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Variance, Estimation Intervals and Foreign Exchange Market: COVID-19 Induced Evidence from Nigeria

Chukwu Agwu Ejem[1], Maxwell Onyemachi Ogbulu[2]
Department of Banking and Finance, Abia State University, P.M.B. 2000, Uturu, Nigeria.
* E-mail of the corresponding author: ecjah71@yahoo.com

Abstract
The position of Nigeria in the comity of Nations, mostly as an oil exporting nation, makes it imperative to ascertain exchange rate risk amidst economic vagaries such as the COVID-19 pandemic ravaging the country and the world at large. For that, this study is conceived to examine the relationship between Conditional Variance and Exchange rate Market amidst COVID-19 pandemic ravaging the entire globe with emphasis in Nigeria using different estimation intervals (daily, weekly, and monthly) of exchange rate price computed from the exchange rate between the United State of America Dollars and the Nigeria Naira sourced from the Central Bank of Nigeria Statistical bulletin. ARCH, GARCH and EGARCH were employed for the analysis of secondary data collected from the Central Bank of Nigeria Statistical bulletin. For strong inferences, adequate comparison and concrete policy recommendations that will guide investors and other economic agents, the scope of this study is dissected into two periods; period preceding the outbreak of COVID-19 pandemic (pre-COVID-19 period) in Nigeria (February 26, 2018, to February 26, 2020) and two years into the pandemic (COVID-19 period) (February 27, 2020, to February 27, 2022) inclusive. In the pre-COVID-19 period, it was discovered that high volatility heralded the exchange rate market. The asymmetry parameter was found to be positive and significant level for both daily and weekly exchange rates, suggesting presence of leverage effects in the foreign exchange market in Nigeria within the scope of the study. It was also found that the conditional volatility (capturing the exchange rate-volatility relationship) for the daily exchange rate was negative and significant, while insignificant on a weekly basis. This shows that investors or speculators in the foreign exchange market are not adequately rewarded for taking additional risks in the pre-COVID-19 period. The persistent parameter was found to be significant for all the intervals, suggesting volatility in exchange rate price between Naira and US Dollar is persistent in the pre- COVID-19 period in Nigeria. It was also found that in the COVID-9 period there is a significant relationship between the price series and their lagged values, indicating that historical exchange rate prices on daily interval could be used to predict current and future prices in the foreign exchange market. It is suggested that the Central Bank of Nigeria initiates measures to forestall the persistent rise in the price of exchange rate experienced in COVID-19 period which has made the exchange movement become volatile and predictable. If such measures are taken, it will restore the evaporated trust and confidence in the foreign exchange market. This study has theoretical and practical implications for exchange rate management in Nigeria.

Keywords: Exchange rate price, COVID-19 pandemic, Volatility Modelling, Purchasing Power Parity, ARCH family, Nigeria.
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I. Introduction

Exchange rate risk is seen as the likelihood of variability in price due to the tendency that the currency of a nation in which the economy operates may dwindle in the value relative to currencies of other trading nations. This volatility in the price may be as result of difficulty of limited convertibility occasioned by economic vagaries such as the COVID-19 pandemic ravaging Nigeria and the world at large. Such volatility in the exchange rate price is worth investigating in a moment like this. Exchange rate volatility modelling has continuously become prominent in recent scholarly literatures, mostly now the COVID-19 pandemic is distorting the world economy like a tsunami. In Nigeria, investors believe that increase in the number of confirmed COVID-19 cases will further intensify exchange rate volatility. As result, the need to examine the volatility of exchange rate is to negate the fears of major players or speculators in the market due to their consciousness that fluctuations in the exchange rates signal huge gains or losses emanating from exchange rate misalignment in countries operating monolithic economy as perceived in Nigeria, as such heading to economic uncertainties. (Harris & Sollis, 2005; Salisu & Fasanya, 2012; Oyinlola, 2018). Besides, exchange rate volatility exposes investors to quagmire of uncertainty which result to

huge gains or losses from such venture, thus COVID-19 has negatively affected exchange rate (Pasiouras & Daglis, 2020; Devpura, 2021). Havva, (2021) is of the opinion that forecasting of information on exchange rate volatility is useful for asset pricing and risk management since exchange rate volatility has the tendency to amplify transaction costs and reduce gains in international trade, mostly daily exchange rate returns amidst the COVID-19 pandemic.

However, the foreign exchange market is generally seen as a market in which individuals, firms and banks purchase and sell foreign currencies or foreign exchange. It is the mechanism, institutional arrangement through which foreign currencies, futures and options are traded (Ezirim, 2005). The main function of the foreign exchange markets is the transfer of funds or purchasing power from one nation and currency to another (Ejem & Jombo, 2011). The market offers facilities for determination of realistic exchange rates among currencies of different nations in a bid to assist the flow mechanism of such currencies among participants of concerned nations, alongside settlement of international account. This is usually aided by electronic fund transfer media. Before now, it was mainly accomplished by telegraphic transfer, which is a cheque that is wired rather than mailed. With this, a domestic bank instructs its correspondent bank in a foreign monetary centre to pay a specified amount of the local currency to a person, firm, or account. The innovations like direct dialing telephone or electronic mail services anywhere in the world, the telex has become relatively less important (Salvatore, 2004; Ezirim, 2005).

