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Modelling Volatility Persistence and Asymmetry of Naira-Yuan Exchange Rate

Abdulganiy G. Abdullahi[a*]

[a]*Department of Statistics, Faculty of Physical Sciences, Modibbo Adama University, Yola. Nigeria*

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ABSTRACT

This study investigates the impact of the Naira-Yuan Swap agreement on the stability, volatility, and potential symmetry and asymmetry of the Naira-Yuan/Renminbi exchange rate in the interbank market (Selling Rate) using daily data from January 2015 to November 2024. We employ the Augmented Dickey-Fuller (ADF) test and various asymmetric conditional volatility models, including Autoregressive Conditional Heteroscedasticity (ARCH), Generalized Autoregressive Conditional Heteroscedasticity (GARCH), GJR-GARCH, APARCH, and PARCH, to estimate the instability and variations in exchange rates across the market. Our findings indicate that persistence is generally explosive in the interbank rates under symmetric models. The symmetric GARCH model effectively captures the explosive nature of the series compared to the ARCH model, while the asymmetric PARCH (1,1) outperforms both the APARCH (1,1) and GJR-GARCH models. The GARCH model shows a coefficient of 1.0736334, indicating non-stationarity and explosiveness in the series regarding exchange rate volatility, whereas the asymmetric PARCH model, with a coefficient of -0.0451384, demonstrates superior performance in reflecting dynamics in leverage behavior. These results underscore the importance for monetary authorities to consider market developments and reactions to news, particularly in the Interbank Exchange Market, when formulating effective exchange rate policies for Nigeria. Understanding these dynamics is crucial for enhancing policy formulation and guiding investor decisions in the context of exchange rate volatility.

1. Introduction

A key issue that has attracted considerable attention in international economics is modelling the dynamics of exchange rate in an economy. In spite of the elaborate and detailed literature on volatility of the financial time series, there are still divergent views on the major causes of economic fluctuations in developing countries. Some studies in the literature have explained these fluctuations through the perspective of inflation and oil price volatility, volume of imports and exports (Nwangene & Akamobi, 2024; Ugoh, *et al*., 2023; Dogo & Aras, 2021; Fasanya & Adekoya, 2017). Fofanah (2021) and Isah and Ekeocha (2023) stated that exchange rates in Africa have been extremely volatile notably since the switch to the system of flexible exchange rate which had adverse effects on several macro-economic variables. Consequently, the official Naira Exchange rate was permitted to float in reference to other currencies, within a predetermine band, thus enabling the market forces of supply and demand to determine the band (Emanike, 2016).

The degree of exchange rate volatility in emerging markets, such as Nigerian market driven by a number of factors, the Chinese Yuan, the bilateral trade between the countries, domestic competition between United State dollar and Naira, as a major trading currency. In the last two decades, the volatility (spikes) between Naira and Dollar has been considerable high and often unrelated to economic fundamentals. This has prompted monetary authorities in most

* Corresponding author. Tel.: +2348056567594
E-mail address: ag.abdulganiy@mau.edu.ng (Abdulganiy G. Abdullahi)
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developing countries to intervene regularly in the markets with the objective of stabilizing the exchange rate. The recent swap agreement between Nigerian Government and People's Republic of China aim to reduce unnecessary pressure of the Dollar on Naira. However, such interventions are often done without any clear sense of a sustainable equilibrium. In addition, the interventions operate with lags and sometimes too late to forestall severe exchange rate misalignment and volatility. The natural reactions to these imbalances include economic fluctuations, protectionist trade pressures, and inevitably sharp exchange rate policy reversals. Indeed, the exchange rate instability experienced in Nigeria particularly between 2019 and 2024 exposed all these foregoing challenges.

The Nigerian economy aspires to be one of the biggest by the year 2020, according to the vision 2020. Instead, imports have increased more dramatically, China became Nigeria's largest import source in Q1, 2021, China was the country from which more goods and commodities were imported than from any other nation, including India, the Netherlands, the United States, and Russia. According to the Nigeria Bureau of Statistics (Oseni et al, 2023), China overtook the United States as Nigeria's top importer in the second quarter of 2021, accounting for more than 30% of the N6.95 trillion in total imports during that period. Prior to China becoming Nigeria's primary importer, the United States of America was the country from which Nigeria sourced the majority of her imports. All products imported into Nigeria were paid for in dollars, and all goods exported from Nigeria were paid for in dollars. Even after the Bretton Woods system collapsed in 1971(Oseni et al, 2023), which officially put an end to the gold standard, this method of payment has persisted for years. With each phase of exchange rate management (ERM) bringing its own potential issues, the Nigerian economy has been clearly enthusiastic.

In order to improve the administration of foreign reserves and simplify trade between China and Nigeria, the Central Bank of Nigeria (CBN) and the Peoples Bank of China (PBoC) inked a contract in May 2018. This agreement, also known as the currency SWAP, enables importers of goods from China to continue their commerce in Renminbi, commonly known as Yuan, rather than Naira to Dollar. Nigeria joined South Africa and Egypt as the third African nation to sign a similar contract with China. According to the agreement, Nigeria and China could exchange a total of 15 billion Renminbi, also known as Yuan, for N720 billion over the course of the next three years. Meanwhile, between 2020 and 2024, the Naira to Yuan exchange rate has been steadily rising. Prior to that, the exchange rate between the Naira and Yuan, popularly known as the Renminbi, had been static and somehow steady. However, an unusual rise in the Yuan to Naira in the exchange rate market was noted on the September,2020 which coincided with first possible structural break and the last was on the January 2024 which was the last Structural break, the naira to yuan exchange rate was about 45 NGN in January 2020 to 1 Yuan and by the first quarter of 2024 the exchange rate-which has been steadily growing over time was over 200NGN to 1 Yuan.

