Exchange rate volatility and exchange rate uncertainty in Nigeria: a financial econometric analysis (1970- 2012)

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2013

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ABSTRACT

This research paper examines exchange rate volatility over time (1970-2012) using the Generalized Autoregressive Conditional Heteroscedasticity (AR GARCH) model of the Maximum Likelihood techniques. Our AR GARCH result showed that lagged (last year) exchange rate is significantly responsible for the dynamics of Naira/ Dollar exchange rate in Nigeria. Most glaring is that our ARCH and GARCH parameters indicate that exchange rate volatility shocks are rather persistent in Nigeria. We also find that exchange rate uncertainty has a direct relationship with current exchange rate in Nigeria. Further, the Granger causality test conducted shows that the direction of causality is more powerful and significant from exchange rate uncertainty to actual exchange rate in Nigeria. Thus the paper suggests a proper management of exchange rate, to forestall costly distortions in the Nigerian economy.

Keywords: GARCH Models, Financial Econometrics, Foreign Exchange rate, Monetary Policy
JEL Classification: C22, C58, F31, E52

Paper to be Presented at the Eighteenth Annual Conference of the African Econometric Society, Accra, Ghana

1. Introduction

Foreign exchange rate as generally defined in economic literature is the rate at which one country's currency can be traded for another country's currency. While exchange rate *volatility,* implies the liability of a country's currency relative to another country's currency to *fluctuate* over time. Exchange rate volatility could depend on two basic policies, that is the fixed exchange rate policy and the flexible exchange rate policy. By fixed exchange rate policy (regime), we mean a situation, when the exchange rate is set and government is committed to buying and selling its currency at a fixed rate, while flexible exchange rate policy defines a situation when the exchange rate is set by market forces (demand and supply for a country's currency). Although most economists have argued that a country should not have a fixed exchange rate policy because exchange rates are mostly determined by market forces, this belief could have the *sinew* of the *classical* faith.

However, Gbanador (2007) associated some advantages of a market determined exchange rate, to include its ability to correct balance of payments imbalances and domestic independence of external influences; this is not devoid of its potential to raise uncertainties and speculation that may be attributed to fluctuations as explained by the prominent *Speculative Dynamic Model*.

According to Agiobenebo (1999), some markets tend to exhibit perpetual oscillations in prices in which price movements cannot be accounted for by unplanned exogenous changes in demand and supply, this behavior is typical in foreign exchange market, and may lead to an obstacle of economic development which Jhingan (2005) described as *foreign exchange constraint*.

It is against this background that the management of financial time series volatility, particularly the foreign exchange rate has become a great concern to policy makers like Engle (1982) and Bollerslev (1986) that have craved various sophisticated approaches such as the Autoregressive Heteroscedastic (ARCH/GARCH) models of the maximum likelihood techniques and some of its likes to identify and tackle the various forms and manifestation of volatility in financial time series such as the exchange rate. The GARCH (1, 1) which according to Engle (2001) is the simplest and most robust of the family of volatility models is *rattling* as adopted in this study.

2 Literature Review

Literature on the study of various aspects of exchange rate and financial time series volatility and uncertainties are enormous and replete. However No attempt is made to exhaust all the available literature in this review.

Wang and Barrett (2007) estimated the effect of exchange rate volatility on international trade flows by studying the case of Taiwan's exports to the United States from 1989-1999. They employed sectoral level monthly data and an innovative multivariate GARCH-M estimator with corrections for leptokurtic errors. They found that change in importing country industrial production and change in the expected exchange rate jointly drive the trade volumes. Interestingly, they also found that monthly exchange rate volatility affects agricultural trade flows, but not trade in other sectors.

Ruiz (2005) examines the effects of inflation and exchange rate uncertainty on real economic activity in Columbia, by using a generalized autoregressive conditional variance

(GARCH) model of inflation and exchange rates, the conditional variances of the model's forecast errors were extracted as measures of uncertainty, his results suggest that higher levels of inflation Granger cause more uncertainty and vice versa for the Colombian economy. While, only inflation uncertainty matters for output by exerting a negative influence.

Hansen and Lunde (2004) in their analysis, compared 330 ARCH-type models in terms of their ability to describe the conditional variance, they however found no evidence that a GARCH (1, 1) is outperformed by more sophisticated models in their analysis of exchange rates, whereas the GARCH(1,1) is inferior to models that can accommodate a leverage effect.

Engle (2000) proposed another form of multivariate GARCH models that is simple and is based on the likelihood function known as the Dynamic Conditional Correlation (DCC), according to Engle, the DCC have the flexibility of univariate GARCH models coupled with parsimonious parametric models for correlations.

Aikaeli (2007) examined money and inflation dynamics response in Tanzania using seasonally adjusted monthly data for the period 1994-2006 by applying GARCH model. Their estimated results indicate that a current change in money supply would affect inflation rate significantly in the seventh month ahead. They show further that the impact of money supply on inflation is not a sort of one-time strike on inflation but a kind of persistent shock.

Mandelbrot, Fisher and Calvet (1997a) described a Multifractal Model of Asset Returns (MMAR) as an alternative to ARCH- type model, thus they suggested econometric models that are time- invariant and scale- invariant.

Avellaneda and Zhu (1997) employed the exponential ARCH (E-ARCH) to examine the joint evolution of 1 month, 2 month, 3 month, 6 month and 1 year 50-delta options in currency pairs. Their results show that there exist three uncorrelated state variables which account for the parallel movement, slope oscillation, and curvature of the term structure and which explain, on average, the movements of the term-structure of volatility to more than 95%.

Mandelbrot, Fisher and Calvet (1997b) further investigated multifractality in Deutschemark / US Dollar currency exchange rates. They concluded that the multifractal model is a new econometric tool which can be used in the evaluation of risk.