The rate of exchange in the foreign exchange market is determined by the quantity of a local currency (say Nigerian Naira) that is required to purchase a foreign currency (say United State America (USA) Dollar) (Salvatore, 2004; Ejem & Jombo, 2011). In a market driven economy, it is determined by the forces of demand and supply, where both the buyer and seller will always agree to sell at the rate which clears the market for foreign exchange, that is the equilibrium rate (the rate the demand for foreign currency equals the supply of foreign currency) (Ejem & Jombo, 2011). If a nation's total demand for foreign exchange during foreign transactions exceeds its total foreign exchange earnings, the rate at which currencies exchange for one another will have to change to equilibrate the total quantities demanded and supplied. If such an adjustment in the exchange rates were not permitted, the nation's commercial banks would have to borrow from the nation's central bank. The Central Bank of Nigeria (CBN) for instance would then act as the lender of last resort and draw down its foreign exchange reserve (a balance of payment deficit for the reporting nation). Conversely, if the nation generated an excess supply of foreign exchange during its business transactions with other nations and the adjustment in exchange rates were disallowed; the excess supply would be exchanged for the national currency at the nation's central bank, thereby increasing the nation's foreign currency reserves (a balance of payment surplus for the reporting nation) (Salvatore, 2004).

1.2 Statement of the Problem

The economic, social and health effects of the COVID-19 pandemic as it continues to spread across the world with the dynamics of exchange rates is a matter of concern to scholars and policy makers. Theoretical and empirical analysts are yet to confirm the impact of COVID-19 pandemic on exchange rate volatility. For example, Gen-Ping et al (2021) posit that parameters like government response system, overall government response index, containment and health index stringency index, and economic support index all have a restraining effect on exchange rate volatility. Ivy (2020) and Putnam (2020) observed that drastic measures have been taken to curtailing the spread of the virus thereby strengthening the reported countries' currencies. Due to the corona virus induced exchange rate volatility, there are no absolutes, and everything has become relative. Many countries have witnessed daily rises in new COVID-19 cases, with a resultant weakening of their respective currencies. In the words of Putnam (2020), from the perspective of fundamentals, the influence of the virus on currency markets worked its way through the channel of changing relative expectations of future economic growth. Countries with healthy economies could attract global capital flows, and capital flows are an important driver of exchange rates. Pasiouras and Daglis (2020) also found that the COVID-19 has affected the overall economic system, in many ways; leading to its disorganization and that exchange rate is not an exception. Farayibi and Asongu (2020) added that the COVID-19 pandemic has insignificant negative impacts on basic macroeconomic variables in Nigeria such as inflation, employment, exchange rate, Gross Domestic Period (GDP) growth, among others. Hence, it is obvious from the above that no clear consensus has been established between COVID-19 pandemic and exchange volatility. This justifies the need for this study.

1.3 Objectives of the Study

To main objective of this study is to examine the relationship between Conditional Variance and Exchange rate volatility amidst COVID-19 pandemic. The specific objectives are to:

i. determine the relationship between conditional variance (volatility) and exchange rate movement in pre-COVID-19 and COVID-19 pandemic periods in Nigeria.
ii. examine volatility persistence in exchange rate market in pre-COVID-19 and COVID-19pandemic periods in Nigeria.
iii. evaluate asymmetric effect in exchange rate market in pre-COVID-19 and COVID-19 pandemic periods in Nigeria.
iv. ascertain volatility clustering in exchange rate market in pre-COVID-19 and COVID-19 pandemic periods in Nigeria.

1.4 Scope of the Study

This study on volatility modelling and exchange rate movement in COVID-19 pandemic period is dissected into two periods; period preceding the outbreak of COVID-19 pandemic (pre-COVID-19 period) in Nigeria (February 26, 2018, to February 26, 2020) and two years into the pandemic (COVID-19 period) (February 27, 2020, to February 27, 2022).

The rest of the paper is divided as follows; Section two looks at conceptual, theoretical, and empirical review. Section three is the methodology. Section four looks at the analysis and results, while section five is the conclusion and recommendation.

2. Literature Review

This section of the study covers conceptual review, theoretical framework, and empirical reviews. The Literature gap is explained at last.