This agreement between the Nigerian monetary authorities and the Chinese comes despite the continued dominance of the dollar in Nigerian international transactions. The volume of trade between Nigeria and China has grown over the years. In 2020, Nigeria imported goods worth $17.4 billion from China, while exporting goods worth $2.54 billion (Observatory of Economic Complexity, 2020). Using the Chinese Yuan and Nigerian Naira to facilitate such volume of trade in direct exchanges will enable smoother trade between both countries. However, the volume of trade between Nigeria and the rest of the world is still largely denominated in US dollars. For example, in 2020, the total volume of Nigerian export was $35.63 billion while the total volume of import stood at $55.4 billion (Statista, 2020). If the imports from, and export to China is removed from this import and export figures, it is still a substantial amount. Thus, it is likely that the Naira-Dollar exchange rate will have a more enduring effect on economic growth in Nigeria than the Naira-Yuan exchange rate, given that the volume of trade conducted with the dollar is more than the with the Chinese yuan.

It is incontrovertible that economic activities in Nigeria rely mostly on imported luxurious finished goods, in addition to this, the average consumer has excessive preference for foreign goods due to product quality disparity. On the exports side, Nigeria's major export commodity is oil that is subject to deterministic concept of international market challenges and quota allocations. This has had a one-sided moderating impact on the flow of foreign exchange leading

to high exchange rate volatility over the years. In other words, exchange rate volatility in an import dependent economy may lead to huge losses or gains to government and domestic investors that engage frequently in foreign trade and hence are confronted with greater risk of uncertainty about the exchange rate, thus a gain for imported primary goods and in fact huge losses for imported luxurious goods. Thus, the extent of exchange rate volatility is of great importance to both the policy makers and investors.

The effect of exchange rate and economic growth in Nigeria has received a lot of attention from academic researchers throughout the years. While some studies found negative effects of exchange rate on economic growth (Ewubare and Ushei, 2022; Nwobia, Ogbonnaya and Okoye, 2020; Akinbode, Fapetu, Olabisi and Ojo, 2019; Ufoeze, Okuma, Nwakoby and Alajekwu, 2018; Abayomi, Adepoju and Aasa 2017; Adedoyin, Oluwafunke, Victor, and Asaleye, 2016), others found that exchange rate has a positive significance on economic growth (Shim, Kalemli-Ozcan and Liu, 2020). However, little to no research has been conducted on this topic, or has used the data of the Naira-Yuan exchange rate to assess the stability of Naira or establish the volatility in Naira-Yuan Exchange Rate in Nigeria since the gradual increase in the Naira to Yuan exchange rate and since China became Nigeria's top trading partner in 2021. Most, if not all, academics that studied how the dollar exchange rate affected Nigeria's economic growth used data on the dollar to Naira exchange rate to determine the connection between the two variables. The academic researchers have expressed their views and proposed solutions to the frequent depreciation of the Nigerian currency, aiming for its resurgence and a stable Naira-to-Dollar exchange rate that could strengthen the Nigerian economy. Hence, the study attempts to add to the growing body of literature in this area by estimating the extent to which each of the yuan-Naira variables affects the Nigerian economic growth. Oseni, Adefabi and Akpa(2023), Olowe (2009), Clement and Samuel (2011), Adeoye and Atanda (2013), Bala and Asemota (2013), Emenike and Peter (2016), Ajao and Igbekoyi (2013), Clement and Samuel (2011), and Musa and Abubakar (2014) have focused more on the official exchange rate markets. However, the main related study is that of Oseni et al (2023) which employed VEC to study the effect of Naira-Yuan and Yuan-Dollar, but the study doesn't consider the volatility in the series, quarterly data were used different from daily generated data, among other things. Specifically, this paper contributes to the literature on exchange rate in Nigeria in two main ways.

First, the stability of Naira-Yuan exchange rate is considered to study the performance of Naira against Yuan. Since the primary intention of the SWAP agreement between the two (Nigerian and China) countries is to stabilize the Naira value against Dollar. However, it is pertinent to establish the stability between Naira and Yuan before an extension study can be made about its performance impact against the Dollar, Secondly, persistent volatility of exchange rate is critical to the understanding of exchange rate behaviour in Nigeria and call for concern in exchange market. Also, the upward and downward movements of domestic currency against foreign currency (i.e. Naira/Yuan) in the foreign exchange markets over the years create more uncertainty for the players in the markets. A critical look at foreign exchange rate episodes in Nigeria from 2019 to late 2024 indicates that official market experienced significant shocks in terms of excessive demand pressure and speculative aggression from foreign exchange market participants which promote volatility in this market. The huge activities in the foreign exchange markets which official market failed to handle prompted the booming of unofficial foreign exchange market which has damning consequences on official rate fluctuations. This study considers legitimate official rate for better understanding of exchange rate to establish stability, volatility is necessary for efficient and effective policy formulation. In addition, the demand pressure was heightened in 2023 and 2024 after the introduction of Swap Agreement exchange rate regime. Thus, understanding and comparing the level of volatility persistence in these markets may shed more light on the challenges facing the foreign exchange markets as well as guide the investors in decision making particularly in their portfolio diversification.

The rest of this paper is organized as follows. Section two presents some reviewed work-facts on development in the foreign exchange market, section two contains a review of literature; section three contains the research methodology where we dealt with data issues and estimation technique; section four, discusses results while in section five conclude the study, with policy implications for Nigeria.