Hondroyiannis et. al. (2005) examined the relationship between exchange-rate volatility and aggregate export volumes for 12 industrial economies based on a model that includes real export earnings of oil-producing economies as a determinant of industrial-country export volumes. They however employed five estimation techniques, including a generalized method of moments (GMM) and random coefficient (RC) estimation, on panel data covering the estimation period 1977:1-2003:4 for three measures of volatility. According to them, there is no single instance in which volatility has a negative and significant impact on trade.

Goldstein (2004) argues that China's exchange rate policy is seriously flawed given its current macroeconomic circumstances and its longer-term policy objectives. He made the following conclusions;

(i) The “RMB” is significantly under-valued;

(ii) China has been "manipulating" its currency, contrary to the IMF rules of the game;

(iii) It is in China's own interest, as well as in the interest of the international community, for China to initiate an appreciation of the “RMB” soon; and

(iv) China should neither stand pat with its existing currency regime nor opt for a freely floating “RMB” and completely open capital markets.

Goldstein recommended that China should undertake a "two step" currency reform. Step one would involve a switch from a unitary peg to the US dollar to a basket peg, a 15-25 percent appreciation of the “RMB”, and wider margins around the new peg. Step two, would involve a transition to a *managed float*, along with a significant liberalization of China's capital outflows.

Benigno and Benigno (2000) used a simple two-country general equilibrium model to evaluate monetary policy regimes. They showed that the behavior of the exchange rate, and other macroeconomic variables, depends crucially on the monetary regime chosen, though not necessarily on monetary shocks.

Gupta, Chevalier and Sayekt (2000) examine the relationship between the interest rate, exchange rate and stock price in the Jakarta stock exchange for the period 1993 to 1997. They found sporadic unidirectional causality from closing stock prices to interest rates and vice versa and weak unidirectional causality from exchange rate to stock price. Although, their results did not establish any consistent causality relationships between any of the economic variables under study.

Allayannis, Brown and Klapper (2001) examined Exchange Rate Risk Management of East Asia for the period 1996 and 1998. They found that firms use foreign earnings as a substitute for hedging with derivatives and evidence that East Asia firms engage in "selective" hedging. Also, they found that firms using derivatives before the crisis perform just as poorly as nonhedgers during the financial crisis.

Hooper and Kohlhagen (1976) examined the effect of exchange rate uncertainty on the prices and volume of international trade for the U.S. and German trade flow, during the period 1965 to 1975. They developed an equilibrium model for export supply and import demand functions inorder to analyze the impact of exchange risk on trade prices and volumes; they however found that if traders are risk averse, an increase in exchange risk will unambiguously reduce the volume of trade whether the risk is born by importers or exporters. They also found a bi- directional relationship between exchange risk and the price of traded goods.

Nwafor (2006) applied the Augmented Dickey-Fuller (ADF) unit root and Johansen-Juselius cointegration methods to investigate whether the Flexible Price Monetary Model (FPMM) of exchange rate is consistent with the variability of the naira-dollar exchange rate from 1986- 2002 based on quarterly time series data. He found at least one cointegrating vector, suggesting a long-run equilibrium relationship between the naira-dollar exchange rate and the Flexible Price Monetary Model (FPMM) fundamentals.

Bouakez, Kano and Xu (2007) explores whether imperfect information and learning are helpful in accounting for exchange rate volatility and persistence, and for the co-movement of exchange rates and other macroeconomic variables, such as output, consumption, and interest rates. They showed that misperception and learning can constitute a strong internal propagation mechanism in a dynamic stochastic general-equilibrium model of exchange rate determination, they also stated that consumption, investment and production decisions are affected by misperception. Hence, they concluded that there is no disconnection between exchange rate movements and macroeconomic fundamentals

Kellard and Sarantis (2007) examines the proposition that forward premium persistence can be explained solely by exchange rate volatility, they showed that that the fractionally integrated behaviour of the forward premium can be jointly explained by similar behaviour in the true risk premium (TRP) and the conditional variance (volatility) of the spot rate

Busse, Hefeker and Koopmann (2004) examined trade and exchange rate regimes in Mercosur (Members of Mercosur are Argentina, Brazil, Uruguay and Paraguay), they suggested a dual currency boards that could be a workable solution for the Mercosur countries.

Kidane (1999) studied the relationship between Real exchange rate price and agricultural supply response in Ethiopia, his econometric estimates (where fixed effect model was applied) showed that there was positive response for both the short run and the long run, he also stated that as a result of increased domestic prices, farmers may not take advantage of incentives and thereby increase their income.

Kuijs (1998) estimated a macroeconomic model of the determinants of inflation, exchange rate and output in Nigeria. His results is in line with classical assertions concerning the dichotomy between the real and monetary spheres. He showed that in the long run, price level is determined by monetary policy, as an excess of money supply over money demand leads to a rise in the rate of inflation, while the long run effect of import prices is insignificant. He also showed that the long run equilibrium real exchange rate is determined by the real demand for and supply of foreign exchange.

Adubi and Okunmadewa (1999) establish that exchange rate volatility has a negative effect on agricultural exports, while price volatility has a positive effect. Thus, the more volatile the exchange rate changes, the lower the income earnings of farmers, which subsequently also leads to a decline in output production and a reduction in export trade. Also an appreciation of the local currency decreases export earnings, while an increase in export price influences the level of exports positively. Their study further showed that the Structural Adjustment Programme (SAP) era, though beneficial in terms of price increases of agricultural exports, has also resulted in a high level of price and exchange rate fluctuations.

Bailliu, Lafrance, and Jean-François Perrault (2002) estimate the impact of exchange rate arrangements on growth in a panel-data set of 60 countries over the period from 1973 to 1998 based on a dynamic generalized method of moments estimation technique. They found that exchange rate regimes characterized by a monetary policy anchor (whether they are pegged, intermediate, or flexible) exert a positive influence on economic growth. They also found evidence that intermediate/flexible regimes without an anchor are detrimental for growth. Their results thus suggest that it is the presence of a strong monetary policy framework, rather than the type of exchange rate regime per se, that is important for economic growth. Hence, their work emphasized the importance of considering the monetary policy framework that accompanies the exchange rate arrangement when assessing the macroeconomic performance of alternative exchange rate regimes.