2.1 Conceptual Review

2.1.1 Foreign Exchange Market

The foreign exchange market is an institutional arrangement designed for purchasing, selling, as well as the determination of rate of conversion of foreign exchange. It can also be seen as an organizational setting within which individuals, businesses, governments, and banks buy and sell foreign currencies and other debt instruments (Ibrahim et al, 2011), although, a small fraction of daily transactions in foreign exchange involves trading of currency. There are various reasons for foreign exchange transactions, such as lubrication of international trade, tourism, foreign investment, and even for speculation. As a result, three operators are identified in the foreign exchange market to include the dealers, the brokers, and the central banks. The dealers are the respective banking institutions licensed to operate on behalf of their customers, who may be private individuals or corporate bodies. The dealers act to meet the purchasing or selling needs of their customers (Salvatore, 2004). In Nigeria, they provide facilities for the operation of foreign currency domiciliary accounts. The brokers on their own are the intermediaries between banks. In situation the stock of foreign exchange with dealers in the exchange market rises over or falls below desired level, and the banks intend to sell or purchase currency, the brokers will mediate to facilitate such transactions either among banks or between other economic units. The central banks, as the apex banks act to maintain, monitor and manage the exchange rate of the nation's currency and to generally supervise and control the foreign exchange market. In Nigeria, the CBN not only serves these functions but also constitutes an active dealer and participant in the market (Salvatore, 2004; Ezirim, 2005; Ejem & Jombo, 2011).

2.1.2 Volatility Modelling

Modelling and forecasting volatility inherent in financial assets have over the decades occupied empirical and theoretical investigations by finance and economics experts. This academic excursion has a lot of motivations due to the prime place taken by volatility in the field of finance. The fundamental feature of any financial assets is its return seen as a random variable. The spread of outcomes of these variables, known as assets volatility, is indispensable in many financial applications (Gujarati, 2003). Brooks (2008) sees volatility as measured by the standard deviation or variance of returns, is sometimes applied as a crude measure of the total risk of financial assets. It's main usage in estimating the value of market risk can never be overemphasised. All modern option pricing techniques rely on a volatility parameter for price evaluation. Volatility is also applied in other areas apart from financial asset, such as risk management and in general portfolio management. It is important in financial

management not only to know the current value, also extended to predicting their future values. Volatility forecasting is used by financial institution in area of option trading and portfolio management (Nelson, 1991).

Another important concept in volatility modelling is volatility clustering, also known as volatility pooling. It is the tendency of large changes in prices of financial assets to cluster together resulting to persistence of these magnitude of changes. The tendency of financial markets to appear in bunches. Hence large returns (of either sign) are expected to follow large returns, and small returns (of either sign) to follow small returns. This implies that information arrivals which drive price changes themselves occur in bunches rather than being evenly spaced over time (Brooks, 2008). It is also seen as the period in which prices show wide swings for extended time followed by periods in which there is relative calm (Gujarati, 2003). This occurs when large financial asset prices changes are followed by large prices changes of either signs or small changes are followed by periods of small price changes (Okpara, 2016).

Asymmetric effect is also discussed along with volatility of financial assets. In the words of Brooks (2008), it is the tendency for volatility to rise more following a large price fall than following a price rise of the same magnitude. Ejem (2017), asymmetric effect is the tendency for negative news and positive news of equal size or magnitude to produce different impacts on volatility. If negative news produces more volatility than positive news, then the asymmetric effect becomes leverage effect (Black, 1976). In contrast, if positive news has more impact on volatility, then the asymmetric response is positive. Although, many empirical African studies have reported evidence of asymmetric effects in the foreign exchange markets, there is no agreement however, on whether the observed asymmetric response of volatility is positive or related to leverage effect.

However, volatility models for evaluating market risk need the estimations or forecast of volatility parameters. From previous study the mostly used stationarity models are original Autoregressive Conditional Heteroskedastic (ARCH) presented by Engle (1982), which permits the conditional variance to change over time as a function of past errors leaving the unconditional variance constant. Furthermore, Engle et al (1987) introduced the ARCH-M model, an extension of ARCH model which allows the conditional variance to be the determining factor of the mean. Engle et al model was applied to three different data sets of bond yields; hence came out to opine that risks are not time invariant; instead risks vary systematically with the assumptions of underlying uncertainty. Other models are improvement of ARCH model, such as Generalized Autoregressive Conditional Heteroskedasticity (GARCH), introduced by Bollerslev (1986). This generalized ARCH model allows for a longer memory and a more permissible and flexible lag structure at the same time. It provides a relatively long lag in the conditional variance equation and negates the problems associated with negative variance parameters in a fixed lag structure. The difference between the ARCH and GARCH is that in ARCH model, the conditional variance is specified as a linear function of past sample variance only, while the GARCH process permits lagged conditional variances to also enter in the model. ARCH and GARCH family models are to provide a volatility measure applied in financial decisions about risk analysis, portfolio selection and derivative pricing (Bollerslev 1986, Bollerslev et al, 1992; Engle &Nelson, 1993; Bera &Higgins, 1993). Another is the Exponential GARCH (EGARCH) model which according to Brook (2008) is an improvement of the GARCH which imposes a non-negativity constant on market variable and permits for conditional variance to respond asymmetrically to returns innovations of different signs. The EGARCH used to describe the behaviour of return volatilities by Nelson (1991) was proposed to test the hypothesis that the variance of return was affected differently by positive and negative excess returns, and that excess returns were negatively related to stock market variance. In order to avoid the imposition of a symmetric response of volatility to positive and negative shocks in GARCH model, Glosten et al (1993) presented the Threshold GARCH (TGARCH) models and came out boldly that there is a positive and significant relation between the conditional mean and conditional volatility of the excess return on stocks when the standard GARCH-M framework is used to model the stochastic volatility of stock returns, they also find that positive and negative unexpected returns have vastly different effects on conditional variance (Christie,1982; Schwert ,1990; Pagan &Schwert ,1990).