2. Review of Literature

2.1 Developments in the Foreign Exchange Market and Exchange Rate Movements in Nigeria

The management of the foreign exchange (forex) rate market in Nigeria has witnessed series of reforms which first led to a shift from a controlled ex-change rate to the Second-tier Exchange Market introduced in September 1986. As part of the reform, the Bureau de Change Foreign Exchange Market was introduced in 1989 purposely to deal with privately sourced foreign exchange. The introduction of this segment of the exchange rate market led to large volatility in the rates, thus prompting further reforms ranging from the formal pegging of the naira exchange rate to reaffirmation of the illegality of the parallel exchange rate market. By 1995, the Central Bank of Nigeria enhanced the sale of foreign exchange to end-users through the Autonomous Foreign Exchange Market. According to Moses-Ashike, 2023, the CBN declared intention to stop the subsidy by the year 2023 but the subsidy was not removed until early 2024 which consequentially witness the highest volatility that ever occur in exchange rate, thus this witnesses a surge in exchange rate from N449.0500, N899.8930 and N1,535.8176 for the 2022, 2023 and 2024 respectively.

2.2 The Purchasing Power Parity Theory (PPP)

The purchasing power parity (PPP) is one of the earliest and perhaps most widely used theories of exchange rates between two currencies, assuming the absence of trade barriers and transaction costs and the existence of the purchasing power parity (PPP). In its most basic form, the purchasing power parity (PPP) doctrine equates the equilibrium exchange rate with the ratio of domestic to foreign price levels (Lyon, 1992). If all countries produced the same tradable goods, the PPP doctrine would be equivalent to applying the law of one price. It is critical to understand that the PPP is a key component of the monetary approach. The purchasing power parity (PPP) between two currencies, as calculated by Gustav Cassel in 1998, is the amount of purchasing power. The relative version of the PPP doctrine relates the equilibrium exchange rate to the product of the exchange rate in a base period and the ratio of the country's price by definition, we have the related Purchasing power parity (PPP) (Lawal, et. al., 2016).

2.3 Optimal Currency Area Theory

The optimal currency area (OCA) theory, developed by Mundell (1961) and McKinnon (1963), is a framework for evaluating the costs and benefits of different exchange rate regimes. However, OCA has faced criticism for its inability to provide a clear recommendation for the optimal exchange rate regime. The reason for this is that the links between the nominal exchange rate regime and macroeconomic performance can both counterbalance and reinforce each other. For example, a fixed exchange rate regime can reduce exchange rate volatility, which lowers the cost of hedging against currency risk. Investment may be encouraged as businesses can plan more easily for the future. Additionally, a fixed exchange rate can lower the currency premium on interest rates, which can also make it cheaper for businesses to borrow money. All of these factors can lead to increased trade and output growth. However, a fixed exchange rate can also make it difficult for a country to adjust its currency in response to changes in economic conditions. This can lead to trade imbalances and ultimately reduce economic growth (Akpan and Atan, 2011).

2.4 Empirical Literature

The modelling of exchange rate volatility has increasingly gained prominence in the international economics literature in recent years and a number of factors have been attributed to this development. First is the availability of high frequency exchange rate series, which provides robust evidence for the presence of statistically weighty correlations between series. Secondly, high frequency data on exchange rate creates the possibility of time varying volatility which is popularly known as conditional heteroscedasticity (Harris and Sollis, 2004). Oseni et al, (2023) in their study observed that innovations to the dollar-naira exchange rate causes a cyclical response in economic growth rate across the forecast horizon. There is more cyclicality in economic growth than in the dollar-naira exchange rate.

The effect of shock to the yuan-naira exchange rate dies faster than that of the dollar-naira exchange rate and in the first quarter, about 2 percent of the forecast error in RGDP is explained by the dollar-naira exchange rate, in the first quarter, about 0.8 percent of the forecast error in RGDP is explained by the yuan-naira exchange rate. The policy implication of the is that Nigeria should prioritize the stability of the dollar-naira exchange rate given that the dollar-naira exchange rate has more effects on the country's economic growth using VAR.

In Nigeria, a number of studies have attempted to model exchange rate volatility. A notable work in this regard is Adeoye and Atanda (2012). The study revealed the presence of overshooting volatility shocks. However, the study did not account for asymmetric impacts in the model. This is because the ARCH and GARCH framework only account for symmetric impacts and shocks in a model. Further, Bala and Asemota (2013) in their paper on modelling exchange rate volatility in Nigeria, argued that asymmetric impacts and shocks are important when dealing with high frequency data. Therefore, evaluating the presence of asymmetric shocks on exchange rate is very pertinent to investors and policy makers. In their paper, Atoi and Nkwede (2017) examined asymmetric analysis of exchange rates volatility in Nigeria using three segments of the Nigerian foreign exchange market, namely; (Inter-bank Foreign Exchange Market (IFEM), Bureau de Change and Wholesale Dutch Auction System (WDAS). The authors employed Asymmetric Thresh-old Generalized Autoregressive Conditional Heteroscedasticity (TGARCH) and their results showed that there was persistence of exchange rate volatility in all markets. They found that interbank exchange rate volatility was persistent and explosive compared to the other two markets. Similarly, Musa and Abubakar (2014) employed different approaches such as GARCH, GJR-GARCH, TGARCH and TS-GARCH and found the persistence of exchange rate volatility and non-existence of leverage effect.

