelihood Estimator was used for the analysis.

5. Empirical Analysis

5.1 Unit Root Test

Before proceeding to examine the volatility of exchange rate dynamics in the selected WAMZ countries, we first undertake to analyze the characteristics of the series to ascertain their order of integration, and the volatility estimation is informed by the order of integration in these series. To do this, we employed the Augmented Dickey-Fuller (ADF) unit root test and the results are presented in table 2.

Table 2: Augmented Dickey-Fuller Unit Root Test Result

VARIABLES	NIGERIA		GAMBIA		GUINEA		SIERRA-LOENE	
	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
EXR	-0.75	-4.77**	-1.18	-4.59**	-1.22	-4.37**	-1.87	-6.39**
RGDPGr	-3.83**	-9.74**	-4.91*	-4.15**	-3.45*	-5.54**	-2.74	-23.15*
M2	-0.06	-3.62*	-0.26	-3.59**	-0.54	-3.21**	-1.39	-2.75*
CPINF	-3.16*	-5.15**	-3.37*	-5.15**	-1.79	-4.15**	-2.93*	-9.59**

Notes: The asymptotic critical values of Augmented Dickey-Fuller unit root tests are in their respective levels of significance. ** (*) denotes the rejection of the null hypothesis at 1%(5%) significance levels.

Source: Authors' computation

It is evident from statistics in table 1 that exchange rate and money supply variables exhibit non-stationarity in all the countries at level but only became stationary after the first difference which implies that exchange rate is integrated of order one. However real output growth volatility exhibited a stationarity variable in all the countries indicating a series integrated of order zero. But CPI inflation also was found to be a stationary series at level in all the countries except for Guinea where stationarity was found only at first difference. Based on the above order of integration, we proceed to test for the presence of volatility in the exchange rate series of each country by the ARCH-effect test presented in table 3.

5.2 Testing for ARCH-Effect on Exchange Rate Series of WAMZ

Before proceeding to estimate the volatility models, one must first undertake the ARCH-effect test to ascertain that there is ARCH-effect in the series and table 3 presents the results for each country.

Table 3: ARCH Effect Test for Exchange Rate.

	F-Stat	Chi-Square
NIGERIA	3.46 (0.06)	3.45 (0.06)
GAMBIA	56.84 (0.00)	51.57 (0.00)
GUINEA	208.44 (0.00)	150.56 (0.00)
SIERRA-LOENE	10.67 (0.00)	10.49983 (0.00)

Notes: probability values are in parenthesis

Source: Authors' computation

From table 3, the results showed that there is ARCH effect in the exchange rate series of these countries as the null hypothesis of homoscedasticity is rejected by both the F-statistics test and the chi-square test. Though, the significance of that of the series for Nigeria is low indicating that Nigeria's exchange rate is not as volatile as those of the other countries. Since, the existence of volatility is established in the series, we proceed to the volatility models estimation as presented in terms.

5.3 ARCH/GARCH Result for Exchange Rate Volatility in WAMZ

The ARCH models have become the prominent models for modeling volatile series and in this regard, table 4 presents the results for the ARCH model on exchange rate of these countries.

Table 4: ARCH Result for Exchange Rate Volatility in WAMZ

Volatility	**NIGERIA**		**GUINEA**		**GAMBIA**		**SIERRA-LOENE**	
	Mean Equation		**Mean Equation**		**Mean Equation**		**Mean Equation**	
	Coefficient	Prob.	Coefficient	Prob.	Coefficient	Prob.	Coefficient	Prob.
C	0.038***	(0.00)	6.53	(0.18)	0.04***	(0.00)	0.16	(0.43)
d(exr(-1))	-0.14***	(0.00)	0.55***	(0.00)	-0.38***	(0.00)	0.65***	(0.00)
	Variance Equation		**Variance Equation**		**Variance Equation**		**Variance Equation**	
C	0.003***	(0.00)	3028.5***	(0.00)	0.002***	(0.00)	3.25***	(0.00)
ARCH(-1)	1.07***	(0.00)	0.62***	(0.00)	1.39***	(0.00)	0.29***	(0.00)
ARCH(-2)	0.44***	(0.00)	0.069704	(0.2697)	0.04	(0.58)	0.15*	(0.06)
ARCH(-3)	0.35***	(0.00)	-0.01	(0.80)	0.34***	(0.00)	0.68***	(0.00)
ARCH(-4)	-0.07***	(0.00)	-0.02	(0.17)	0.04	(0.19)	0.10**	(0.02)
ARCH(-5)	1.17***	(0.00)	0.005	(0.85)	0.67***	(0.00)	1.03***	(0.00)