2.1.3. Features of financial assets (Exchange rate) Volatility

In Nigeria, the exchange rate volatility is majorly exacerbated and driven by the US Dollar which is a major trading currency and efforts have been continuously made by the Central Bank of Nigeria (CBN) to counteract the fluctuations in trade between the two countries. The striking issue here is modelling the dynamics of the exchange rate in an economy (Oyinlola, 2018) and there is need to exhume the features of financial assets volatility. As a result, there are two major features of financial assets volatility that continue to appear in finance literature: volatility persistence and asymmetric effects. Volatility persistence means that unpredictable shocks have long memory and their effects last for many periods ahead. Volatility persistence has to do with how long it takes for unpredictable shocks to die out or revert to its long run average. It is of particular interest to investors because it

is one of the important determinants of financial asset returns, hence volatility persistence has been found to characterize most foreign exchange markets, especially the emerging markets (Adeoye & Atanda, 2011; Miambo et al 2013; Luguterah et al, 2015; Ikumariegbe & Ejem, 2018). Finance scholars and researchers have introduced various models to explain and predict these patterns in volatility. The orthodox measure as represented by variance or standard deviation is unconditional and does not recognize that there are interesting patterns in asset volatility, such as time-varying and clustering properties (Caiado, 2004).

2.1.4 COVID-19 Pandemic

The outbreak of what is today known as COVID-19 pandemic was because of the SARS-CoV-2 virus. It was reportedly started in December 2019 in Wuhan city in Hubei province of China. It was formerly named on February 11, 2020, by the World Health Organization (WHO) as the Severe Acute Respiratory Syndrome Corona virus 2 (SARS-CoV-2). The novel COVID-19 continues to spread across the world with clusters of pneumonia cases. China initially was reported to be the epicentre of the outbreak with reported cases either in China or being travellers from China. This outbreak after thorough examination was declared a Public Health Emergency of International Concern (PHEIC) by the World Health Organization (WHO) on January 30, 2020 (United Nations, 2020). Later named the Corona virus disease 2019 with abbreviation; COVID-19 (Zhu et al, 2020; WHO, 2020; Bioassay & Ruhgcharoenkitkkul, 2020).

As result of the outbreak, government at different levels has been dosing out measures to curtail and ameliorate the adverse effects of the pandemic. Researchers around the globe are also making frantic efforts to find out the health, economic, social, and political impacts of the pandemic. In Nigeria, a good number of measures are put in place to combat the spread of the pandemic since the first index case of corona virus (COVID-19) heralded the nooks and crannies of Nigeria on February 27, 2020. For instance. President Muhammadu Buhari directed the cessation of all movements in Lagos and the Federal Capital Territory (FCT) for an initial period of 14 days, which took effect from 11 pm on Monday, 30th March 2020. The movement restriction, which was extended by another two-week period, was partially put on hold with some businesses commencing operations from May 4, 2020. On April 27th, 2020, Nigeria's President, Muhammadu Buhari declared an overnight curfew from 8pm to 6am across the country, as part of new measures to contain the spread of the COVID-19. This came along with the phased and gradual easing of lockdown measures in FCT, Lagos, and Ogun States, which took effect from Saturday, 2nd May 2020, at 9 am. On Monday, 29th June 2020 the Federal government extended the second phase of the eased lockdown by 4 weeks and approved interstate movement outside curfew hours with effect from July 1, 2020 (Nairametrics, 2020). Though, most of the measures are relaxed, efforts are still in top gear to curtail the spread of the pandemic.

2. 2 Theoretical Literatures

2.2.1 Purchasing Power Parity (PPP)Theory

It is pertinent to rest this study on the foundation of the theory of purchasing power parity (PPP). This theory underpins that the ratio of two nations' price levels (absolute PPP) or price indices times a base period exchange rate (relative PPP) as the indispensable variable that decides the exchange rate, though it allows both for other explanatory variables and for random influences (Cassel, 1918; Officer, 1976; Rogoff, 1996, Sollis, 2005). The foundation of the theory is built on the value of currency is fundamentally determined by the amount of goods and services that a unit of the currency can purchase in the country of issue. Sequel to that, PPP is seen as one of the revered theories in elucidating the behaviour of exchange rate. Furthermore, this theory of PPP informs that exchange between two currencies will adjust to reflect price levels changes between two countries. The theory asserts that the same goods, in terms of basket should have the same costs in each country given that allowance between different currencies is taken into consideration. This theory is based on the law of one price which suggests that uniform or identical goods should be sold at the same price irrespective of the country of origin (Atoi & Nkwede, 2017).