This present study recognizes that some studies have captured both the symmetric and asymmetric effects on Naira-Dollar and Naira-Dollar-Yuan exchange rates in Nigeria. However, such works did not consider a single currency studies and those that consider single currency differ in methodology and approach. This particular study examines the stability of Naira effect of Naira-Yaun after the Swap agreement on official exchange market in Nigeria and model for Naira-Yuan Exchange Rate. Thus, to complement results from the previous studies, we examine this stability to provide better insight to investors and policy makers since they also engage in buying and selling of currencies in market and inform the government on the policy framework to enhance the swap agreement. In addition, this paper considered the plausible effects of the presence of without multiple breaks of the series in the analysis. This study therefore, fills this gap by attempting to model exchange rate volatility persistence in symmetry and asymmetry in the SellingRate; Naira-Yuan interbank exchange rate markets using the ARCH, GARCH, GJR-GARCH, TGARCH, PARCH, APARCH, TARCH, EARCH, TARCH AND EGARCH frame-works.

3. Research Methodology

3.1 Research design

Ex-post facto research design was used in this study. It used secondary data, in which the researcher has no direct control over the variable involved, and the issue investigated is based on already-completed events that examine the relationship between exchange rate and economic growth over time. The secondary data used is thought to be the most suitable for the variables to be used in this research study, it spans the period 2019–2024 daily data, and data filter was carried out. The study focuses on the Nigerian currency's naira stability against yuan with a data span of 5 years. The data used was sourced from the Central Bank of Nigeria (CBN) statistical bulletin 2024 and data filter was done to correct a mis-specified data point.

3.2 Data sources and construction

The daily interbank naira-yuan exchange rates data obtain from CBN will be utilized in this study were collected on interbank market (official market rate). The data cover the above stated period were obtained from Central Bank of Nigeria (CBN) online database. Thus, as a standard precondition in the literature for dealing with volatile

financial series, the pre-estimation analysis is done in three stages: the first provides descriptive statistics for the exchange rate considered; the second tests for stationarity/stability in the series; while the third tests for potential heteroscedasticity feature of the series using ARCH LM test.

A time series exhibiting conditional heteroscedasticity-or autocorrelation in the squared series is said to have autoregressive conditional heteroskedastic (ARCH) effects. To test the probable existence of ARCH effects in the respective interbank exchange rate series under consideration, we explore the ARCH Lagrangian Multiplier (LM) test procedure developed by Engle (1982) which begins with a univariate model as specified below:

$$\tau_t = \lambda + \sum_{i}^{k} \delta \tau_{t-i} + \varepsilon_i; \quad i = 1,...,k, t = 1,...,\mathrm{T} \tag{1}$$

$$and\ \varepsilon_i \sim iid(0, \sigma^2); |\delta t| < 1$$

where τ_t denote exchange rate returns and is measured in this paper as:

Yuan = 100 [log(SellingRate)] (2)

where Yuan in equation (2) denotes the sellingRate, Interbank Naira-Yuan official exchange rate and is a first difference operator.

In this section, we consider different plausible symmetric and asymmetric GARCH modeling frameworks to capture volatility and persistence in the Naira-Yuan interbank exchange rate markets. Starting with the ARCH model, which is suitable for modelling volatility clustering around the mean error when effect of past shocks decays quickly as display in correlogram

$$\sigma_t^2 = \omega + \sum_{i=1}^{q} \alpha_i \varepsilon_{t-1}^2 \tag{3}$$

where:

σ_t^2 = Conditional variance

ε_t =Residual at time t

ω =Constant term

α_i =Coefficients for lag squared

We consider symmetric GARCH and GJR-GARCH model, our mean equation following the standard GARCH (1, 1) procedure is as follow:

$$\tau_t = \eta + \delta \tau_{t-1} + \alpha_1 D_{1,t} + \alpha_2 D_{2,t} + \varepsilon_t \tag{4}$$

where τ_t represents the returns on interbank exchange rates, Di;t = 1ift SellingRatei and zero otherwise; SerialNo i (i = 1;2) denote the selected break dates. Given that " $\varepsilon_t = \sigma_t e_t$ and e_t (0,1). However, while the mean equation (5) is applicable to all the models used in this research paper, the variance for the GARCH(1,1) model can be expressed as:

$$\sigma_t^2 = \omega + \alpha_i \varepsilon_{t-1}^2 + \gamma \sigma_{t-1}^2; \quad \alpha > 0, \beta \geq 0, \gamma \geq 0 \tag{5}$$

Equation (5) typically expresses the conditional-variance dependent on information about volatility observed in the previous period (the ARCH term," ε_{t-1}^2) and forecasted variance from last period (the GARCH term, σ_{t-1}^2)

The persistence of σ_t^2 is captured by $\alpha + \gamma$ and covariance stationarity requires that $\alpha + \gamma < 1$.The model is consistent with volatility clustering where large changes in returns are likely to be followed by further large changes and small values of variance from last period will be followed by small values of conditional variance in current period (Mandelbrot, 1963). The GARCH model captures persistent volatility clustering and is more parsimonious when compared with ARCH. The pattern of the volatility clustering may vary if bad and good news are received. Zivot (2008) argued that the signs of the residuals or shocks have no effect on conditional volatility in the basic GARCH model because the observed volatility in the previous period enters in squared value. The study also noted the fact that bad news (negative shocks) tends to have a larger impact on volatility than good news (positive shocks) of the same magnitude. In other words, volatility tends to be higher with negative shocks than with positive shocks. Black (1976) inferred that this effect increases the leverage effect and causes more volatility. Based on this conjecture, the asymmetric news impact on volatility is commonly referred to as the leverage effect. This asymmetric effects is demonstrated in this study with the use of PARCH(1,1),APARCH,TARCH and TGARCH(1,1),GJRARCH, after a flat likelihood was encountered in EGARCH.