Bitzenis and Marangos (2007) examined the flexible-price monetary model for the Greek drachma-US dollar exchange rate based on the Johansen multivariate technique of cointegration. They employed quarterly data covering the period 1974–1994, they found strong evidence in favour of the existence of co-integration between the nominal exchange rate, relative money supply, relative income and relative interest rates.

Adam and Cobham (2008) estimate the effect of a menu of exchange rate regimes on trade within a gravity model, using the Baier & Bergstrand (2006) Taylor expansion technique to allow for multilateral trade resistance. They allowed simulations of the effects of changes in the exchange rate regime for a particular country or region which explicitly take into account the associated changes in multilateral and world trade resistance. They found that in terms of the trade effects for most Middle East and North African (MENA) countries it would be better to anchor on the euro than on the dollar, but for some others (typically small oil exporters with large exports to Asian countries) it would be better to continue to anchor on the dollar.

Similarly, Nabli (2002) studied exchange rate regime and competitiveness of manufactured exports on a panel of 53 countries, 10 of which are MENA economies; he showed that Middle East and North African (MENA) countries were characterized by a significant overvaluation of their currency during the 1970s and 1980s, and that this overvaluation has had a cost for the region in terms of competitiveness.

Bhattarai and Armah (2005) examined the effects of exchange rates on the trade balance of Ghana. They first derived the real exchange rate as a function of preferences and technology of two trading economies and then applies small price taking economy assumption to the Ghanaian economy, for annual time series data from 1970-2000 to estimate trade balance as a function of the real exchange rate, domestic and foreign incomes. Their Cointegration analyses of both single equation models and VAR-Error correction models confirm a stable long-run relationship between both exports and imports and the real exchange rate. Their short-run elasticity's of imports and exports indicate contractionary effects of devaluation in terms of the Marshall-Lerner-Robinson conditions though these elasticities add up to almost 1 in the long-run estimates. The overall conclusion drawn from their study is that for improved balance of trade in Ghana, coordination between the exchange rate and demand management policies should be strengthened and be based on the long-run fundamentals of the economy.

Dufrenot and Yehoue (2005) developed a panel co-integration techniques and common factor analysis to analyze the behavior of the Real Exchange Rate (RER) in a sample of 64 developing countries. They studied the dynamic of the RER with its economic fundamentals: productivity, the terms of trade, openness, and government spending. They derive a number of common factors that explain the dynamic of the RER. They found that some fundamentals such as productivity, terms of trade and openness are strongly related to common factors in low-income countries, but no such link was found for the middle-income countries.

Balogun (2007) study examines the effect of exchange rate policy on the bi-lateral intra-WAMZ (West African Monetary Zone) and global inter-WAMZ export trade, with a view to gauging its relative veracity among other determinants. His results show that the coefficient estimates of bilateral exchange rate was not significant in explaining the changes in the bilateral intra-WAMZ exports, but not the case with the world inter-WAMZ regression results in which one of the partner’s exchange rate is significant and positively influence their collective exports to the rest of the world. He concluded that the maintenance of independent flexible exchange rate policy by either party to the bilateral trade makes no difference in terms of export performance, and may indeed constitute an impediment (microeconomic costs of foreign exchange conversion and high incident of trade diversion) to free trade within the WAMZ region.

Rutasitara (2004) studied exchange rate regimes and inflation in Tanzania, their estimated model from quarterly data for 1967–1995 showed that the parallel rate had a stronger influence on inflation up until the early 1990s compared with the official rate and that the exchange rate remains potentially sensitive to exogenous shocks.

Bleaney and Fielding (1999) Tests on a sample of 80 developing countries over the period 1980- 1989 showed that the median developing country has had significantly higher inflation than the median advanced country since the early 1980s. From their results, they further suggested that the widespread adoption of floating exchange rates in the developing world has had a significant cost, with inflation tending to be over 10% p.a. faster than in the typical pegged-rate country

Velasco (2000) examined exchange-rate Policies for Developing Countries during the 1997–1998 Asian crises, he concluded that adjustable or crawling pegs are extremely fragile in a world of volatile capital movements. They suggested that any exchange-rate regime, and especially one of flexible rates, requires complementary policies to increase its chances of success.

Yeyati and Sturzenegger (1999) indicated that as volatility increases, most countries *are forced to* edge towards floating their exchange rates. They also stated that many countries that claimed to run a floating rate displayed little exchange rate volatility coupled with intense foreign exchange market intervention, so that in reality they are closer to a fix exchange rate regime.

Chukwuma (2002) examined the real exchange rate distortions and external balance position of Nigeria, based on a single equation procedure. He found that over the sample period, real exchange rate misalignment (measured as the deviation of the actual from the estimated equilibrium path) was irregular but persistent. Also, Misalignment was also found to be higher during the period of deregulation than during that of regulation. He further showed that real exchange rate distortions (misalignment and volatility) hurt both the trade balance and the capital account. Thus he recommends a more realistic management of investment environment (with an eye on stability), public sector expenditure and other fundamentals as a necessary complement to nominal devaluations in the search for stronger external positioning (Chukwuma, 2002).

Canetti and Greene (1991) studied monetary growth and exchange rate depreciation as causes of inflation in African countries (ten African countries: The Gambia, Ghana, Kenya, Nigeria, Sierra Leone, Somalia, Tanzania, Uganda, Zaïre, and Zambia.); they used Granger causality tests and the vector autoregression analysis to separate the influence of monetary growth from exchange rate changes on prevailing and predicted rates of inflation. Their Variance decompositions indicates that monetary dynamics dominate inflation levels in four countries, while in three countries, exchange rate depreciations are the dominant factor.

Tenreyro (2006) examined the effect of nominal exchange rate variability on trade, from a broad sample of countries from 1970 to 1997; his estimates indicate that nominal exchange rate variability has no significant impact on trade flows.