Notes: The asymptotic critical values of Augmented Dickey-Fuller unit root tests are in their respective levels of significance. ***, ** (*) denotes the rejection of the null hypothesis at 1%, 5%(10%) significance level.
Source: Authors' computation

From Table 4, the results show evidence of volatility in the exchange rate series for all the countries though at different ARCH levels. For instance, for Nigeria and Sierra-Leone, we found up to ARCH (5) being significant indicating that previous news explains the volatility of exchange rate behaviour in Nigeria and Sierra-Leone. But for Guinea, the ARCH effect was only established in ARCH(1) that only a period lag news explains the volatility of exchange rate behaviour in thats country. For Gambia, we found ARCH effect up to ARCH (5) except for ARCH (2) and ARCH (4) that were not significant indicating that the two and four period lag news never explained the volatility of exchange rate behaviour in this country. However, one of the drawbacks of the ARCH model is its inability to incorporate lagged conditional variance terms to ascertain the effect of previous volatility of a series on contemporary volatility, hence the GARCH model presented in table 5.

It is evident from table 5 that only in Gambia and Sierra-Leone that GARCH effects were found implying that previous volatility of exchange rate never explained the volatility of contemporary exchange rate in Nigeria and Guinea but for Gambia and Sierra-Leone previous exchange rate volatility contributes to the volatility of exchange rate in contemporary times. In fact, the effect was found to be negative at GARCH (2) and GARCH (4) on these countries. But the ARCH/GARCH process never differentiate between the effect of positive and negative news in explaining the volatility of a series thus the need for employing asymmetric effect modeling processes.

Table 5: GARCH Result for Exchange Rate Volatility

Volatility	**NIGERIA**		**GUINEA**		**GAMBIA**		**SIERRA-LOENE**	
	Mean Equation		**Mean Equation**		**Mean Equation**		**Mean Equation**	
	Coefficient	Prob.	Coefficient	Prob.	Coefficient	Prob.	Coefficient	Prob.
C	0.24	(0.63)	7.02*	(0.08)	0.03***	(0.00)	-0.01	(0.92)
d(exr(-1))	0.19	(0.38)	0.59***	(0.00)	0.30***	(0.00)	0.84***	(0.00)
	Variance Equation		**Variance Equation**		**Variance Equation**		**Variance Equation**	
C	6.48***	(0.00)	2552.9***	(0.00)	0.001***	(0.00)	0.012***	(0.00)
ARCH(-1)	0.06	(0.19)	0.29***	(0.00)	0.42***	(0.00)	0.59***	(0.00)
GARCH(-1)	0.41	(0.38)	0.17	(0.18)	1.29***	(0.00)	0.69***	(0.00)
GARCH(-2)	0.002	(0.99)	-0.08	(0.18)	-1.12***	(0.00)	-0.55***	(0.00)
GARCH(-3)	-0.02	(0.96)	-0.03	(0.45)	0.65***	(0.00)	0.81***	(0.00)
GARCH(-4)	-0.05	(0.82)	0.01	(0.86)	-0.05	(0.32)	-0.19***	(0.00)

Notes: The asymptotic critical values of Augmented Dickey-Fuller unit root tests are in their respective levels of significance. ***(*) denotes the rejection of the null hypothesis at 1% (5%) significance levels.
Source: Authors' computation

5.4 Asymmetric Effect Analysis on Exchange Rate Volatility in WAMZ

Exchange rate is a crucial factor considered by both local and foreign investors in most developing import dependent economies. For local investors, it affects their cost of production through importations of inputs to production but for foreign investors it creates so much risk at times of uncertainty, having the possibility of eroding the value of their investment. It is therefore important to analyze possible leverage effect on exchange rate behaviour in these countries through the asymmetric volatility models. Presented in tables 6 and 7 are the EGARCH and TGARCH models results analyzing leverage effect.

From the result of the EGARCH, the coefficient is found to be significant in all countries indicating the existence of leverage effect. For Nigeria and Sierra-Leone, it is positive while for Guinea and Gambia it is negative. This indicates that for Nigeria and Sierra-Leone, positive news triggers the volatility of exchange rate behaviour in these countries than

negative news while in Guinea and Gambia the reverse is the case as the coefficient was found to be negative indicating that negative news impacts on the volatility of exchange rates in these countries than positive news. For the purpose of robustness check, we corroborated the results with another asymmetric effect model presented in table 7.