The TGARCH model is a modification of equation (5) by the inclusion of the dummy variable It.

$$\sigma_{t-1}^2 = \alpha + \beta \varepsilon_{t-1}^2 + \gamma \sigma_{t-1}^2 + \psi \varepsilon_{t-1}^2 \mathrm{I}_{t-1} \tag{6}$$

where I_t, I = 1 if t 1 > 0 and 0 otherwise. Hence, there is evidence of asymmetric effect if $\psi < 0$ which implies that positive shocks reduce the volatility of τ_t by more than negative shocks of the same magnitude and likewise if $\psi > 0$ which implies that negative shocks reduce the volatility of τ_t by more than positive shocks of the same magnitude.

The TARCH model, which assumed that volatility responds to both socks with threshold effect in this paper is specified as

$$\sigma_t^2 = \omega + \sum_{i=1}^{q} \alpha_i \varepsilon_{t-i}^2 + \sum_{i=1}^{q} \gamma_i \, \varepsilon_{t-i}^2 \mathrm{I}_{t-i} + \sum_{j=1}^{p} \beta_j \, \sigma_{t-j}^{\delta} \tag{7}$$

where:

γ_i is asymmetry parameter, (-1< γ_i <1)

I_{t-i} is an indicator function with condition equals 1 if $\varepsilon_{t-1} < 0$ and 0 otherwise

The Power Arch, PARCH asymmetric model volatility using a power transformation of absolute residuals, particularly when the shocks are not necessarily quadratic and its specification follows

$$\sigma_t^2 = \omega + \sum_{i=1}^{q} \alpha_i \left(|\varepsilon_{t-i}| - \gamma_i \varepsilon_{t-i} \right)^{\delta} + \sum_{j=1}^{p} \beta_j \sigma_{t-j}^{\delta} \tag{8}$$

where:

δ is the power parameter

γ_i is asymmetry parameter, (-1< γ_i <1)

The EARCH model, which generalizes EARCH allows for the logarithm modelling of the conditional variance instead of variance itself and also allows more flexible modelling and avoids the needs for non-negative constraints on the coefficient asymmetry and is given by:

$$\ln(\sigma_t^2) = \omega + \sum_{i=1}^{p} \alpha_i g\left(\varepsilon_{t-i}\right) + \sum_{j=1}^{q} \beta_j \ln(\sigma_{t-j}^2)$$

where:

σ^2 is the conditional variance at time t

ε_t is residual shock at time t

ω is the constant term

α_i is the coefficients for the function of lagged residuals

β_j is the coefficients for lagged log conditional variance

4. Analysis and Discussion of Results

4.1 Descriptive statistics

Table 1 below presents the descriptive statistics for the interbank exchange rate returns in the Exchange Rate Market covering the entire period under investigation. There appears to be evidence of significant spikes and fluctuations in exchange rate as shown by the large difference between the minimum and maximum values of the official market values. On the statistical distribution of official exchange rate, the rate shows evidence of positive skewness for all the sample period, suggesting that the right tail was predominant. In relation to kurtosis, the rate shows leptokurtic of the official exchange rate. Lastly, the study discovered that Naira-Yuan exchange rate is not normally distributed in the official rate, judging by the Jarque Bera (JB) statistic, which invariably suggested for the presence of volatilities and spikes in the series.

Table 1: Descriptive Statistics of Interbank Market Exchange Rate

Descriptive Statistics	SellingRate/Interbank Rate
Mean	91.20352
Median	64.1085
Maximum	232.6871
Minimum	24.997
Std. Dev	56.56012
Skewness	1.530944
Kurtosis	3.818504
Jarque-Bera (prob)	495.6
Observations	1,184

An analysis of the trend of the exchange rate in the selling Rate markets in Nigeria is presented in Figures 1. Figure 1 depicts the trends of returns in the interbank exchange rate market and the underlying data. The trajectory of Figure 1 presents an apt picture of instability of exchange rate. The Figure portends traits of volatility clustering; the period begins with little spike, then followed by low volatility, then spikes, then periods of high volatility shadowed by that of relatively low volatility and continue in this trend. This reflection supports the evidence in Table 1 thus demonstrating that volatility is highest in late 2023 and around 2024 which coincided with the sluggish global financial crises recovery from covid 19 and the fall in global oil price that affected the Nigerian economy. Indeed, as a consequence of the structure of the economy that aims at diversifying from dependent mainly on crude oil for foreign exchange to non-oil dependent economy.