Esquivel and Larraín (2002) examines the impact of G-3 exchange rate volatility on developing Countries, they showed that G-3 exchange rate volatility has a robust and significant negative impact on developing countries' exports. They stated empirically that a one percentage point increase in G-3 exchange rate volatility decreases real exports of developing countries by about 2 per cent, on average. Also, G-3 exchange rate volatility also appears to have a negative influence on foreign direct investment to certain regions, and increases the probability of occurrence of exchange rate crises in developing countries (Esquivel and Larraín, 2002).

According to Gylfason (2002), real exchange rates are likely to fluctuate on their way towards long-run equilibrium because of the dynamic interaction between real exchange rates and the current account.

Bleaney and Francisco (2007) studied the performance of exchange rate regimes in developing countries, from 73 countries for 1984-2001; they showed that three out of four alternative schemes that use official exchange rates agree with the official classification in suggesting that growth rates in developing countries are not significantly different under soft pegs and floats.

Coricelli and Jazbec (2001) studied real exchange rate dynamics in transition economies; their empirical results show that the nature of the real appreciation was significantly different in the countries of the former Soviet Union (FSU), except for the Baltic countries, and in Central and Eastern Europe.

Nkurunziza (2002) investigated exchange rate policy and the parallel market for foreign currency in Burundi; his results show that the premium is determined by the expected rate of devaluation, trade policy variables and GDP growth.

Alaba (2003) found that parallel market exchange rate is an important driver of real economic process in Nigeria. He also concluded that exchange rate volatility is not a serious source of worry for investors in the Nigerian economy.

Grauwe (1988) argued that a “near- rational” expectations model can better explain the long- run drift in real exchange rate, he also argued that the rational expectations model fails to explain the long run cycles in the real exchange rates.

Alvarez-Diaz (2008) employed a composition of weekly data from January 1973 to July 2002, comprising a total of 1541 observations, to examine exchange rates of Japanese Yen and British Pound against the US Dollar; his results indicate the existence of a statistically significant short-term predictable structure in the exchange rates dynamic.

Chen, Rogoff and Rossi (2008) showed that “commodity currency” exchange rates have remarkably robust power in predicting future global commodity prices, both in-sample and out-of sample. They found that commodity prices Granger-cause exchange rates

Joshi (2003) used India as a case-study to illustrate that the optimal external payments regime would be a combination of an intermediate exchange rate with capital controls.

Monetary Policy and Exchange Rate

Weeks (2008) examined the effectiveness of monetary policy under a flexible exchange rate regime with perfectly elastic capital flows, according to Weeks (2008), monetary policy will be more effective than fiscal policy if and only if the sum of the trade elasticity's exceeds the import share, and developing countries data indicates a low effectiveness of monetary policy under flexible exchange rates. He concluded that fiscal policy is more effective, whether the exchange rate is fixed or flexible.

Cheng (2007) examines the impact of a monetary policy shock on output, prices, and the nominal effective exchange rate for Kenya using data during 1997-2005 based on the vector auto regression (VAR) technique. Cheng (2007) results suggest that an exogenous increase in the short-term interest rate tends to be followed by a decline in prices and appreciation in the nominal exchange rate, but has insignificant impact on output. Moreover, he found that variations in the short-term interest rate account for significant fluctuations in the nominal exchange rate and prices, while accounting little for output fluctuations.

Caporale, Cipollini and Demetriades (2003) stated that while tight monetary policy helped to defend the exchange rate during tranquil periods, it had the opposite effect during the Asian crisis.

Jarmuzek, Orlowski and Radziwill (2004) applied the institutional and behavioural transparency measures of monetary policy in the Czech Republic, Hungary and Poland. They however found an association between the two measures of transparency, which they attributed to the active exchange rate management policy that undermines the actual transparency proxied by the behavioural measure.

3 Methodology

This study adopts the Maximum Likelihood (ML) method (a.k.a. large sample method) to examine the Autoregressive Conditional Heteroscedasticity (ARCH) model. According to Gujarati (2003), the method of Maximum Likelihood (ML) is a method of point estimation with some stronger theoretical properties than the method of Ordinary Least Squares (OLS). Just like the OLS, the ML estimator of σ^2 is also unbiased. It also holds the assumption that the μ_i follows the normal distribution and uncorrelated.

Model Specification

ARCH models as introduced by Engle (1982) and generalized as GARCH by Bollerslev (1986) are popularly used to measure volatility in macroeconomic financial time series. It follows an Autoregressive (AR) process. Thus;

Let,

$$EXR_t = C + \mu_i \quad \text{----------} \quad (1)$$

Where

C= Mean of EXR

EXR_t= Exchange Rate at time t (current period)

μ_i= error term with zero mean

To allow for Conditional Heteroscedasticity (CH), we write the variance conditional by assuming that

$$Var_{t-1}(\mu_t) = \sigma_t^2 \quad \text{----------} \quad (2)$$

We however rewrite eq. (2) as;

$$\sigma_t^2 = \pi_0 + \pi_1 \mu^2_{t-1} \quad \text{----------} \quad (3)$$

Since we have established in eq. (2) that $Var_{t-1}(\mu_t) = \sigma_t^2$, even though $E(\mu_t) = 0$. Hence, we rewrite eq. (3) as;

$$\mu_t^2 = \pi_0 + \pi_1 \mu^2_{t-1} + \varepsilon_t \quad \text{------------------------------ (4)}$$

The Akaike Information Criterion (AIC) and Schwartz Information Criterion (SIC) are used to choose the appropriate number of lags for the model.

We also study exchange rate uncertainty. The rationale for exchange rate uncertainty is built on the premise of lack of information about the determinants of exchange rate in an emerging market economy. According to Ball (1992) in Nwani et al (2004), uncertainty is defined as the variance of the stochastic or unpredictable component of a variable. Similarly, Black (2002) refers to uncertainty as a consciousness of lack of knowledge about present facts or future possibilities. By adopting the definition by Black (2002), we adopt the GARCH model to show the variance of stochastic innovations in the exchange rate.

