Exchange Rate Volatility in Nigeria: Consistency, Persistency & Severity Analyses

Babatunde W. Adeoye[1] and Akinwande A. Atanda[2]

The adoption of the International Monetary Fund (IMF) Structural Adjustment Programme (SAP) in 1986 resulted in the transition from fixed exchange rate regime to floating exchange rate regime in Nigeria. Ever since, the exchange rate of naira vis-à-vis the U.S dollar has attained varying rates all through different time horizons. On this basis, this study examines the consistency, persistency, and severity (degree) of volatility in exchange rate of Nigerian currency (naira) vis-a-vis the United State dollar using monthly time series data from 1986 to 2008. The standard Purchasing Power Parity (PPP) model was used to analyze the long-run consistency of the naira exchange rate while the time series properties of the data was examined using the ADF and PP approach, the stationary process, and order of the incorporated series. The ARCH and GARCH models were used to examine the degree or severity of volatility based on the first difference, standard deviation and coefficient of deviation estimated volatility series for the nominal and real exchange rate of naira vis-a-vis the U.S dollar. The result indicated the presence of overshooting volatility shocks. The econometric analyses further revealed that the nominal and real exchange rates of naira vis-a-viz the U.S dollar are not with the traditional long-run PPP model. All the incorporated measures of volatility indicated presence and persistency of volatility in the nominal and real exchange rate for naira vis-à-vis U.S dollar in Nigeria. This however proves the ineffectiveness of monetary policy in stabilizing exchange rate and therefore, calls for the need of more tightened measures especially in controlling the high demand for foreign currency.

Keywords: Exchange rate, volatility, Purchasing Power Parity (PPP), Consistency, Persistency, Severity/ Degree, ARCH, GARCH.

JEL Classification: C10, E3, F31.

1.0 Introduction

There is a widespread contention that volatility of the exchange rates of developing countries is one of the main sources of economic instability around the world. The impact of the global economy on emerging countries like Nigeria is driven significantly by swings in the currencies of the major economic powers like United State. In recent years these swings have been enormous, volatile and frequently unrelated to underlying economic fundamentals (Philippe *et al., 2006)*. This has prompted monetary authorities in developing countries that keep close trade ties with the developed nations to intervene on totally ad hoc and episodic basis, without any clear sense of a sustainable equilibrium. Such exchange rate stability intervention typically comes too late to prevent severe currency misalignment and volatility. These imbalances, in turn, trigger major economic distortions, protectionist trade pressures, and inevitably sharp currency reversals (Philippe *et al., 2006)*. Though, currency instability and volatility could only exist during flexible

[1]Economics Department, University of Lagos, Akoka Lagos, Nigeria. badeoye2010@yahoo.com, tadeoye@unilag.edu.ng
[2]Strategic Analysis Unit, Datatric Research Consulting, Nigeria datatricng@gmail.com

exchange rate regime where the cross-country exchange rate is determined by the forces of demand and supply.

The liberalization of capital flows in developing countries over the last three decades and the enormous increase in the scale and variety of cross-border financial transactions have clearly increased the magnitude of exchange rate movements in most countries with underdeveloped capital markets and where there is not yet a track record of consistently stable economic policies. Currency crises in emerging markets, which have become more frequent in the last two decades, are especially notable cases of large exchange rate volatility (Carrera and Vuletin, 2003). This has been of particular concern to developing countries and emerging market economies. In addition, the transition to a market-based system often involves major adjustments in the international value of these economies' currencies.

Other changes in the world economy may have reduced the impact of exchange rate volatility. The proliferation of financial hedging instruments over the last 20 years could reduce firms' vulnerability to the risks arising from volatile currency movements. In addition, for multinational firms, fluctuations in different exchange rates may have offsetting effects on their profitability (Carrera and Vuletin, 2003). As a growing fraction of international transactions is undertaken by these multinational firms, exchange rate volatility may have a declining impact on world trade. On the balance, it is not clear whether the major changes in the world economy over the past two decades have operated to reduce or increase the extent to which international trade is adversely affected by fluctuations in exchange rates. One aspect of this issue is the extent to which such volatility itself has changed, and another is the degree to which firms are sensitive to exchange rate risk and can take steps to mitigate it at low cost. It is therefore necessary to examine new empirical evidence at this issue, especially the consistency of exchange rate volatility.

Exchange rate regime varies with the level of financial development. Throughout the developing world, the choice of exchange rate regime stands as perhaps the most contentious aspect of macroeconomic policy (Calvo and Reinhart, 2002). Witness, on the one hand, the intense international criticism of Africa's inflexible exchange rate system and on the other hand, West African policy makers are chastised for not doing enough to stabilize their country's highly volatile currency. Empirical evidences have shown that exchange rate volatility in turn is caused by both real and financial aggregate shocks (Calvo and Reinhart, 2002). Yet, despite the perceived implications of the exchange rate regime to long- run growth and economic stability, the existing theoretical and empirical literature on Africa (Nigeria in particular considering the level of the country's economic integration through trade and foreign capital inflows) offers little guidance. The theoretical literature is mainly tailored to richer countries with highly developed institutions and markets (e.g., Garber and Svensson, 1995; Obstfeld and Rogoff, 1996), and there is almost no discussion of long-run growth.

The most known theoretical explanation of long-term stability and consistency of bilateral exchange rate is Purchasing Power Parity (PPP) hypothesis. Testing for long-run PPP is important for number of reasons: many monetary models *á lá* Dornbusch (1986), hinges on the validity of long-run PPP theory, while many other macroeconomic models often use PPP to link domestic and foreign development especially in developing countries like Nigeria. Furthermore, although the PPP hypothesis may not be regarded as an explicit exchange rate theory, it may still serve to provide fundamental determinants that can be used to calculate the long-run exchange rates and assess the appropriate level of exchange rates when a long-run relationship exists. However, both nominal and real exchange rates are studied in this study since a sizable discrepancy often exists between these two exchange rates and often used alternatively in empirical research and considering an highly regulated environments like Nigeria where the supply of foreign exchange is often insufficient to meet the market demand.