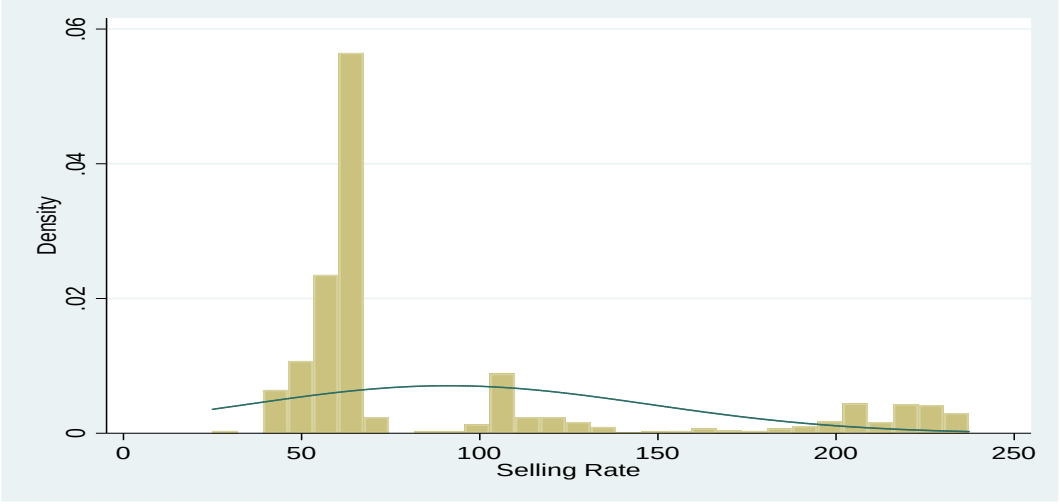

Figure1: Histogram (Platonic) dipcting SellingRate of Interbank Exchange Rate

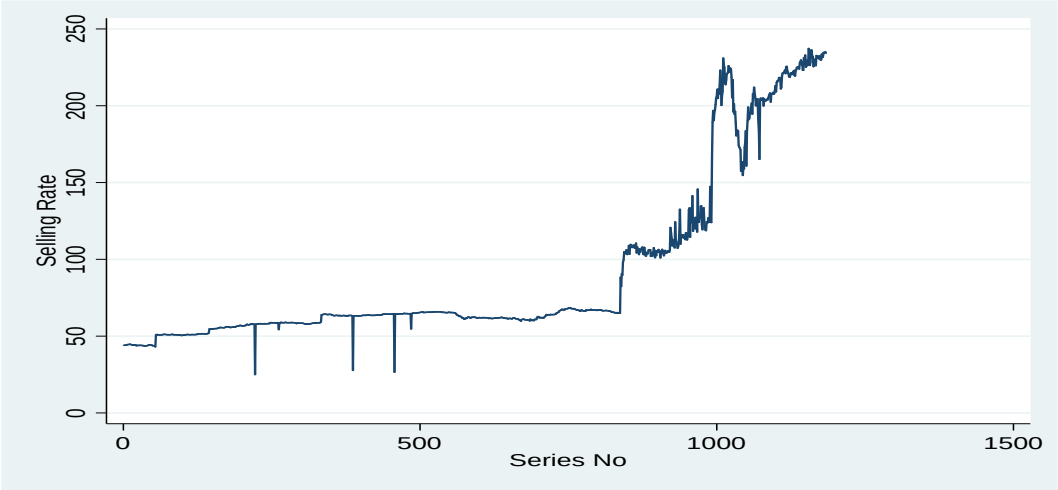

Figure 2: Graph of Naira_Yuan Interbank Exchange Rate Returns

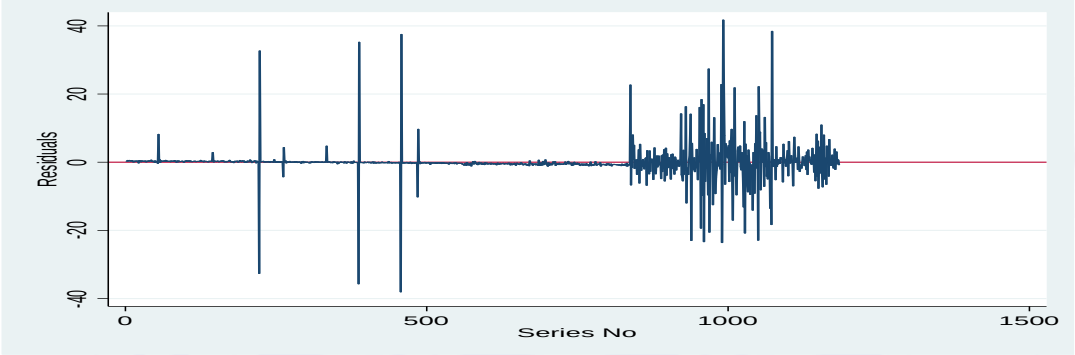

Figure 3 Unit Root:shows the plot of Residuals around the mean error

The graph shows a little cyclic decay at the beginning follow by a spike and so for a while until towards the last series that display spikes and decays successfully

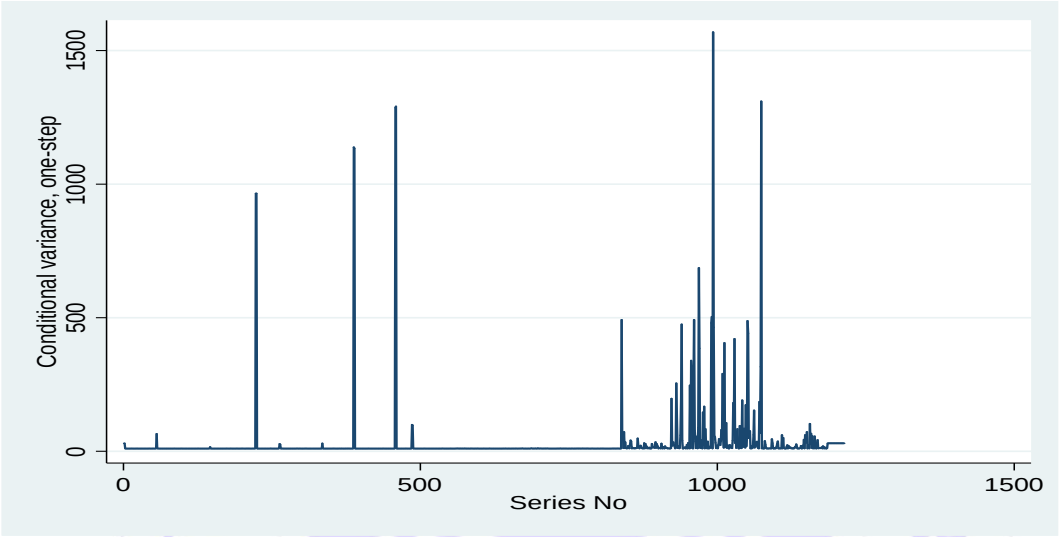

Figure 4: Graph of Conditional Variance of Naira-Yaun Interbank Exchange Rate Returns

Figure 4 shows the dynamics of volatility and how the conditional variance behaves during the period considered of interbank exchange market and its underlying data. It that the errors are not constant and hence non-normality of the Naira-Yuan interbank data.