The one- step forecast error of the variance equation that is computed is used as a proxy for exchange rate uncertainty. However, the equations below establishes the relationship between actual exchange rate (σ_t) and exchange rate uncertainty (¿)

$$\sigma_t = \sum_{i=1}^{n} \pi_0 ¿_{t-1} + \sum_{j=1}^{n} \pi_1 \sigma_{t-1} + \mu_{3t} \ldots\ldots (5)$$

$$¿_t = \sum_{i=1}^{n} \delta_0 ¿_{t-1} + \Sigma \boldsymbol{\delta}_1 \sigma_{t-1} + \mu_{4t} \ldots\ldots (6)$$

Where

σ_t = Actual Exchange rate

¿= Exchange rate uncertainty

μ_{3t} and μ_{4t}= are uncorrelated by assumption

(4) Empirical Results and Discussion

This section critically presents and analyzes our empirical result based on our method of analysis as stated in the previous section. As the model (ARCH) suggests, it implies that heteroscedasticity or unequal variance may have an autoregressive structure such that heteroscedasticity observed over different periods are uncorrelated.

It is modish (fashionable) to state that, the hunch of ARCH is based on the fact that financial planning is often difficult due to volatility in financial time series, in this case is the exchange rate. It is also imperative to state the three basic assumptions that underlie the ARCH model;

a. Normality (Gaussian) Distribution
b. Students t- distribution
c. Generalize Error Distribution (G.E.D)

The results of our models are presented trenchantly below using statistical tools (tables and equations);

Unit Root Tests for Stationarity

Table 1: Unit Root Test of Stationarity Results

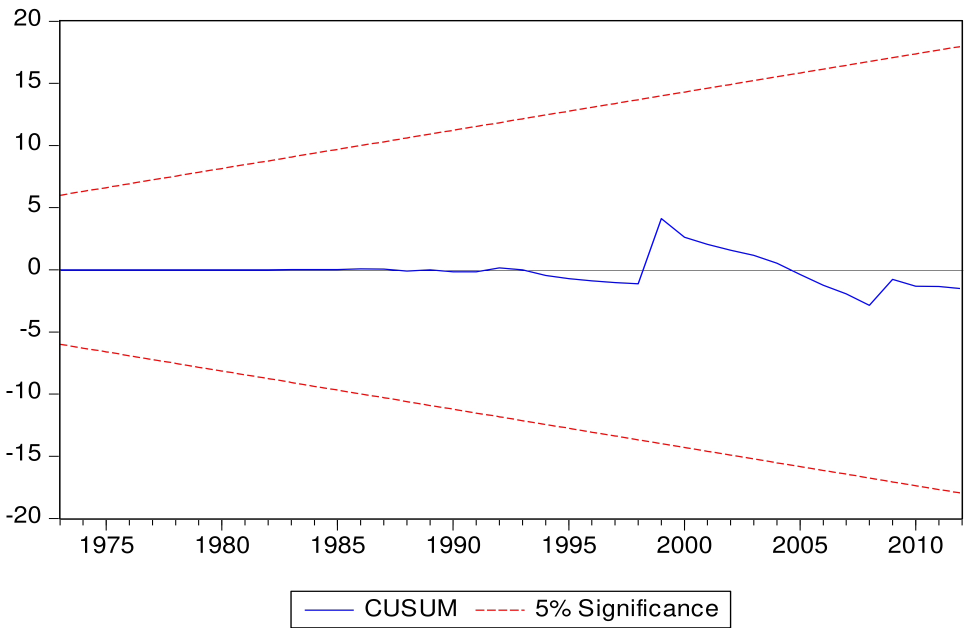
The table 1 below shows the results from Augmented Dickey- Fuller (ADF) and Phillips-Perron (PP) unit root tests with an intercept;

Test	Variables	Levels		Differences		Order of Integration
		t- statistic	Critical	t- statistic	Critical	
ADF	σ_t			-6.000661	3.600987 *	I(1)
	¿$_t$			-5.984230	-3.621023*	I(1)
PP	σ_t			-5.999641	3.600987*	I(1)
	¿$_t$			-5.983379	-3.621023*	I(1)

*Note: * Implies significance at 1%*
Source: Author's Computation based on data from Central Bank of Nigeria Publications

An application of the Augmented Dickey- Fuller (ADF) and Philllips- Perron (PP) tests reported in table 1 above indicates that the unit root test results show that the actual exchange rate in the model is integrated of the order one, I(1), implying that they are stationary at their first difference, also, exchange rate uncertainty is integrated of order one, I(1).

The Cumulated Sum of Residuals (CUSUM) Test



The CUSUM tests is used in this study to test for parameter stability, our graph shows that the plots of the residuals remain within the 5% critical bounds, therefore, we can accept that the parameters of the model are stable.

ARCH LM Test for ARCH Effects

To test if the variance equation is correctly specified, we use the ARCH LM test (default lag), since the ARCH LM test is not statistically significant, it suggest that the variance equation is correctly specified and thus, there is no ARCH left in the standardized residuals.

The AR GARCH Estimation Results

Table 2: AR GARCH Estimation of Exchange Rate in Nigeria (1970- 2010)

Independent Variable	Dependent Variable	
	σ_t (With GARCH)	σ_t (without GARCH)
π_0	-0.056903 (-0.013477)	2.995317 (1.266953)
σ_{t-1}	1.039021 (24.30655)	1.016784 (30.84171)
Statistics		
R- Squared	0.957896	0.959645
F- Statistics	168.5477	951.2114
D.W Statistics	1.941826	1.960440
Variance Equation		
ARCH (1)	-0.062311 (-6.481900)	
GARCH (1)	1.260841 (21.53850)	
ARCH LM TESTS	0.016683 (ρ= 0.8979)	

Note: z- values are in parenthesis ( )
Source: Author's Computation based on data from Central Bank of Nigeria Publications

The results obtained as shown in the *appendix G* can be interpreted noting that this is a Maximum Likelihood (ML) estimation results. Specifically, the main output from ARCH or GARCH estimation is divided into two sections- the upper part provides the standard output for the mean equation, while the lower part labeled "Variance Equation" contains the coefficients, standard errors, z- statistics and ρ- values for the coefficients of the variance equation.