On this basis, the objectives of this paper are highlighted as follows:

- To investigate the consistency of exchange rate volatility in Nigeria.
- To determine the existence and persistency of volatility in the nominal and real exchange rate of naira vis-a-vis U.S dollar.
- To establish the degree or severity of exchange rate volatility between 1986 and 2008 in Nigeria.

The volatility degree of exchange rate of naira to U.S dollar is critically examined across the three phases of exchange rate regime (SAP period, Lethargy era and Post-SAP era) in Nigeria between 1986:M1 and 2008:M12. The remaining section of this study is categorized into five sections. Section II presents a survey of relevant literature and conceptual issues. While the measurement and the description of data in respect of exchange rate volatility are contained in section III, section IV covers methodology. Section V presents empirical results and discussion, and the final section concludes the paper and proffer recommendation based on the empirical findings.

2.0 Survey of Literature and Conceptual Issues

2.1 Survey of Literature

Despite the saturation of the literature with studies on exchange rate volatility, the literature is still scanty with respect to developing countries. The few studies are panel data in nature and have traced the effects of macroeconomic shocks on exchange rate volatility. For instance, Carrera and Vuletin (2003) seek to analyze the relationship between exchange rate regimes and short-term volatility of the effective real exchange rate. The study sets out the relative importance of these links, specifically by analyzing the exchange rate regime influence on the RER volatility using a dynamic panel data analysis. For this ends a sample of 92 countries for the 1980-1999 period was considered. The study finds evidence on how other variables influence RER volatility and it also analyses the persistence of shocks in RER. The study further finds more evidence of more openness, acceleration in per capita GDP growth, reduction in volatility. Conversely, positive monetary shocks and growth in capital inflows and in public expenditure increase this real volatility. Evidence from the study also supports the view that the analysis of the dynamics of the exchange rate regimes needs to differentiate between developed and developing countries.

Benita and Lauterbach (2007), studied the daily volatility of the exchange rate between the US Dollar and 43 other currencies in 1990-2001. The study uses several macroeconomic variables, that proxy for the domestic economy uncertainty, wealth, and openness to international markets, as controls in the analysis. The well-known GARCH statistical behavior of exchange-rate volatility was also accounted for. The main finding of the study was that exchange rate volatility was positively correlated with the real domestic interest rate and with the degree of central bank intervention. In the panel, the study finds *positive* correlations between exchange rate volatility, real interest rates and the intensity of central bank intervention

In Nigeria, studies have been conducted to estimate exchange rate volatility (see Akpokodje, 2009; Aliyu, 2010; Aliyu, 2009a; Aliyu, 2009b; Ogunleye, 2009; Olowe, 2009; Yinusa & Akinlo, 2008; Yinusa, 2008; Yinusa, 2004). Most of the studies on exchange rate volatility in Nigeria measure the impacts of exchange rate volatility on trade balance with little attention to other internal macroeconomic variable shocks. For instance, Akpokodje (2009) explored the exports and imports effects of exchange rate volatility with specific reference to the non Communaute Financiere Africaine (non-CFA) countries of Africa during the period, 1986 – 2006. The countries chosen included Ghana, Lesotho, Malawi, Nigeria, Sierra Leone, South Africa, Uganda and Zambia. A GARCH approach was employed to generate on annual basis the real exchange rate volatility series for each country. The study reveals a negative effect of exchange rate volatility on exports and imports in the selected African countries. The adverse effect of exchange rate volatility on exports in the sampled countries, as found in the study suggests the need for policy interventions that will help to minimize and, where possible, eradicate exchange rate volatility.

Also, Yinusa (2008) investigated the relationship between nominal exchange rate volatility and dollarization in Nigeria by applying Granger causality test for the period 1986–2003 using quarterly data. The study reported a bi-causality between them but the causality from dollarization to exchange rate volatility appears stronger and dominates. He however concluded that policies that aim to reduce exchange rate volatility in Nigeria must include measures that specifically address the issue of dollarization. But, the exact measure of exchange rate volatility in the study was not reported.

In the same vein, Ogunleye (2009) investigated the relationship between exchange rate volatility and Foreign Direct Investments (FDI) inflows in Sub- Saharan Africa using Nigeria and South Africa as case studies. By endogeneizing exchange rate volatility, the study uses a two – stage

Least Squares methodology. The study finds that in Nigeria, there is a statistically significant relationship between the variables, with exchange rate volatility retarding FDI inflows and FDI inflows increasing exchange rate volatility. As revealed by the study, this relationship is however weak for South Africa. The possible reason adduced by the study is the sound capital flows management policy of the South African Reserve Bank.

Further attempts were made by Aliyu (2009a) and employed standard deviation measure of exchange rate volatility based quarterly observation and further assesses the impact of exchange rate volatility on non-oil export flows in Nigeria between 1986 and 2006. Empirical result revealed that exchange rate volatility decreased non-oil exports in Nigeria. In another study, Aliyu (2009b) examined the impact of oil price shock and exchange rate volatility on economic growth in Nigeria and measuring exchange rate volatility as the consumer price index based real exchange rate approach. But he failed to examine the degree and persistency of exchange rate volatility using standardized econometric.

However, among the entire studies on the macroeconomic effects of exchange rate volatility in Nigeria over the past three decades, it is only the study of Olowe (2009) that is found to investigate the volatility of Naira/Dollar exchange rates in Nigeria using several variants of Generalized Autoregressive Conditional Heteroskedasticity (GARCH) models. He used monthly data over the period January 1970 to December 2007 and found that all the GARCH family models indicated that volatility is persistent and reported similar evidence for the fixed exchange rate and managed float rate regimes.
The review so far shows that there exists a dearth of research on the consistency/ persistency analysis of the measures of exchange rate volatility in Nigeria which is the focus of this research.