4.2 ARCH LM test

Cameron & Trivedi's decomposition of the LM-test in Table 2 clearly shows all three diagnostic components—heteroskedasticity, skewness, and kurtosis are highly statistically significant ($p < 0.0001$), indicating strong violations of core model assumptions. Specifically, the heteroskedasticity component ($\chi^2 = 606.94$, $df = 2$) suggests that the error variances differ across observations; the skewness component ($\chi^2 = 405.44$, $df = 1$) reveals substantial asymmetry in the residual distribution; and the kurtosis component ($\chi^2 = 68.46$, $df = 1$) indicates non-normal tail behavior likely heavy tails or peakedness.

Table 2: Cameron & Trivedi's Decomposition of LM-test

Source	Ch-square	df	P-value
Heteroskedasticity	606.94	2	0.0000
Skewness	405.44	1	0.0000
Kurtosis	68.46	1	0.0000

Table 3: Choosing optimum Lag for Arch and Garch Models

Lag	LL	LR	d.f	p	**FPE**	**AIC**	**HIC**	SBIC
0	-3493.33				21.9713	5.92762	5.92924	5.93192
1	-3427.06	132.54	1	0.0000	19.6685	5.81689	5.82014	5.8255
2	-3414.86	24.397	1	0.0000	19.2984	19.2984	5.80276	5.81081
3	-3408.42	12.882*	1	0.0000	19.1211*	5.78867*	5.79516*	5.80588*
4	-3408.17	.50218	1	0.479	19.1454	5.78994	5.79805	5.81145

In Table 3, the lag order increases from 0 to 3, the log-likelihood (LL) improves substantially, and the likelihood-ratio (LR) tests remain highly significant (p = 0.0000), confirming that each additional lag up to 3 enhances model fit. Information criteria, Final Prediction Error (FPE), Akaike (AIC), Hannan-Quinn (HIC), and Schwarz-Bayesian (SBIC), all decline to their lowest values at lag 3, striking the optimal trade-off between fit and complexity, and signaling the best specification. At lag 4, both the LR test becomes non-significant (p = 0.479) and the criteria slightly worsen, suggesting that further lags add unnecessary complexity without meaningful gains. Therefore, lag 3 is the well-supported optimal ARCH/GARCH lag length. This aligns with standard model-selection practices that favor the lag minimizing these criteria.

Essentially, Engle (1982) proposes three steps for the implementation of ARCH test: the first step is to estimate equation (3) by OLS and obtain the fitted residuals; the second step is to regress the square of the fitted residuals on constant and lags of the squared residuals, i.e., estimate equation (9) below:

$$\hat{\varepsilon}_t^2 = \rho_0 + \rho_1 \hat{\varepsilon}_{t-1}^2 + \rho_2 \hat{\varepsilon}_{t-2}^2 + ... + \rho_p \hat{\varepsilon}_{t-p}^2 + \mu_t \tag{9}$$

and the third and final step is to use the LM test option to evaluate the validity or otherwise of the null hypothesis of no ARCH effects,

H_0: $\rho_1 = \rho_2 = \ldots = \rho_p = 0$

Table 4: ARCH LM test results for autoregressive conditional heteroskedasticity (ARCH)

lags(p)	chi2	df	Prob > chi2
1	183.421	1	0.0000
2	192.702	2	0.0000
3	207.972	3	0.0000
4	211.844	4	0.0000
5	212.196	5	0.0000

The ARCH Lagrange Multiplier test results in Table 4 show that, at every tested lag (1–5), the chi-square statistic is highly significant (p = 0.0000), with values rising from 183.42 at lag 1 to 212.20 at lag 5. This consistent significance across lags indicates strong evidence against the null hypothesis of no ARCH effects meaning that the variance of residuals depends on past squared residuals. Such clear ARCH effects suggest the presence of volatility clustering, and that modeling using ARCH or GARCH specifications is appropriate to accurately capture the time-varying conditional heteroskedasticity in the series.

Table 5: Choosing optimum for ARCH and GARCH Models

Model	Obs	ll(null)	ll(model)	d.f	**AIC**	BIC	C,Arch **FPE**
ARCH1	1,183		-3216.493	4	6440.987	6461.29	0.2593348
ARCH 2	1,183		-3386.144	4	6780.288	6800.592	0.2124179
ARCH 3	1,183		-3361.211	4	6730.422	6750.726	0.1690632

The Table 5 presents three competing ARCH models (orders 1–3) estimated over 1,183 observations, showing that ARCH(3) yields the highest log-likelihood (–3361.21), lowest information criteria (AIC = 6730.422, BIC = 6750.726), and the lowest FPE among them indicating the best balance of model fit and parsimony. In model selection, lower AIC/BIC signifies a preferable model, particularly when these criteria reach their minima. Thus, ARCH(3) is supported as the optimal specification in this set for capturing conditional heteroskedasticity.