Table 6: EGARCH Result for EXR Volatility

Volatility	**NIGERIA**	**GUINEA**	**GAMBIA**	**SIERRA-LOENE**
	Mean Equation	**Mean Equation**	**Mean Equation**	**Mean Equation**
	Coefficient	Coefficient	Coefficient	Coefficient
C	0.001***	2.20E-05	-0.02***	0.02***
d(exr(-1))	0.59***	0.52***	0.39***	0.89***
	Variance Equation	**Variance Equation**	**Variance Equation**	**Variance Equation**
C(3)	0.06***	0.41***	-0.32***	-0.001
ABS(RESID(-1)/ @SQRT(GARCH(-1)))	-0.145***	0.30***	0.47***	0.14***
RESID(-1)/ @SQRT(GARCH(-1))	0.30***	-0.05***	-0.07***	0.32***
LOG(GARCH(-1))	0.97***	0.93***	0.97***	0.98***

Notes: The asymptotic critical values of Augmented Dickey-Fuller unit root tests are in their respective levels of significance. *** denotes the rejection of the null hypothesis at 1% significance level
Source: Authors' computation

Table 7: TGARCH Result for EXR Volatility

Volatility	**NIGERIA**	**GUINEA**	**GAMBIA**	**SIERRA-LOENE**
	Mean Equation	**Mean Equation**	**Mean Equation**	**Mean Equation**
	Coefficient	Coefficient	Coefficient	Coefficient
C	0.38	3.40	0.02***	-0.002
D(Exr(-1))	0.25***	0.76***	0.26***	0.81***
	Variance Equation	**Variance Equation**	**Variance Equation**	**Variance Equation**
C	5.97	315.45***	0.001***	0.001***
RESID(-1)^2	0.07**	1.39***	0.31***	0.42***
RESID(-1)^2*(RESID (-1)<0)	-0.79**	1.68***	0.26***	-0.28***
GARCH(-1)	0.59***	0.19***	0.77***	0.89***

Notes: The asymptotic critical values of Augmented Dickey-Fuller unit root tests are in their respective levels of significance. *** (**) denotes the rejection of the null hypothesis at 1%(5%) significance level
Source: Authors' computation

From table 7, the results of the TGARCH model confirms the previous EGARCH asymmetric effect result as the coefficients of the TGARCH are significant establishing the existence of leverage effect on exchange rate behaviour in all the countries. For Nigeria and Sierra-Leone, the coefficients are negative while in Guinea and Gambia, they are positive confirming the robustness of the previous results that positive news explains the volatility of exchange rate behaviour more than negative news in Nigeria and Sierra-Leone but the reverse was the case for Guinea and Gambia exchange rate behaviour.

5.5 Results for Selected Macroeconomics Variables Effects on Exchange Rate Volatility in WAMZ

In this section, we examined the effect of some selected macroeconomic variables[4] as they explained the volatility of exchange rate in these countries. Consequently, the results are presented in tables 8 and 9. Table 7 presents the results by examining the effect on the behaviour or mean of exchange rate in these countries while table 8 presents the results analyzing the effect on the variance or volatility of exchange rate. From table 8, the results showed that real uncertainty as proxy for output growth volatility and inflation rate had negative impact on exchange rate behaviour in Nigeria, though it was not significant but money supply was found to positively and significantly impact exchange rate behaviour. This is not surprising as volatile output growth impacts exchange rate through the output gap channel, especially for an import surplus country like Nigeria. Inflation rate also had such effect because higher prices discourage export and thereby result in trade deficit that affect the foreign reserve, which invariably affects the exchange rate. Also, expansionary monetary policy results in income increase that facilitates more importation and capital outflow for an import dependent economy like Nigeria, and this affects the exchange rate. For Guinea, inflation rate and output growth volatility were found to positively impact exchange rate behaviour but money supply had a negative impact though not significant. This reason is not far fetch as Guinea's economy is more diversified than Nigeria's in terms of their export bases. For Gambia, inflation and money supply impacted positively on exchange rate behaviour but output growth volatility had a negative impact explaining the fact that expansionary monetary policy facilitates domestic production via investment, thereby impacting exchange rate through exports, even as higher prices encourage more investment. For Sierra-Leone, all the selected macroeconomic variables positively influenced exchange rate, explaining import substitution effect from domestic production that is boosted by higher prices and money supply.