2.2. Conceptual and Methodological Issues in Exchange Rate Volatility

Despite huge body of literature literature on exchange rate volatility and trade, there is, however, no consensus on the appropriate method for measuring such volatility. There is no generally accepted model of firm behaviour subject to risk arising from fluctuations in exchange rates and other variables. Consequently theory cannot provide definitive guidance as to which measure is most suitable. Moreover, the scope of the analysis will to some extent dictate the type of measure used. If the focus is on advanced countries, for instance, then one could take into account forward markets for the assessment of exchange rate volatility on trade, whereas this would not be possible if the analysis extended to a large number of developing countries. In addition, one needs to consider the time horizon over which variability is to be measured, as well as whether it is unconditional volatility or the unexpected movement in the exchange rate relative to its predicted value, that is the relevant measure. Finally, the level of aggregation of trade flows being considered will also play a role in determining the appropriate measure of the exchange rate to be used.

IMF (2005) provided a comprehensive empirical review of measure of volatility in exchange rates across the entire Fund membership for which data are available. The study starts with an examination of the relationship between aggregate exchange rate volatility and aggregate trade. Recognizing the limitations of looking at the aggregate data, the paper then turns to analyzing the effect of exchange rate volatility on trade across different country pairs and over time. Methodologically, the switch to bilateral trade and volatility allows one to better control a variety of other factors that could affect trade other than volatility. As a consequence, the chance to detect an effect of exchange rate volatility on trade improves.

Given this methodological approach, the basic building block in the analysis is the volatility in the exchange rate between the currencies of each pair of countries in the sample. For the descriptive part of the study which looks at the exchange rate volatility facing a country as a whole, it is necessary to aggregate the bilateral volatilities using trade shares as weights to obtain what is referred to as the "effective volatility" of a country's exchange rates. This ensures that the measures of volatility in the descriptive and econometric parts of the study are fully consistent.

Such a measure of "effective volatility" presupposes that the exchange rate uncertainty facing an individual firm is an average of the variability of individual bilateral exchange rates (Lanyi and Suss, 1982). However, if a trading firm engages in international transactions with a wide range of countries, any tendency for exchange rates to move in offsetting directions would reduce the overall exposure of the firm to exchange rate risk. This would argue for using the volatility of a country's effective exchange rate as the measure of the exchange rate uncertainty facing a country. This would seem particularly appropriate for advanced economies where much trade is undertaken by diversified multinational corporations.

It is important to realize that the degree of exchange rate variability a country is exposed to is not necessarily closely related to the type of exchange rate regime it has adopted. A country may peg its currency to an anchor currency, but it will float against all other currencies if the anchor does as well. Thus, as with effective exchange rates, effective volatility is a multidimensional concept. Pegging can reduce nominal exchange rate volatility vis-à-vis one trading partner, but it can by no means eliminate overall exchange rate variability.

The choice between using nominal and real exchange rates depends in part on the time dimension that is relevant for the economic decision being taken. In the short- run where costs of production are known and export and import prices have been determined, the exchange rate exposure of a firm is a function of the nominal exchange rate. However, the decision to engage in international transactions stretches over a longer period of time during which production costs and export and import prices in foreign currency will vary. From this perspective, exchange rates measured in real terms are appropriate. Nonetheless, as nominal and real exchange rates tend to move closely together, given the stickiness of domestic prices, the choice of which one to use is not likely to affect significantly measured volatility or the econometric results. Nonetheless, real rates are preferable on theoretical grounds and are used in the benchmark measures of volatility below. Consumer prices are used to construct the real rates, as they are the most widely available measures of domestic prices.

While exchange rates are often highly volatile, the extent to which they are a source of uncertainty and risk depends on the degree to which exchange rate movements are foreseen. When hedging instruments are available, the predicted part of exchange rate volatility can be hedged away and hence may not have much effect on trade. This suggests that the appropriate measure of risk should be related to deviations between actual and predicted exchange rates. One possibility along these lines would be to use the forward rate as a prediction of the future spot rate, and to use the difference between the current spot rate and the previous period forward rate as an indicator of exchange rate risk. One problem with this approach is that the forward rate is not a good predictor of future exchange rates.

More generally, there are a wide variety of methods (ranging from structural models to time series equations using ARCH/GARCH approaches, for example) that could be used to generate predicted values of exchange rates (McKenzie, 1999). However, as pointed out by Meese and Rogoff (1983), there are inherent difficulties in predicting exchange rates. The most widely used measure of exchange rate volatility is the standard deviation of the first difference of logarithms of the exchange rate. This measure has the property that it will equal zero if the exchange rate follows a constant trend, which presumably could be anticipated and therefore would not be a source of uncertainty. Following the practice in most other studies, the change in the exchange rate is computed over one month, using end of month data. The standard deviation is calculated over a one-year period, as an indicator of short-run volatility, as well as over a five-year period to capture long-run variability.

3.0 Exchange Rate Volatility in Nigeria: Measurement, Data Description and Trend Analysis

3.1 Measurement of Volatility

There are several measurements of exchange rate volatility in literature[3], but the three of the most common measures of exchange rate volatility are the first order difference measure (FD), standard deviation of the growth rates of exchange rate (SD) and the coefficient of variation measure (CV). The first order difference (FD) measure consider the difference between the current logarithm value of exchange rate[4] and previous. It is defined as:

$$FD_t = \left(\ln EX_t - \ln EX_{t-1}\right) - \ln \overline{EX} \qquad (1)$$

[3]See McKenzie (1999) for a review of the alternative measures of volatility that have been used in literature on exchange rate volatility.
[4]The exchange rate can either be the nominal or price adjusted (real). Although most studies employed real exchange rate in their computations. This study use both form of hypothetical PPP bilateral exchange rates.

where EX is the bilateral exchange rate; $\overline{EX}$ is the mean of the bilateral exchange rate and $\ln$ is the natural log.

The second measure, standard deviation of the growth rates of exchange rate (SD)[5], is approximated by time-varying measure defined as follows:

$$SD_{t+m} = \left[\frac{1}{m} \sum_{i=1}^{m} \left(\ln EX_{t+i-1} - \ln EX_{t+i-2} \right)^2 \right]^{1/2} \quad (2)$$

where m is the order of moving average.

The last alternative measure of the exchange rate volatility is defined as the time-varying twelve-month co-efficient of variation (CV) of the bilateral exchange rate (this is, in fact, a measure of dispersion of the real exchange rate). It is defined as:

$$CV_{t+m} = \frac{\left[\frac{1}{m} \sum_{i=1}^{m} \left(EX_{t+i-1} - \overline{EX} \right)^2 \right]^{1/2}}{\overline{EX}} \quad (3)$$

where $\overline{EX}$ is the mean of the bilateral exchange rate between month t and $t+m-1$.