2.2.2: Asset Approach models

Another theory is the Asset Approach models; a modern theory of exchange rate that lays bare the role of exchange rate as one many prices in the global market for financial assets. This modern exchange rate theory placed emphasis on finance-asset markets. Rather than the traditional view of exchange rates adjusting to balance international trade in goods, the exchange rate is viewed as adjusting to equilibrate international trade in financial assets. Because goods prices adjust slowly relative to financial asset prices and financial assets are traded continuously each business day and the shift in emphasis from goods market to asset market has important implication. Exchange

rates will change every day or even every minute as supplies and demands for financial assets of different nations change. An implication of the asset approach is that exchange rate should be much more variable than goods' prices (Ugwuja, 2017). This seems to be empirical facts. For example, if the means of absolute changes in price and exchange rate of countries are taken, we then look at the average absolute change because exchange rate could be very volatile (Husted & Melvin, 1993). Husted and Melvin (1993) emphasis that within the family of asset-approach models, there are two basic groups: the monetary approach and the portfolio-balance approach. The monetary approach argues that the exchange rate for any two currencies is determined by relative money demand and supply between the two countries. Those relative supplies of domestic and foreign bonds are unimportant. The portfolio balance approach allows relative bonds supplies and demands as well as relative money market conditions to determine the exchange rate (Ugwuja, 2017). The essential difference is that monetary approach (MA) models assume domestic and foreign bonds to be perfect substitutes, whereas portfolio balance (PB) models assume imperfect substitutability.

2.3 Empirical Review

The effect of COVID-19 on macroeconomic variables is a new discourse in the field of economics and finance, thus there are scanty empirical literatures on this study and are greatly increasing. For instance, with Error Correction Model, Oketooyin, (2022) tried to find out the effect of COVID-19 pandemic on foreign exchange rate volatility in Nigeria with data spanning from February 29, 2020, to March 31, 2021, obtained from the Nigerian Centre for Disease Control (NCDC) and daily exchange rates USD/Naira from the Central Bank of Nigeria (CBN) statistical bulletin. The outcome of the analysis disclosed that daily reported COVID-19 instances, daily death cases, and cumulative death cases had a positive effect on Nigerian exchange rate volatility. Again, that confirmed cumulative coronavirus cases do not impact the exchange rate in Nigeria in the short run.

Chuanjian et al, (2022) employed ARDL model to examine the relationship between COVID-19 and exchange rate movement in China and USA. The study used data spanning from January 22, 2020, till May 7, 2021, and found that COVID-19 has a negative impact on the exchange rate.

Rui and Hortense (2021) used exponents Detrended Fluctuation Analysis (DFA) to know if the impact of global pandemic (COVID-19) created long memories in international foreign exchange markets. The results of analysis found that the exchange rate between USD/THB, USD/MYR and USD/SGD have long memories, to a lesser extent the pairs of USD/GBP and USD/EUR. It was also found that USD/RMB, USD/JPY, USD/CHF and USD/PHP exhibited anti persistence within the scope of the study.

Gen-Fu et al, (2021) applied system GMM estimation to investigate the response of exchange rate volatility to COVID-19 and government interventions. The study used exchange rate volatility in 20 countries during the period of January 13, 2020, to July 21, 2020, and the results found that an increase in confirmed cases does significantly raise exchange rate volatility. It was also revealed that the various policies adopted by governments in response to the pandemic, such as closing schools, restrictions on internal movements, and public information campaigns also inhibit exchange rate volatility.

With MS-ARCH method, Havva, (2021) examined the relationship between Exchange rate volatility and COVID-19 period using the return values of USD/TRY exchange rate in the trading days between March 2020 and October 2021, the month March 2020 when the first COVID-19 case appeared in Turkey. In the study two volatility regimes, low volatility, and high volatility, were used and the results found that the COVID-19 pandemic, along with various economic and political events in Turkey and the world, affected exchange rate volatility and that these volatility periods are permanent. It was also found that the USD/TRY return series has high volatility and a strong regime dependency.

2.4 Literature Gap

There exists scanty work on exchange rate volatility amidst the COVID-19 in Nigeria. The available papers on the topic only concentrated on the COVID-19 pandemic period. Here, effort will be made to dissect the work based on periods preceding the index case in Nigeria (Pre-COVID-19 period) and periods into the COVID-19 pandemic starting when the index case was announced in Nigeria (COVID-19). A few numbers of literature reviewed on this topic used either ARCH or GARCH or EGARCH, but in this study the researchers will employ the three variants of ARCH, i.e., ARCH, GARCH and EGARCH.