From the glaring AR GARCH result presented in table 2, the t- statistic show that lagged (last year) exchange rate is significantly responsible for the dynamics of Naira/ Dollar exchange rate in Nigeria. The overall summary statistics is also glaring, thus, the R- squared of 0.959645 (95%) indicates that the model has a good fit for prediction and policy purposes.

The F- statistic shows overall significance of the model, while the Durbin- Watson statistic indicates the absence of serial autocorrelation in the model, whether positive or negative.

In this study, the sum of ARCH and the GARCH coefficients is used to capture the nature of volatility shocks over time. From our result, the sum of the ARCH and GARCH coefficients is not close to unity; this indicates that exchange rate volatility shocks are not quite persistent in Nigeria.

Further, to show the estimated relationship between the actual exchange rate and exchange rate uncertainty as proposed in equations (5) and (6), it is;

$\sigma_t =$ 3.450066 + 0.853518 σ_{t-1} + 1.676835 ¿$_t$ …………… (7)
(1.320226) (4.510929) (0.860538)
$R^2 =$ 0.958647
F- Statistic= 417.2723
D.W Statistic= 2.101687

¿$_t$ = -0.068057 + 0.358278 ¿$_{t\ t-1}$ + 0.059422 σ_t …………..… (8)
(-0.231190) (2.875713) (5.172988)
$R^2 =$ 0.946772
F- Statistic= 311.2759
D.W Statistic= 2.291710

In comparing between equations (7) and (8) above, it is obvious that exchange rate uncertainty has a direct relationship with current exchange rate in Nigeria. This is evidence, that consciousness of lack of knowledge about present exchange rate or future possibilities of changes in the exchange rate by economic agents will definitely influence the current exchange rate, than the previous exchange rate. The overall summary statistics (R^2, F- Statistic and D.W Statistic) are supportive.

The Granger Causality Test

A test of causality conducted is shown below;

Null Hypotheses	Probability
1. ¿$_t$ does not Granger Cause σ_t	0.0311*
2. σ_t does not Granger Cause ¿$_t$	0.0615

*Note: *Indicates significance at 5%*
Source: Author's Computation based on data from Central Bank of Nigeria Publications

We however conclude that exchange rate uncertainty *Granger* cause exchange rate in Nigeria. Inotherwords, the results show that the direction of causality is more powerful and significant from exchange rate uncertainty to actual exchange rate in Nigeria. This finding supports the results of equation (7) and (8).

5 Summary of Major Findings, Recommendations and Conclusion

In this research, we conduct a closer examination of exchange rate volatility in Nigeria with respect to both the fixed and flexible exchange rate regime. One of the frequent reasons as cited in literature for the adoption of flexible exchange rate policy is that it helps to correct balance of payments imbalances and its ability to accommodate unexpected domestic fluctuations. However, very few studies offer direct empirical evidence to support this view.

Inorder to capture the exchange rate volatility and the effects of exchange rate uncertainties that is associated to the actual exchange rate, we employed the maximum likelihood techniques.

We find evidence from the AR GARCH result that lagged (last year) exchange rate is significantly responsible for the dynamics of Naira/ Dollar exchange rate in Nigeria. The result shows that exchange rate volatility shocks are not quite persistent in Nigeria.

We also find that exchange rate uncertainty has a direct relationship with current exchange rate in Nigeria. Further, the Granger causality test conducted shows that the direction of causality is more powerful and significant from exchange rate uncertainty to actual exchange rate in Nigeria.

Recommendations

Based on our findings, the following recommendations are made;

1. There should be proper management of exchange rate, to forestall costly distortions in the Nigerian economy.

2. With hind-sight, nevertheless this study suggests that subsequent researchers should ascertain the determinants of exchange rate uncertainties.

3. It is plausible to recommend exchange rate targeting to the Nigerian monetary authorities.

4. It is important that monetary authorities ensure transparency in determining exchange rate process such that various economic distortions associated with exchange rate may be minimized.

Conclusion

Many researchers have argued that unanticipated foreign exchange rate may lead to balance of trade deficit, and therefore causes disequilibrium which is detrimental to achieving macroeconomic stabilization objectives. In this paper, we analyze exchange rate volatility in Nigeria between 1970 and 2010; we find evidence that *ceteris paribus* lagged exchange rate is significantly responsible for the dynamics of current exchange rate in Nigeria. This implies that prior information about exchange rate can be useful to ascertain the exchange rate at current time period. One clear conclusion which emerged from the granger causality analysis conducted is that the direction of causality is more powerful and significant from exchange rate uncertainty to actual exchange rate in Nigeria.

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APPENDIX B: AUGMENTED DICKEY- FULLER UNIT ROOT TEST ON EXCHANGE RATE

Null Hypothesis: D(σ) has a unit root				
Exogenous: Constant				
Lag Length: 0 (Automatic - based on SIC, maxlag=9)				
			t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic			-6.000661	0.0000
Test critical values:	1% level		-3.600987	
	5% level		-2.935001	
	10% level		-2.605836	
*MacKinnon (1996) one-sided p-values.				
Augmented Dickey-Fuller Test Equation				
Dependent Variable: D((σ_t,2)				
Method: Least Squares				
Date: 02/09/13 Time: 10:02				
Sample (adjusted): 1972 2012				
Included observations: 41 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(σ (-1))	-0.958892	0.159798	-6.000661	0.0000
C	3.669489	2.009968	1.825645	0.0756
R-squared	0.480055	Mean dependent var		0.087776
Adjusted R-squared	0.466723	S.D. dependent var		16.82897
S.E. of regression	12.28949	Akaike info criterion		7.902917
Sum squared resid	5890.235	Schwarz criterion		7.986506
Log likelihood	-160.0098	Hannan-Quinn criter.		7.933356
F-statistic	36.00793	Durbin-Watson stat		2.008326
Prob(F-statistic)	0.000001			