3.2 Data Description

The bilateral nominal and real (price adjusted) exchange rates for naira vis-à-vis U.S dollar are used as the main sourced data set. The monthly data of nominal exchange rate (NR) and real exchange rate (RR) for naira vis-à-vis U.S dollar between 1986 (which marks the beginning of floating exchange rate) and 2008 are sourced from the Central Bank of Nigeria (CBN) Statistical Bulletin, Golden Jubilee edition, December, 2008. The data set (NR and RR) are used to compute each of the considered measures of volatility (FD, SD and CV) as defined above to make six data composition set for this study.

3.3 Trend

The adoption of the International Monetary Fund (IMF) Structural Adjustment Programme (SAP) facilitated the deregulation of the financial market that necessitated floating exchange rate regime in the wake of 1986 and prevail till the end of April 1993 for its first face (as shown in the gap before the shaded portion of figure 1). During this period (1986:M1 and 1993:M4), the nominal exchange rate exhibit steady increase with little spike but attained its first high spike in between the end of 1991 and March 1993. While, the real bilateral exchange rate of naira to a unit of U.S dollar witnessed high deterioration within the first nine months of the commencement of floating exchange rate regime and later depreciated steadily till April 1990 before it spike up in May 1990 and make a downward steep from December 1990, through the second phase of fixed and

[5]It worth noting that some authors have use this indicator as if it was a measure of the standard deviation of the exchange rate (and not of its growth rate). This measure has been used, among others, by Kenen and Rodrick (1986), Chowdhury (1993), Arizeet. al (2000), and Gerardo and Felipe (2002).

floating exchange rate regimes, to December 2000 before making a reversal to create the first spike at the second phase of floating regime.

Afterwards, the nominal and real (starting from 1999:M3and 2001:M1 respectively) exchange rates of naira to U.S dollar have been maintained upward trend till date, exhibiting the ineffectiveness of the monetary authority in stabilizing the forex market through the demand and supply of currency, controlling excessive importation of goods and improper management of the country's external reserve to back up the weak currency. Even though, there tends to be wide dispersion between the real and nominal bilateral exchange rate between 1986 and 2008, but it started widen up from December 1991 and this marks the onset of intense high inflationary period in Nigeria. However, the series fluctuations and spikes that the bilateral exchange rate of naira to U.S dollar witnessed all through the first and second phase of floating exchange rate regime and during the second phase of the fixed regime period prompted this study to examine the presence and degree of volatility during the review periods.

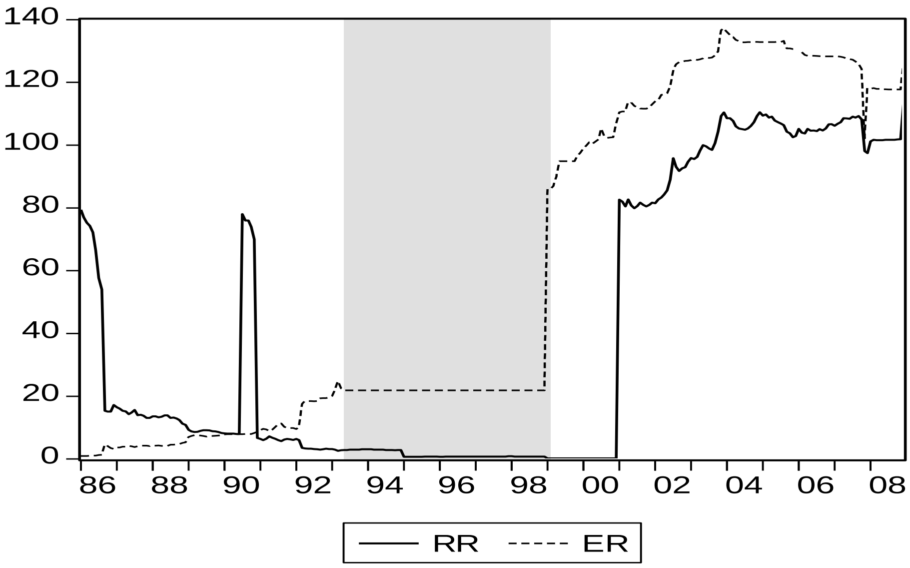

Figure 1: Time series plot of real and nominal bilateral exchange rate for naira vis-à-vis dollar between 1986M1 and 2008M12.

Data Source: CBN Statistical Bulletin (2009)

The time series of the volatility generated for the bilateral nominal and real exchange rate of naira to U.S dollar using each of the three incorporated measures defined above are plotted as follows. The chart 2 and chart 3 present the first difference, standard deviation and coefficient of variation volatility series plots for bilateral nominal and real exchange rate of naira to U.S dollar in Nigeria between February 1986 and December 2008 respectively, while the shaded area represent the periods of fixed exchange rate regime. A closer look at chart 2 and 3 revealed that the standard deviation volatility measure of bilateral nominal and real exchange rates clearly stands out in its distribution pattern and distinct from the other two alternative measures (first difference and coefficient of variation) that exhibit clear representation of volatility clustering during the review periods based on the series of fluctuations and spikes shown. This implies that the first difference and coefficient of variation volatility series plots for bilateral nominal and real exchange rate of naira to U.S dollar in Nigeria between February 1986 and December 2008 respectively show more swings and clear volatility clustering properties based on series plots. This is similar to the volatility measure differential findings given by Gerardo and Felipe (2002).