3. Research Methods

3.1 Data

For strong inferences, adequate comparison and concrete policy recommendations that will guide investors and other economic agents, the scope of this study is dissected into two periods; period preceding the outbreak of COVID-19 pandemic (pre-COVID-19 period) in Nigeria (February 26, 2018, to February 26, 2020) and two years into the pandemic (COVID-19 period) (February 27, 2020, to February 27, 2022) inclusive. The data used for both periods in this study comprised of different intervals involving daily, weekly, and monthly exchange rate obtained from Central Bank of Nigerian (CBN) publications.

3.2. Methods

This study adopted ARCH, GARCH and EGARCH models, and the exchange rate prices data are compounded by taking logarithms, $R_t = \ln(p_t/p_{t-1})$, where R_t, is the current market returns, p_t is the current market index price, p_{t-1} is the previous market index price.

3.2.1: Methodology for ARCH model

The ARCH model is seen as a diagnostic model that examines the ARCH effects and autocorrelation of financial data. It remains the right model used to test in a volatility model the presence of ARCH effects and autocorrelation and where a model of no ARCH effects is a good model (Hojatallah et al, 2010). Here, two pertinent tests must be carried out for ARCH model: test of stationary with unit roots test in the residuals, and ARCH effects test. unit root in a time series is checked using Augmented Dickey- Fuller test (ADF), which incorporates regressing the first difference of the series against the series lagged k times (Brooks, 2008; Gujarati, 2013). Here, the series is assumed to be stationary if the ADF test rejects the null hypothesis of a unit root in the return series. This may not be used in this study. Engle (1982) gave a process of testing for the presence of ARCH effects in a residual as seen below.

$$LM = n.\ R^2 \sim \chi^2_{(p)} \quad (1)$$

Where, n = sample size; R^2 is arrive by regressing $\varepsilon_t^2 = \alpha_0 + \alpha_1\varepsilon_{t-1}^2 + \ldots + \alpha_p\varepsilon_{t-p}^2 + u_t$

Whenever the sample is seen to be large nR^2 follows the Chi-square distribution with *df* equal to the number of autoregressive terms in the auxiliary regression model. Here, whenever there is non-rejection of the null hypothesis, it shows no volatility clustering, and the rejection of same null hypothesis indicates the presence of ARCH effects. To test for heteroscedasticity, the linear ARCH (q) model for heteroscedasticity is used (Engel, 1982).

$$h_t^2 = \beta_0 + \sum_{i=1}^{q}{}_{i=1}^{q}\beta_1\varepsilon_{t-p}^2 \quad (2)$$

If $\beta_1 = 0$, then there is no volatility clustering. The AIC (Akaike Information Criterion) and SBIC (Schwartz Bayesian Information Criterion) are applied to determine the ARCH model order (the value of q) where the model with the minimum value of information criterion is to be preferred.

3.2.2 *Methodology for GARCH family*

Here, some of the models in GARCH family to be considered are GARCH, EGARCH and TGARCH. GARCH (p, q) specifies the conditional variance to represent linear combination of (q) lags of the squared residuals ε_t^2 from the conditional return equation and (p) lags from the conditional variance σ_{t-j}^2. This GARCH (p, q) conditional variance is expressed as.

$$\sigma_t^2 = \omega + \sum_{i=1}^{p}\alpha_i\varepsilon_{t-i}^2 + \sum_{j=1}^{q}{}_{j=1}^{q}\beta_j\sigma_{t-j}^2 \quad (3)$$

This is estimated under the constraints; $\alpha_1\beta > 0$ and $(\alpha + \beta) < 1$. It's (GARCH model) adequacy is examined by standardized residual $\frac{\varepsilon}{\sigma}$. Where (σ) = conditional standard deviation, arrived by the GARCH (p, q) model as seen in eqn (3).

(ε) = residuals of the conditional return equation, and the standardized residuals are assumed to be independently and identically distributed (IID). To test for independence of the error term, a two- step is needed: First, according to Ljung and Box (1978), calculate the Liung-Box statistics on the squared observation of the raw data. This test is normally applied to test for the remaining serial correlation in the mean equation; if the mean equation is correctly specified; all Q-statistics is expected not be significant. Second, this one is a diagnostic test, also known as post hoc analysis step; it examines the specification of the variance equation. It involves the calculation of the Q- statistics of squared standardized residuals, again if the variance equation correctly specified, all Q-statistics should not be significant. It is a Chi-square statistic, χ^2_{m-p-q}. Here the rejection of null hypothesis signifies that there are no autocorrelation and that the series under examination signposts volatility clustering. Moreso, the adequacy of the GARCH model and selection criteria are examined or tested using the same method as of the ARCH model. For that, since the standard GARCH model cannot take account of leverage effects and does not permit for any direct feedback between the conditional variance and the conditional mean, hence the postulations of two popular GARCH models; Threshold GARCH (TGARCH) model or according to Glosten, Jagannathan and Runkle in1993 called GJR model, and the Exponential GARCH (EGARCH) model (Nelson, 1991). Meanwhile, the TGARCH or GJR model is a simple extension of GARCH with additional feature or term to account for possible asymmetries. Here, the conditional variance is given as. $\sigma_t^2 = \omega + \alpha\varepsilon_{t-1}^2 + \gamma\varepsilon_{t-1}^2 d_{t-1} + \beta\sigma_{t-1}^2$ (4)