Table 8: Results on Exchange Rate Behaviour Determination

Volatility	**NIGERIA**	**GUINEA**	**GAMBIA**	**SIERRA-LOENE**
	Mean Equation	**Mean Equation**	**Mean Equation**	**Mean Equation**
	Coefficient	Coefficient	Coefficient	Coefficient
C	0.31	3.01**	0.01***	0.001
d(exr(-1))	-0.001	0.73**	0.29**	0.69**
CPINF	-0.02	4.03**	0.02**	0.01**
M2	-0.001**	-0.001	0.03	0.01
RGDPGR	-0.14	0.094	-0.001	-0.02**
	Variance Equation	**Variance Equation**	**Variance Equation**	**Variance Equation**
C	5.60	229.60**	0.001**	9.93E-06**
ARCH(-1)	-0.003	2.19**	0.35**	0.48**
GARCH(-1)	0.58	0.19**	0.78**	0.87**
Adjusted R^2	0.67	0.68	0.73	0.82
Durbin Watson	1.87	1.95	2.60	2.18

Notes: The asymptotic critical values of Augmented Dickey-Fuller unit root tests are in their respective levels of significance. *** (**) denotes the rejection of the null hypothesis at 1%(5%) significance level

Source: Authors' computation

[4] Variables selection is guided by the empirical literature and availability.

Table 9: Results on Exchange Rate Volatility Determination

Volatility	NIGERIA	GUINEA	GAMBIA	SIERRA-LOENE
	Mean Equation	**Mean Equation**	**Mean Equation**	**Mean Equation**
	Coefficient	Coefficient	Coefficient	Coefficient
C	0.23	7.91**	0.031	2.491
D(EXR(-1))	0.15	0.74**	0.14	0.59**
	Variance Equation	**Variance Equation**	**Variance Equation**	**Variance Equation**
C	8.56***	116.39**	0.25**	780.42**
ARCH(-1)	0.003	1.88**	0.26**	0.25**
GARCH(-1)	0.57**	0.30**	0.56**	0.49**
CPINF	-0.57**	9.13**	0.02**	-16.79
M2	0.004	0.08	-0.28***	-3.00***
RGDPGR	0.57***	19.19**	-0.03**	45.93
Adjusted R^2	0.62	0.66	0.69	0.74
Durbin Watson	2.17	1.95	2.32	2.06

Notes: The asymptotic critical values of Augmented Dickey-Fuller unit root tests are in their respective levels of significance. *** (**) denotes the rejection of the null hypothesis at 1%(5%) significance level
Source: Authors' computation

From table 9, it is clear that inflation impacted negatively on the volatility of exchange rate in Nigeria while output growth volatility and money supply had positive effect on the volatility of exchange rate. This implies that higher prices result in lower exchange rate volatility while expansionary monetary policy and output growth volatility triggered higher volatility clustering around the exchange rate. For Guinea, all the variables were found to cause higher exchange rate volatility, but for Gambia only inflation rate caused higher exchange rate volatility clustering. In the case of Sierra-Leone, the results show that both inflation and output growth volatility facilitated exchange rate volatility.

6. Conclusion

This study examined the volatility clustering of exchange rates in selected WAMZ countries, for the period 1980-2016, using the symmetric and asymmetric ARCH/GARCH modeling approaches and exchange rate volatility clustering and the existence of leverage effect was confirmed in all the countries. Also, the effect of selected macroeconomic variables in explaining both the mean and variance of exchange rates in these countries was also tested, and mixed results reflecting the diversity of each country's economy was found. The intuition is that despite the fixed exchange rate regime that dominated in these countries over the years, they are still susceptible to external shocks due to commodity price movements. The resultant effect is always expectations that undermine exchange rate stability thereby leading to narrowing current account balances and capital outflow. Consequently, it is imperative for WAMZ countries to ensure adequate policy coordination based on current realities, so as to boost investors' confidence and create needed automatic adjustment mechanism to make the tradable goods sector more competitive.