Figure 2

CURRENCY VOLATILITY (₦=$):
Nominal Exchange Rate
(February 1986- December 2008)

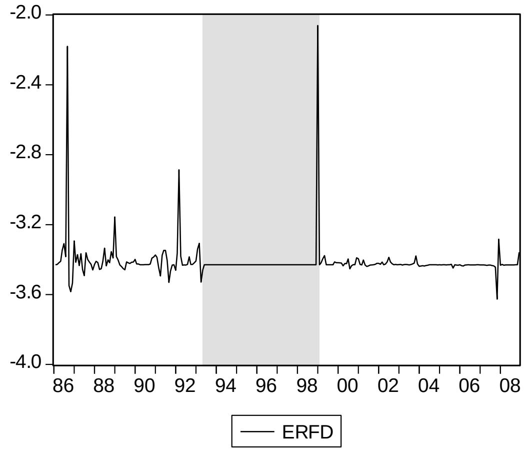

Figure 2(a): **First Difference**

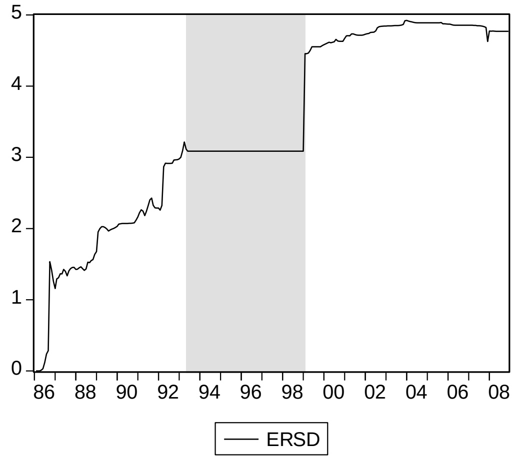

Figure 2(b): **Standard Deviation**

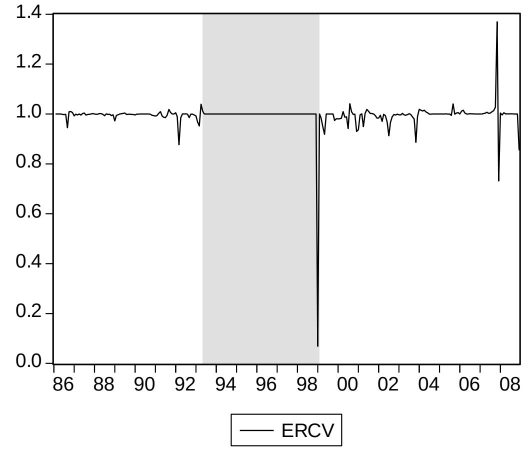

Figure 2(c): **Coefficient of Variation**

Figure 3

CURRENCY VOLATILITY (₦=$):
Real Exchange Rate
(February 1986 - December 2008)

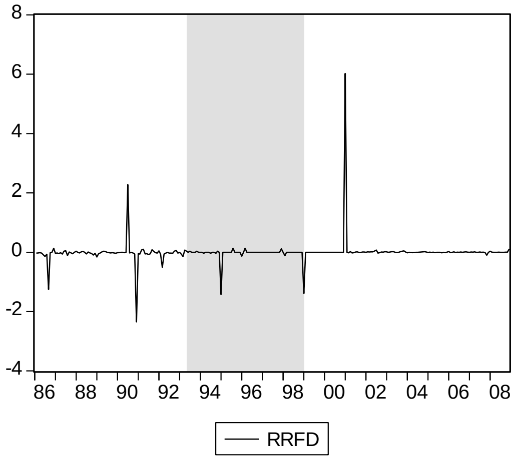

Figure 3(a): **First Difference**

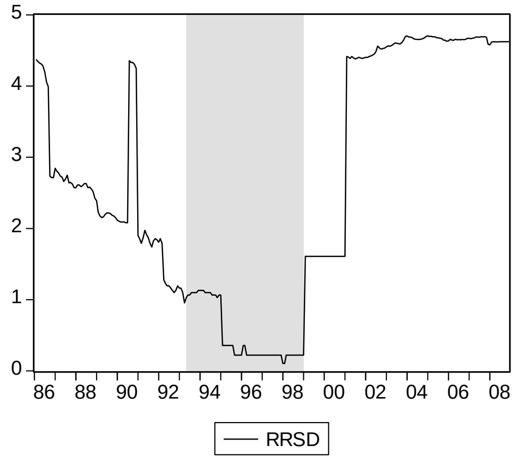

Figure 3(b): **Standard Deviation**

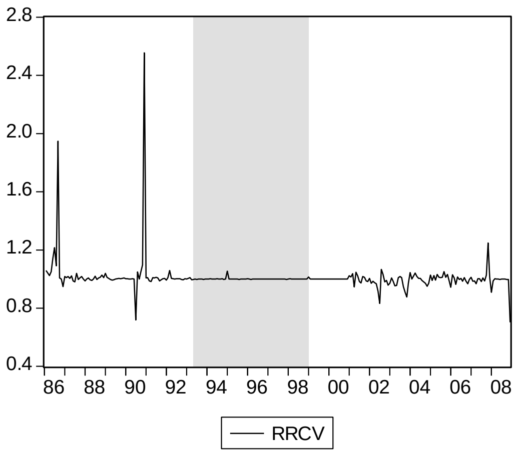

Figure 3(c): **Coefficient of Variation**

Though, this is not sufficient to conclude that there is the presence of volatility clustering in the bilateral nominal and real exchange rate of naira to U.S dollar in Nigeria between February 1986 and December 2008 without appropriate application of econometric methodologies.

4.0 Methodology

4.1 Exchange Rate Consistency Analysis

The time series properties of the bilateral exchange rate for naira vis-à-vis U.S dollar is examined using the unit root test developed by Dickey and Fuller (1981) and Phillips and Perron (1988) on the sourced nominal and real exchange rates data set in order to verify the long-run Purchasing Power Parity hypothesis in Nigeria. This aids the validation of the long-run consistency level of the bilateral exchange rate of naira to U.S dollar based on the PPP theoretical assertion that bilateral exchange rate tends to be stationary and non mean-reverting in the long-run. The Augmented Dickey-Fuller (ADF) unit root test specification is expressed as:

Intercept:

$$\Delta Z_t = \psi_0 + \psi_1 Z_{t-1} + \sum_{i=1}^{\infty} \mu_i \Delta X_{t-i} + \omega_t \quad (4)$$

Intercept + Trend:

$$\Delta Z_t = \psi_0 + \psi_1 Z_{t-1} + \psi_1 t + \sum_{i=1}^{\infty} \mu_i \Delta X_{t-i} + \omega_t \quad (5)$$

where: ω_t is the residual term and Z_t is the time series variable. The lag is determined using the Akaike and Schwarz Information Criteria. The non-parametric statistical method of Phillips-Perron (PP) unit root test specification is defined as:

Intercept:

$$\Delta Z_t = \alpha + \partial Z_{t-1} + \varepsilon_t \quad (6)$$

Intercept + Trend:

$$\Delta Z_t = \alpha_0 + \alpha_1 t + \partial Z_{t-1} + \varepsilon_t \quad (7)$$

The null hypothesis of $\partial \succ 0$ (no stationary) is tested against the alternative hypothesis of $\partial \prec 0$ (stationary).