Where $d_{t-1} = 1$, if $\varepsilon_{t-1} < 0$, = 0, otherwise. However, the conditional variance of the basic GARCH model in eqn (4) is simply extended to include a threshold term, $\varepsilon_{t-1}^2 d_{t-1}$. In this model, $d_1 = 1$, if ε < 0, and 0 otherwise. For leverage effect, γ should be greater than zero, and for non-negativity, the following should be: $\alpha_0 > 0$, $\alpha_1 > 0$, β ≥ 0, and $\alpha_1 + \gamma \geq 0$

Therefore, the model is still admissible, even if γ < 0, given that $\alpha_1 + \gamma \geq 0$. According to Brooks (2008), for EGARCH, model, the conditional covariance is given by:

$$\ln(\sigma_t^2) = \omega + \beta \ln(\sigma_{t-1}^2) + \gamma \frac{\mu_{t-1}}{\sqrt{\sigma_{t-1}^2}} + \alpha\left(\frac{|\mu_{t-1}|}{\sqrt{\sigma_{t-1}^2}} - \sqrt{\frac{2}{\pi}}\right) \quad (5)$$

Where, ω, β, α, γ are constant parameters, Log (σ_t^2) = the one period ahead volatility forecast.

ω = the mean level, β = persistence parameter, α = volatility clustering coefficient, Log (σ_{t-1}^2) = the past variance, γ = the leverage effect.

The above model ensures that even when the parameters are negative, σ_t^2 will be positive and the asymmetry or the leverage effect measure, γ, will be negative even when the relationship between volatility and log returns is negative. The EGARCH is symmetric when = 0, when γ < 0 then positive shocks (good news) generate less volatility than bad news (negative shocks); in other way round, bad news or negative shocks magnify more volatility than good news or positive shock of the same magnitude. When γ > 0, it implies that positive innovations or shocks are more destabilizing than negative innovations or shocks (Black, 1976; Christie,1982). In other words, negative value of γ is called the 'sign effect'. The choice of EGARCH framework is to accommodate examination of conditional variance (volatility), asymmetric effect and volatility persistence and suitable for this study based on the specified objectives. The ∝ parameter represents the symmetric effect of the model, if ∝ is positive, then the conditional volatility tends to rise (fall) when the absolute value of the standardized residuals is larger (smaller), hence magnitude effect'. The GARCH effect β measures how persistent the conditional volatility is. When β is relatively large, then volatility takes a long time to fizzle out or decay or die out following crisis in the market or economy in general. Succinctly, the EGARCH model has a good number of advantages over the normal GARCH specification. First, since the log (σ_t^2) is modeled, then the parameters σ_t^2 will be positive. There is thus no need to artificially impose non-negativity constraints on the model parameters. Second, asymmetries are allowed for under the EGARCH formulation, since if the relationship between volatility and returns is negative, γ, will be negative (Brooks, 2008).

4. Data Analysis and Interpretation

4.1: Trend of Data

The researchers commenced with the trend of data to appreciate the visual behaviour of exchange rate, thereafter the descriptive statistics to know the distributional features of exchange rate in Nigeria. For instance, figures 4.1,

4.2 and 4.3; as well as figures 4.4, 4.5 and 4.6 showed graphical plots of Daily, Weekly and Monthly exchange rates for pre-COVID-19 and COVI-19 respective periods. In figures 4.1, 4.2 and 4.3, pre-COVID-19 period, exchange rate (Naira and US Dollar) was seen around ₦314 and ₦315 between February and March 2018. It then rose to ₦306 and below ₦305 from end of march to May 2018, an indication of slight appreciation in Naira to the US Dollar. The price rose to ₦314 to ₦315 in June 2018, a sharp rise in price (depreciation). The price dropped instantly to ₦306 at a point in June 2018. The exchange price moved around ₦305 to ₦314 towards the end of August 2018. From first week of September 2018 to February 2019, it was seen around ₦305 to ₦307. Again, close to the end of February 2019, it maintained a rate of ₦306, then slightly to ₦307 until October 2019. It moved around ₦306 and ₦307 to the end of December 2019. It was at ₦306 preceding the index case on February 27, 2020.

It was discovered that the price of exchange rate between Naira and US Dollar in figures 4.4, 4.5 and 4.6 (COVID-19 period) suggested a persistent increase (depreciation) the moment the index case of COVID 19 was announced on February 27, 2020. A sharp rise in price from ₦306 to ₦350 was noticed in March 2020. In July 2020 the Naira depreciated to ₦380. This continued throughout the remaining months in 2020. It then moved at the same pace in 2021. It increased to above ₦400 in May 2021 and maintained at the rate to almost ₦420 in February 2022.