APPENDIX C:PHILLIPS- PERRON UNIT ROOT TEST ON EXCHANGE RATE

Null Hypothesis: D(σ) has a unit root				
Exogenous: Constant				
Bandwidth: 1 (Newey-West automatic) using Bartlett kernel				
			Adj. t-Stat	Prob.*
Phillips-Perron test statistic			-5.999641	0.0000
Test critical values:	1% level		-3.600987	
	5% level		-2.935001	
	10% level		-2.605836	
*MacKinnon (1996) one-sided p-values.				
Residual variance (no correction)				143.6643
HAC corrected variance (Bartlett kernel)				142.8975
Phillips-Perron Test Equation				
Dependent Variable: D(σ,2)				
Method: Least Squares				
Date: 02/09/13 Time: 10:05				
Sample (adjusted): 1972 2012				
Included observations: 41 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(σ (-1))	-0.958892	0.159798	-6.000661	0.0000
C	3.669489	2.009968	1.825645	0.0756
R-squared	0.480055	Mean dependent var		0.087776
Adjusted R-squared	0.466723	S.D. dependent var		16.82897
S.E. of regression	12.28949	Akaike info criterion		7.902917
Sum squared resid	5890.235	Schwarz criterion		7.986506
Log likelihood	-160.0098	Hannan-Quinn criter.		7.933356
F-statistic	36.00793	Durbin-Watson stat		2.008326
Prob(F-statistic)	0.000001			

APPENDIX D: AUGMENTED DICKEY- FULLER UNIT ROOT TEST ON EXCHANGE RATE UNCERTAINTY

Null Hypothesis: D(σ) has a unit root				
Exogenous: Constant				
Lag Length: 0 (Automatic - based on SIC, maxlag=9)				
			t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic			-5.984230	0.0000
Test critical values:	1% level		-3.621023	
	5% level		-2.943427	
	10% level		-2.610263	
*MacKinnon (1996) one-sided p-values.				
Augmented Dickey-Fuller Test Equation				
Dependent Variable: D(σ,2)				
Method: Least Squares				
Date: 02/09/13 Time: 17:34				
Sample (adjusted): 1976 2012				
Included observations: 37 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(σ (-1))	-1.012006	0.169112	-5.984230	0.0000
C	0.334765	0.301360	1.110846	0.2742
R-squared	0.505727	Mean dependent var		-0.004124
Adjusted R-squared	0.491604	S.D. dependent var		2.525105
S.E. of regression	1.800447	Akaike info criterion		4.066485
Sum squared resid	113.4563	Schwarz criterion		4.153562
Log likelihood	-73.22998	Hannan-Quinn criter.		4.097184
F-statistic	35.81101	Durbin-Watson stat		2.000061
Prob(F-statistic)	0.000001			

APPENDIX E: PHILLIPS- PERRON UNIT ROOT TEST ON EXCHANGE RATE UNCERTAINTY

Null Hypothesis: D(σ) has a unit root				
Exogenous: Constant				
Bandwidth: 2 (Newey-West automatic) using Bartlett kernel				
			Adj. t-Stat	Prob.*
Phillips-Perron test statistic			-5.983379	0.0000
Test critical values:	1% level		-3.621023	
	5% level		-2.943427	
	10% level		-2.610263	
*MacKinnon (1996) one-sided p-values.				
Residual variance (no correction)				3.066388
HAC corrected variance (Bartlett kernel)				2.953662
Phillips-Perron Test Equation				
Dependent Variable: D(σ,2)				
Method: Least Squares				
Date: 02/09/13 Time: 17:35				
Sample (adjusted): 1976 2012				
Included observations: 37 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(σ (-1))	-1.012006	0.169112	-5.984230	0.0000
C	0.334765	0.301360	1.110846	0.2742
R-squared	0.505727	Mean dependent var		-0.004124
Adjusted R-squared	0.491604	S.D. dependent var		2.525105
S.E. of regression	1.800447	Akaike info criterion		4.066485
Sum squared resid	113.4563	Schwarz criterion		4.153562
Log likelihood	-73.22998	Hannan-Quinn criter.		4.097184
F-statistic	35.81101	Durbin-Watson stat		2.000061
Prob(F-statistic)	0.000001			

APPENDIX F: AR RESULT

Dependent Variable: σ_t				
Method: Least Squares				
Date: 02/09/13 Time: 12:13				
Sample (adjusted): 1971 2012				
Included observations: 42 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
π_0	2.995317	2.364190	1.266953	0.2125
σ_{t-1}	1.016784	0.032968	30.84171	0.0000
R-squared	0.959645	Mean dependent var		47.59804
Adjusted R-squared	0.958636	S.D. dependent var		59.59678
S.E. of regression	12.12081	Akaike info criterion		7.874173
Sum squared resid	5876.561	Schwarz criterion		7.956919
Log likelihood	-163.3576	Hannan-Quinn criter.		7.904502
F-statistic	951.2114	Durbin-Watson stat		1.960440
Prob(F-statistic)	0.000000			