4.2 Test of Exchange Rate Volatility: Model Specification

In literature (see Kenen and Rodrik, 1986; Bailey *et. al*., 1986; Peree and Steinherr, 1989; Cote, 1994; McKenzie and Brooks, 1997), various measures of exchange rate volatility have been employed to examine the variability of pair-wise cross-country exchange rate based on the observation that exchange rate time series are typically heteroskedastic, leptokurtic and exhibit volatility clustering-i.e, varying variance over a specified period of time. On this basis and in line with the research objective, this study examines the degree or extent of exchange rate volatility between the end of fixed currency era, which marks the inception of the adopted IMF Structural Adjustment Programme (SAP) in 1986 and still the era of post Structural Adjustment Programme (SAP)-2008. Like other empirical studies, the Autoregressive Conditional Heteroskedasticity (ARCH) model introduced by Engle (1982) and the Generalized ARCH model by Bollerslev (1986) were used to capture the extent of exchange rate volatility in Nigeria. The choice of models are based on their empirical use in various areas of econometric modeling, especially in financial time series analysis (see for example, Engle, 1982; Bollerslev, 1986; Bollerslev*et al.*, 1992; Yinusa, 2004; Akpokodje, 2009; Olowe 2009) and their approaches in modeling financial time series with an autoregressive structure in that heteroscedasticity observed over different periods may be autocorrelated.

In developing an ARCH model, we consider two distinct specifications- one for the conditional mean and the other for conditional variance. Generalizing this, the standard GARCH (p, q) specification is expressed as:

$$y_t = \alpha + \sum_{i=1}^{k} \eta_i x_{t-i} + \varepsilon_t \tag{8}$$

$$\varepsilon_t \approx N\left(0, \sigma_t^2\right) \tag{9}$$

$$\sigma_t^2 = \omega + \sum_{i=1}^{p} \alpha_i \varepsilon_{t-i}^2 + \sum_{i=1}^{q} \beta_i \sigma_{t-i}^2 \tag{10}$$

The mean equation given in Equation (8) is expressed as a function of a constant α -(taken as mean if other exogenous variables are assumed to be zero), exogenous variable(s) x_{t-i} -(majorly in autoregressive (AR) structure of order k) and with an error term ε_t. Note that y_t is the considered measure of exchange rate volatility at time t. Since σ_t^2 is the one-period ahead forecast variance based on past information, it is called *conditional variance.* Equation (9) expresses the normal distribution assumption (*white noise*) of the error term. The conditional variance equation specified in (10) is a function of three components: the meanω; the news about volatility from the previous period, measured as the lag of the squared residual from the mean equation: ε_{t-i}^2 (the ARCH term); and the last period's forecast variance: σ_{t-1}^2 (the GARCH term).

In Equation (8), the k is the order of the AR term, while in Equation (10), the p is the order of the ARCH term and q is the order of the GARCH term. According to Gujarati (2004), a GARCH (p, q) model is equivalent to an ARCH (p+q) i.e. in our specification ARCH (k), where k=p+q. For instance, a standard GARCH (1, 1) refers to the presence of a first-order ARCH term (the first term in parentheses - p, lagged term of the squared error term) and a first order GARCH term (the second term in parentheses - q, lagged term of the conditional variance).

According to Yinusa (2004), the GARCH specification is often interpreted in financial context, where an agent or asset holder predicts this period's variance by forming a weighted average of a long term (constant), information about volatility observed in the previous period (the ARCH term), and the forecasted variance from the last period (the GARCH term). If the exchange rate changes were unexpectedly large in either the upward or the downward direction, then the agent will increase the estimate of the variance for the next period. The GARCH model is also consistent with the volatility clustering often seen in financial returns data, where large changes in returns are likely to be followed by further large changes. In the mean equation, the presence of volatility means that volatility in the current period is related to its values in the previous periods (k) plus a white noise error term.

For the purpose of this study, the presence of volatility clustering is determined by the significance of the lagged volatility series parameters- y_t. While, the extent or degree of exchange rate volatility is determined by the autoregressive root, which governs the persistence of volatility shocks, is the sum of $\alpha + \beta$ and the indications of volatility degree are expressed as follows:-

If $\alpha + \beta \to 1$ i.e. is close to one, it indicates that volatility is present and persistent;

If $\alpha + \beta > 1$ i.e. is greater than 1, it indicates overshooting volatility; and

If $\alpha + \beta < 0.5$ i.e. is less than 0.5, it indicates no volatility.

4.3 Data Requirements and Sources

The data required for this consistency and persistency analysis of exchange rate volatility is the quarterly series of nominal and real exchange rates of naira vis-a-vis U.S dollar from 1986 to 2008. These data were sourced from the Central Bank of Nigeria (CBN) Statistical Bulletin, Golden Jubilee Edition.

The precise volatility series were generated from the nominal and real exchange rates of naira to U.S Dollar using the earlier described first difference, standard deviation and co-efficient of variation measures of volatility.

5.0 Empirical Results and Discussion

The time series property results of incorporated bilateral nominal and real exchange rates for naira vis-à-vis U.S dollar examined using Augmented Dickey-Fuller (ADF) and Phillips Perron (PP) unit root tests revealed that the series failed to reject the null hypothesis of no stationary at levels for both tests model with intercept and trend based on the results presented in Table 1. The table indicates the evidence that the bilateral nominal and real exchange rates for naira vis-à-vis U.S dollar follow non-stationary process. This finding seems to be valid regardless of whether nominal or real exchange rates are used, although a somewhat stronger mean-reverting behaviour is observed for the bilateral real exchange rate, offering evidence against the assumption of the long-run PPP. Therefore, we then conclude that the bilateral nominal and real exchange rates for naira vis-à-vis U.S dollar are not consistent with the hypothetical long-run PPP. This finding is consistent with previous studies, for example, Olowe (2009), Jun (2000), and Gerardo and Felipe (2002).