Table 6.1 Selection Criterion for Estimation results of Asymmetry Volatility Models without structural Breaks for interbank

Models	II(Model)	df	Std error	AIC	BIC
GJR-ARCH	**-3214.087**	1	1.645018	6438.175	6463.554
APARCH	-3079.341	1	1.650261	6170.714	6201.169
PARCH	-3055.648	1	**1.653754**	**6121.296**	**6146.675**

Table 6.2: Estimation results of symmetry Volatility Models without structural Breaks for interbank

MODELS	II(Null)	II(Model)	df	Std error	AIC	BIC
GARCH	-6452.038	‘’	1	**1.644674**	**12906.08**	**12911.15**
ARCH	-6452.546	‘’	1	1.645382	12907.09	12912.17

Table 6.3 Coefficients of Selected Model for symmetric and asymmetric models

	Selected Model	Coefficients	Model Type
1	GARCH	1.0736334	Symmetry
2	PARCH	-0.0451384	Asymmetry

In comparing the volatility models without structural breaks for interbank data:

i. **Asymmetric models (Table 6.1)**: All three—GJR-ARCH, APARCH, and PARCH—outperform in terms of information criteria, with the **PARCH model** yielding the highest log-likelihood (II(Model) = –3055.65), along with the lowest AIC (6121.30) and BIC (6146.68), indicating the best fit among asymmetric specifications.

ii. **Symmetric models (Table 6.2)**: The GARCH and ARCH models perform nearly identically in log-likelihood and standard errors, with GARCH slightly better in AIC (12906.08 vs. 12907.09) and BIC (12911.15 vs. 12912.17), making GARCH the preferred symmetric model.

iii. **Selected models (Table 6.3)**: Highlighting the top performers—**GARCH** for symmetry (coefficient = 1.0736) and **PARCH** for asymmetry (coefficient = –0.0451)—it appears the PARCH model’s lower AIC/BIC and superior fit mark it as the overall best choice, particularly when asymmetry in volatility is expected.

4.3 Discussion of Results

Volatility persistence and asymmetry of interbank exchange rate without structural breaks in the interbank exchange rate market as shown in Table 6.3 indicates moderate to high persistence particularly in the GARCH (1.0736334) and PARCH (-0.0451384) models. The GARCH symmetric model has a persistence of 1.07, which suggests an explosive persistence. However, on the whole, the results suggest that the interbank exchange rate market is more persistent than the interbank exchange rate market. In terms of the performance of the volatility models, the symmetric model, GARCH(1,1) and asymmetric PARCH(1,1) model proved to have a better t based on the SIC value. This indicates that participants in the interbank foreign exchange market do not respond to news differently.

In summary, the GARCH provides better insight into the impact of news on the exchange rate returns volatility in the interbank market rate/SellingRate. The results may not be unsurprising based on the structure of the market. These results further confirm the responses of the markets to news and indeed, to market forces as determined by the

participants. The interbank market is adjudged more market driven, hence its ostensible asymmetric reaction to news.

As a follow up to the pre-estimation test that confirms the presence of ARCH effects in the foreign exchange markets, the study also provides post-estimation diagnostic test using the F-test. Adjudging by the probability values of the models in the interbank market, we reject the null hypothesis of no ARCH effects in the interbank market (with and without structural breaks). All the values were statistically significant at 5% and 1% levels of significance.

5. Conclusion and Policy Implications

The specific objective of this study is to investigate the stability of Naira to Yuan and model volatility persistence and leverages in symmetry and asymmetry of Naira-Yuan exchange rates respectively in the Interbank market rates (SellingRate) using daily data between January 2019 and November 2024. The essence of volatility in exchange rate is to provide useful information to participants in the official interbank market with respect to uncertainty or risk in the market. The investors are more interested in the stability of exchange rate before investing in the host country, while the government is expecting the Naira-Yuan stability to equally stabilize the Naira-Dollar value. However, it was established the Naira-Yuan is not stable and hence may not be able to stabilize the Naira-Dollar (Augment Dickey Fouler Test). The implication of fluctuation in the exchange rate suggests huge losses (gains) to the investors and thus, low return on investment may be detrimental to both investors and economy as a whole (the presence of Arch effect was established). For the profit maximizing and risk aversion measures to the Government/agents/investors, the occurrence of high volatility persistence may shape the investment decision in the area of portfolio diversification to less risky assets. Therefore, modelling volatility persistence, symmetry and asymmetry is critical to policymakers and thus motivating the study. The contribution of this paper is three-folds. First, we employed Augmented Dickey Fouler to establish the instability in the series of interbank rate, Secondly, we augmented for the latter in both symmetric and asymmetric models without structural breaks.

Based on our model selection criteria without Structural breaks consideration, the symmetric GARCH model, appeared to better capture the persistence in the explosive that are due to positive shocks in exchange rate volatility than the ARCH. Also the asymmetric PARCH appeared to perform better than APARCH and GJR-ARCH in displaying the leverages effects (reactions to negative shocks) of volatility in the interbank market without structural breaks, thus findings revealed evidence of asymmetric effects in the market. The estimation without structural breaks places low emphasis on the cause of sudden explosion in the series and can quickly chat away for an immediate intervention to economic problems, however, it may not be good in a situation where such root causes of such structural breaks are important. In a situation where structural breaks are captured, the models are largely moderated after the shocks (i.e. structural breaks) in the series results and tend to suggest the need to account for market differences when designing appropriate exchange rate policies for the country as the market participants respond differently to developments in the markets. This may go a long way in aligning the exchange rate in the interbank market for proper investment decision making and policy formulation that best capture the shifts in volatility dynamics and improve the model accuracy.

In addition, the persistence in the interbank market without structural breaks was observed, particularly the explosive GARCH appears to be better than the ARCH, while PARCH asymmetric performs better than GJR-ARCH and APARCH. However, the accurate prediction may largely be moderated after the shocks (i.e. structural breaks) are considered as one of the natural features of the underlying interbank exchange rate data.

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