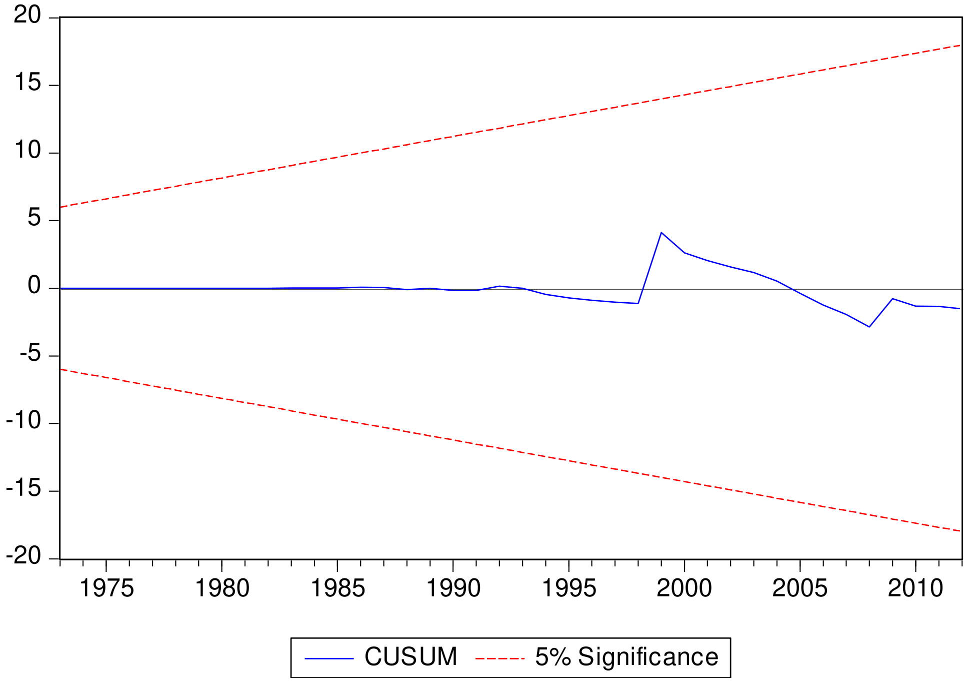
APPENDIX G: ESTIMATED AR GARCH RESULTS

Dependent Variable: EXR				
Method: ML - ARCH (Marquardt) - Normal distribution				
Date: 02/09/13 Time: 11:39				
Sample (adjusted): 1971 2012				
Included observations: 42 after adjustments				
Failure to improve Likelihood after 133 iterations				
Presample variance: backcast (parameter = 0.7)				
GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*GARCH(-1)				
Variable	Coefficient	Std. Error	z-Statistic	Prob.
π_0	-0.056903	4.222376	-0.013477	0.9892
μ_{t-1}^2	1.049585	0.043181	24.30655	0.0000
	Variance Equation			
C	0.067271	0.100505	0.669326	0.5033
RESID(-1)^2	-0.062311	0.009613	-6.481900	0.0000
GARCH(-1)	1.260841	0.058539	21.53850	0.0000
R-squared	0.957896	Mean dependent var		47.59804
Adjusted R-squared	0.956843	S.D. dependent var		59.59678
S.E. of regression	12.38075	Akaike info criterion		5.741360
Sum squared resid	6131.315	Schwarz criterion		5.948225
Log likelihood	-115.5686	Hannan-Quinn criter.		5.817184
Durbin-Watson stat	1.941826			

APPENDIX H: ARCH LM TEST

ARCH Test:				
F-statistic	0.016683	Prob. F(1,39)		0.8979
Obs*R-squared	0.017531	Prob. Chi-Square(1)		0.8947
Test Equation:				
Dependent Variable: WGT_RESID^2				
Method: Least Squares				
Date: 02/09/13 Time: 12:16				
Sample (adjusted): 1972 2012				
Included observations: 41 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.782403	0.488499	1.601647	0.1173
WGT_RESID^2(-1)	0.020675	0.160067	0.129163	0.8979
R-squared	0.000428	Mean dependent var		0.798880
Adjusted R-squared	-0.025202	S.D. dependent var		2.982038
S.E. of regression	3.019382	Akaike info criterion		5.095532
Sum squared resid	355.5500	Schwarz criterion		5.179121
Log likelihood	-102.4584	Hannan-Quinn criter.		5.125970
F-statistic	0.016683	Durbin-Watson stat		2.000083
Prob(F-statistic)	0.897893			

APPENDIX I: STABILITY TEST: CUSUM TEST



APPENDIX J: EXHANGE RATE AND EXCHANGE RATE UNCERTAINTY

Dependent Variable: σ_t				
Method: Least Squares				
Date: 02/09/13 Time: 13:00				
Sample (adjusted): 1974 2012				
Included observations: 39 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	3.450066	2.613239	1.320226	0.1951
σ_{t-1}	0.853518	0.189211	4.510929	0.0001
¿$_t$	1.676835	1.948589	0.860538	0.3952
R-squared	0.958647	Mean dependent var		51.20785
Adjusted R-squared	0.956349	S.D. dependent var		60.37341
S.E. of regression	12.61369	Akaike info criterion		7.981245
Sum squared resid	5727.782	Schwarz criterion		8.109212
Log likelihood	-152.6343	Hannan-Quinn criter.		8.027159
F-statistic	417.2723	Durbin-Watson stat		2.101687
Prob(F-statistic)	0.000000			

Dependent Variable: ¿$_t$				
Method: Least Squares				
Date: 02/09/13 Time: 13:04				
Sample (adjusted): 1975 2012				
Included observations: 38 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.068057	0.294377	-0.231190	0.8185
¿$_{t-1}$	0.358278	0.124588	2.875713	0.0068
σ_t	0.059422	0.011487	5.172988	0.0000
R-squared	0.946772	Mean dependent var		4.578952
Adjusted R-squared	0.943731	S.D. dependent var		5.688891
S.E. of regression	1.349471	Akaike info criterion		3.512959
Sum squared resid	63.73750	Schwarz criterion		3.642242
Log likelihood	-63.74622	Hannan-Quinn criter.		3.558957
F-statistic	311.2759	Durbin-Watson stat		2.291710
Prob(F-statistic)	0.000000			

APPENDIX K:CAUSALITY TEST

Pairwise Granger Causality Tests			
Date: 02/09/13 Time: 13:10			
Sample: 1970 2012			
Lags: 9			
Null Hypothesis:	Obs	F-Statistic	Prob.
¿$_t$ does not Granger Cause σ_t	31	3.22637	0.0311
σ_t does not Granger Cause ¿$_t$		2.61686	0.0615