The non-consistency of bilateral nominal and real exchange rates for naira vis-à-vis U.S dollar with the hypothetical long-run PPP implies that the movements of Nigeria's exchange rate cannot be explained by monetary (or transitory) factors in the economy, and real (or permanent) shocks seem to be important in understanding the long-run movement. However, to some extent, the series of structural changes experienced in the country that necessitated the changes in the real sector of the economy justify the non-stationary process of the bilateral nominal and real exchange rates for naira vis-à-vis U.S dollar which is not consistent with the hypothetical long-run PPP.

Table 2 presents the estimated GARCH model results for the nominal exchange rate for naira vis-à-vis U.S dollar in Nigeria using three variants of exchange rate volatility measures. The second column of Table 2 shows the GARCH model results using the first difference measure of exchange rate measure. The GARCH results for the first difference measure of nominal exchange rate volatility revealed persistency of volatility clustering between the current volatility and the previous two periods of volatility based on the ARCH(2) parameters, though not significant 5%. Also, from the column 2 of Table 2, the sum of the ARCH and GARCH terms which signifies degree of volatility revealed the strong presence and persistency of volatility shocks in the nominal exchange rate for naira vis-à-vis U.S dollar in Nigeria based on the first difference measure of volatility. This is similar to the results reported for the standard deviation and co-efficient of variation measures of volatility. While, the volatility residuals generated from the mean equation is found to be normally distributed based on the reported residual tests for all the measures of nominal exchange rate volatility.

However, in order to conclude that there is presence of volatility in the nominal exchange rate for naira vis-à-vis U.S dollar, the ARCH LM residual and the Wald tests reported in the Table 2 for each of the measure of nominal exchange rate volatility in Nigeria. The ARCH LM residual test results presented in Table 2 for each of the measure of volatility revealed that there are no remaining ARCH effects which have not been captured by the GARCH models judging by the non-significance of the F-statistic. Thus, these results demonstrate that the GARCH models provide a good fit for the nominal exchange rate series for naira vis-à-vis U.S dollar in Nigeria using any of the measures of volatility. Also, the Wald test is conducted for coefficient restrictions, where the null hypothesis of no volatility (i.e. ARCH(1) + GARCH(1) = 0 or $\alpha + \beta =$ 0) is tested against the alternative of the existence of volatility. The result of the Wald-test presented in Table 2 revealed that the coefficients of the ARCH(1) and GARCH(1) are statistically significant at 5% critical level. This implies that the coefficients are statistically different from zero as shown in Table 2 and based on the F-statistic result presented in Table (2), the null hypothesis of no volatility is rejected. On the basis of the evaluation test, we then conclude that there is presence and persistency of volatility shocks in the nominal exchange rate for naira vis-à-vis U.S dollar.

Unlike the Table 2, the Table 3 presents the estimated GARCH model results for the real exchange rate for naira vis-à-vis U.S dollar in Nigeria using the first difference, standard deviation, and coefficient of variation of exchange rate volatility measures. Each of the columns in the Table 3 shows the estimated GARCH model results for the real exchange rate volatility series using each of the measures of exchange rate volatility. The GARCH results for all the measures of real exchange rate volatility revealed persistency of volatility clustering between the current volatility and the previous periods of volatility based on the ARCH parameters, but not significant at 5% for the first difference and standard deviation measures. Also, the sum of the ARCH and GARCH terms which signifies degree of volatility revealed the strong presence and persistency of volatility shocks in the real exchange rate for naira vis-à-vis U.S dollar in Nigeria based on the first difference and standard deviation measures of volatility, but the co-efficient of variation measure of volatility indicated presence of overshooting volatility in the real exchange rate for naira vis-à-vis U.S dollar. While, the volatility residuals generated from the mean equation is found to be normally distributed based on the reported residual tests for all the measures of real exchange rate volatility.

Likewise, to conclude that there is presence of volatility in the real exchange rate for naira vis-à-vis U.S dollar, the ARCH LM residual and the Wald tests reported in the Table 3 for each of the measure of real exchange rate volatility in Nigeria. The ARCH LM residual test results presented in Table 3 for each of the measure of volatility revealed that there are no remaining ARCH effects which have not been captured by the GARCH models judging by the non-significance of the F-statistics. Thus, these results demonstrate that the GARCH models provide a good fit for the real exchange rate series for Naira vis-à-vis U.S dollar in Nigeria using any of the measures of volatility. Also, the Wald test is conducted for coefficient restrictions, where the null hypothesis of no volatility (i.e. ARCH(1) + GARCH(1)=0 or $\alpha + \beta$=0) is tested against the alternative of the existence of volatility. The result of the Wald-test presented in Table 3 revealed that the coefficients of the ARCH(1) and GARCH(1) are statistically significant at 5% critical level. This implies that the coefficients are significantly different from zero as shown in Table 3 and based on the F-statistics result presented in Table 3, the null hypothesis of no volatility is rejected. On the basis of the evaluation test, we then conclude that there is presence and persistency of volatility shocks in the real exchange rate for naira vis-à-vis U.S dollar.

6.0 Conclusion

The conventional PPP hypothesis has been tested in this study following the work of Jun (2000) in examining the long-run consistency and stability of the nominal and real exchange rates of naira vis-à-vis U.S dollar using monthly time series data from1986 (which marks the transition period of fixed exchange rate regime to floating exchange rate regime in Nigeria) to 2008 by examining the time series property of the data series. The Augmented Dickey-Fuller and Phillip Perron unit root test methodologies revealed that the monthly data series of nominal and real exchange rates of a unit U.S Dollar to Naira do not reject the null hypothesis of non stationarity at levels, which is found similar to the result reported by Jun (2000) for most African countries, (Nigeria inclusive). On this basis, this study concludes that the bilateral nominal and real exchange rates for naira vis-à-vis U.S Dollar are not consistent with the hypothetical long-run PPP.