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Appendices

Appendix A: Selected Macroeconomic Indicators

Table A1: Selected Macroeconomic Indicators in WAMZ

		1980	1985	1990	1995	2000	2005	2010	2014
Gambia	Exchange Rate	1.72	3.89	7.87	9.5	12.8	28.6	28.01	41.7
	Interest Rate	15	14.5	26.5	25	24	34.9	27	28
	Openness	89.3	102.8	104.4	108.5	106.1	42.5	35.8	57.8
	Import (%GDP)	66	54	60	63	58	35	26	39
	Export (%GDP)	24	49	44	45	48	7	26	39
	GDPgrowth	0.24	3.4	3.6	0.52	6.13	-0.94	6.5	1.62
	Inflation Rate	5.01	18.3	12.2	6.98	0.85	4.95	5.05	
	FDI net inflow	0.28	-0.5	14.12	15	43.5	87.1	20.4	28.4
	Output gap	5.9	4.8	3.5	-1.2	0.25	-1.1	0.4	-1.33
	Debt(%export)	206.5	280.9	217.5	236.9	-	351.5	179.8	149.2
Ghana	Exchange Rate	0.001	0.01	0.03	0.12	0.54	0.91	1.4	3
	Interest Rate	19	21.2	23.3	23.7	23.4	23	23.3	23
	Openness	54	35	43	55	118	61	90	102
	Import (%GDP)	37	24	26	30	68	38	50	53
	Export (%GDP)	16	12	18	24	51	22	40	53
	GDPgrowth	0.46	5.1	3.3	4.02	4.2	6.2	7.9	4.1
	Inflation Rate	50.01	10.3	37.2	59.3	25.1	15.1	6.7	
	FDI net inflow	15.6	5.6	14.8	106.5	114.9	144.9	2527.4	3356.9
	Output Gap	-3.6	-7.9	-4.3	-3.6	-2.1	-0.2	3.9	8.8
	Debt(%export)	115.6	331.8	393.6	344.4	254.6	181.4	92.8	96
Guinea	Exchange Rate	92	195	660	991	1746	3644	5726	7014
	Interest Rate	17.3	17.4	21.2	21.5	19.4	20.7	20.3	20.3
	Openness	68	67	76	55	66	65	84	125
	Import (%GDP)	32	32	39	29	35	34	53	90
	Export (%GDP)	36	35	38	26	31	31	31	35
	GDPgrowth	2.6	4.9	4.2	4.7	2.5	3	1.9	1.3
	Inflation Rate	39	19	25	5.6	6.8	31	15	
	FDI net inflow	0.56	1.11	17.86	0.77	9.94	105	101	566
	Output gap	-0.1	-0.8	-0.23	0.03	0.4	0.3	-0.29	-0.25
	Debt(%export)	-	311.7	294.8	456.5	406.8	319.5	201.9	60.1
Nigeria	Exchange Rate	0.55	0.89	8.03	67.4	101.7	131.3	150.3	158.6
	Interest Rate	8.4	9.4	25.3	20.2	21.3	17.9	17.6	16.7
	Openness	72	48	52	30	35	32	45	35
	Import (%GDP)	34	15	8	7	8	12	19	12
	Export (%GDP)	38	33	44	23	27	20	26	23
	GDPgrowth	2.2	11.3	11.4	2.2	5.3	6.5	7.8	6.3
	Inflation Rate	9.9	3.2	7.9	72.7	6.9	17.8	13.7	8.5
	FDI net inflow	-738.8	485.5	1002	1271	1309	4978	6098	4693.8
	Output gap	0.04	-0.18	-1.78	-2.25	-1.53	0.5	2.5	2.6

	Debt(%export)	32.2	138.1	226.5	274	149.1	35.8	8.79	14
Sierra-Leone	Exchange Rate	1.05	5.1	151.5	755	2092	2889	3978	4524
	Interest Rate	11	17	52.5	28.8	26.3	24.6	21.3	20.6
	Openness	78	27	24	29	45	46	54	125
	Import (%GDP)	55	16	15	18	35	29	38	51
	Export (%GDP)	23	11	9	11	10	17	16	74
	GDPgrowth	2.9	2.3	3.6	-10	3.8	4.5	5.4	6.9
	Inflation Rate	12.9	76.6	110.9	25.9	-0.92	12.1	17.8	9.8
	FDI net inflow	-18.67	-30.95	32.4	7.28	38.9	90.7	238.4	439.9
	Output gap	1.33	-0.83	-1.14	-4.8	-5.4	1.95	3.3	6.8
	debt (%export)	175.6	443.3	559.3	945.2	1941	664.7	218.3	63.1

Sources: UNCTAD Database Online, 2015; UN Statistical Database Online, 2015; IMF World Economic Outlook Database Online, 2015; World Bank WDI online, 2015.