The presence of volatility in the nominal and real exchange rates of naira vis-à-vis U.S dollar is examined using the Autoregressive Conditional Heteroskedasticity (ARCH) model introduced by Engle (1982) and the Generalized ARCH model by Bollerslev (1986). This was based on the volatility data series generated for the two exchange rates variant using the first difference, the standard deviation and the co-efficient of variation measures and used to generate the entire volatility series for the analysis. From the findings, each of the volatility measure series for nominal and real exchange rates revealed different estimate of volatility between 0.538476 and 1.22842, indicating the presence and persistency of volatility shocks in the nominal and real exchange rates for naira vis-à-vis U.S dollar in Nigeria except the coefficient of variation measure under the real exchange rate which indicated overshooting volatility shocks in terms of degree. However, further evaluation concluded that there is presence and persistency of volatility shocks in the nominal and real exchange rates for naira vis-à-vis U.S dollar in Nigeria between 1986 and 2008. This implies that the conventional monetary management policies instituted have proved ineffective in stabilizing the exchange rate of a unit U.S dollar to naira over the years. This therefore calls for the need of other forex management measures especially in terms of meeting the high demand for foreign currency which characterized and dictate the performance and trade balance and overall economic performance in Nigeria. There is also the need for sound monetary policy to attain stability in the exchange rate.

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Appendix

Table 1: Unit Root Test Results

Level	Nominal Exchange Rate	Real Exchange Rate
ADF Tau Statistics*		
Intercept	-0.5509 [0]	-1.1441 [0]
Trend	-1.8098 [0]	-3.0490 [0]
PP Tau Statistics**		
Intercept	-0.5367 [4]	-1.0311 [16]
Trend	-1.8307 [5]	-2.9808 [18]

Source: *Authors Computation using E-Views 7.1The lag length is parenthesis.*
** lag length selected using the AIC and SIC;*
*** lag length selected using Newey-West Bandwidth*

Table 2: Nominal Exchange Rate Volatility Result

Volatility	First Difference Measure		Standard Deviation Measure		Co-efficient of Variation Measure	
	Mean Equation		Mean Equation		Mean Equation	
	Co-eff.	Prob.	Co-eff.	Prob.	Co-eff.	Prob.
C	-3.543624	0.0000	0.072093	0.1164	1.025253	0.0000
NEV(-1)	-0.010555	0.8044	0.958939	0.0033	-0.037767	0.4611
NEV(-2)	-0.027669	0.6989	-0.015051	0.9668		
NEV(-3)			0.041300	0.6594		
	Variance Equation		Variance Equation		Variance Equation	
	Co-eff.	Prob.	Co-eff.	Prob.	Co-eff.	Prob.
C	0.009041	0.0000	0.009043	0.0000	0.000329	0.0000
α :ARCH(-1)	-0.012349	0.0000	-0.010886	0.7398	-0.006802	0.0000
α :ARCH(-2)			-0.001803	0.9559		
β :GARCH(-1)	0.599795	0.0000	0.551165	0.0000	0.943221	0.0000
	Degree		Degree		Degree	
$\alpha + \beta$	0.587446		0.538476		0.936419	
	Residual Test		Residual Test		Residual Test	
JarqueBera	98995.17		87780.02		161880.2	
Prob.	0.000000		0.000000		0.000000	
	ARCH Test		ARCH Test		ARCH Test	
F-Stat	0.021940		0.104319		2.140510	
Prob.	0.882358		0.746958		0.144613	
	Wald Test		Wald Test		Wald Test	
	Test Value	Prob.	Test Value	Prob.	Test Value	Prob.
F-Stat	8762967	0.0000	1917.890	0.0000	1847212	0.0000
Chi-square	17525934	0.0000	3835.780	0.0000	3694424	0.0000

Source*: Authors Computation using E-Views 7.1*

NEV-is the nominal exchange rate volatility. The appropriate ARCH and GARCH terms are selected based on the minimum Schwarz Information Criteria (SIC).

Table 3: Real Exchange Rate Volatility Result

Volatility	First Difference Measure		Standard Deviation Measure		Co-efficient of Variation Measure	
	Mean Equation		Mean Equation		Mean Equation	
	Co-eff.	Prob.	Co-eff.	Prob.	Co-eff.	Prob.
C	0.044215	0.5132	0.037182	0.5602	-0.963604	0.0001
REV(-1)	-0.004934	0.9791	1.030751	0.0761	1.603792	0.0000
REV(-2)			-0.043626	0.9402	0.214742	0.2912
REV(-3)					0.139114	0.4882
	Variance Equation		Variance Equation		Variance Equation	
	Co-eff.	Prob.	Co-eff.	Prob.	Co-eff.	Prob.
C	0.117867	0.5118	0.018508	0.2839	0.002603	0.0211
α :ARCH(-1)	-0.008082	0.5677	0.022405	0.4510	0.639872	0.0208
α :ARCH(-2)						
β :GARCH(-1)	0.592593	0.3434	0.763327	0.0006	0.588548	0.0000
	Degree		Degree		Degree	
$\alpha+\beta$	0.584511		0.785732		1.22842	
	Residual Test		Residual Test		Residual Test	
JarqueBera	193966.2		43865.39		10319.79	
Prob.	0.000000		0.000000		0.000000	
	ARCH Test		ARCH Test		ARCH Test	
F-Stat	0.002598		0.061438		3.670460	
Prob.	0.959390		0.804426		0.056445	
	Wald Test		Wald Test		Wald Test	
	Test Value	Prob.	Test Value	Prob.	Test Value	Prob.
F-Stat	5128.415	0.0000	15899.17	0.0000	29.02783	0.0000
Chi-square	10256.83	0.0000	31798.33	0.0000	58.05565	0.0000

Source: *Authors Computation using E-Views 7.1*

REV-is the real exchange rate volatility. The appropriate ARCH and GARCH terms are selected based on the minimum Schwarz Information Criteria (SIC).