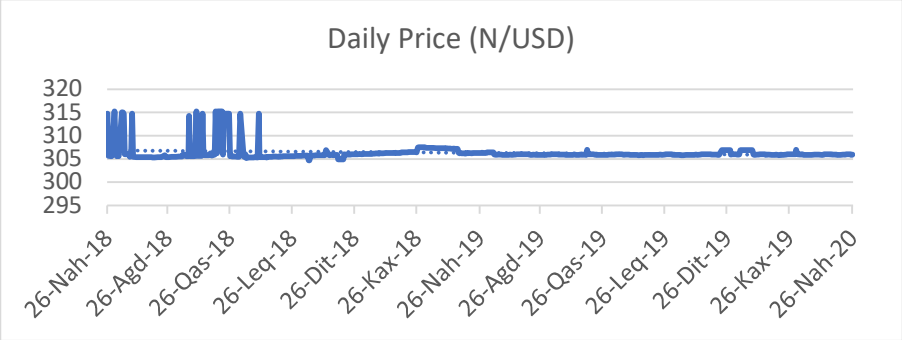

Fig. 4.1

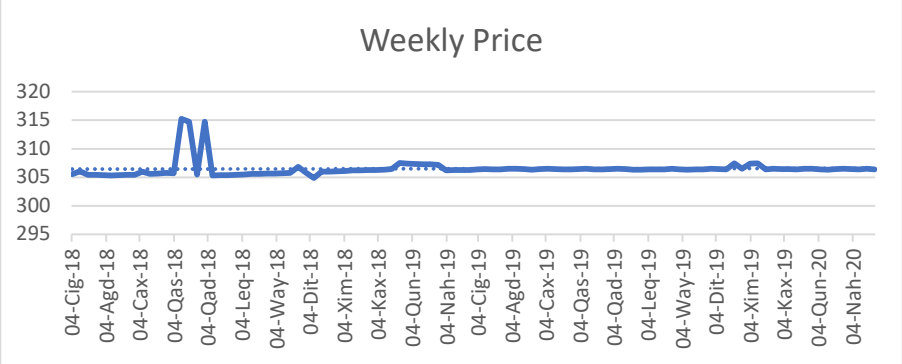

Fig.4.2

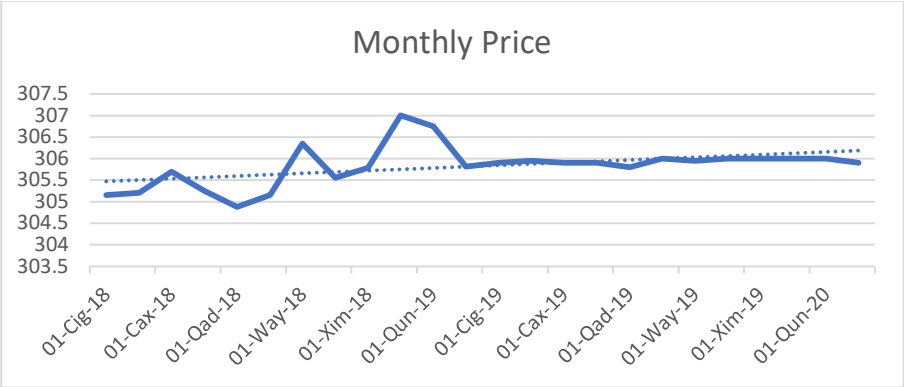

Fig. 4.3

Figures 4.1, 4.2 and 4.3: Graphs of Exchange rate Price in Pre-COVID-19 Period

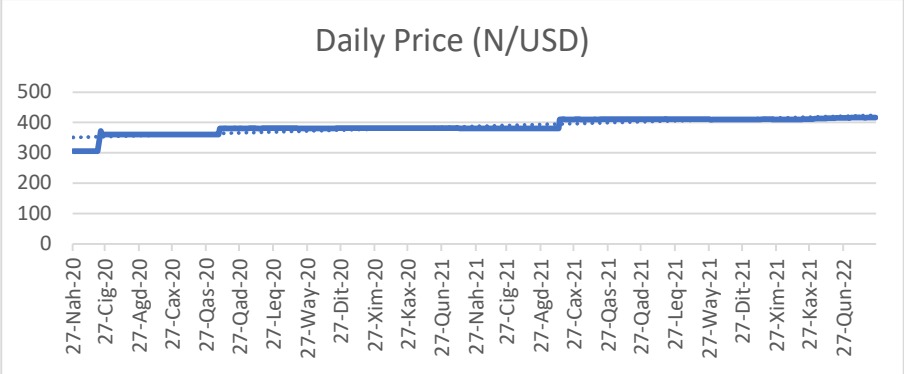

Fig. 4.4

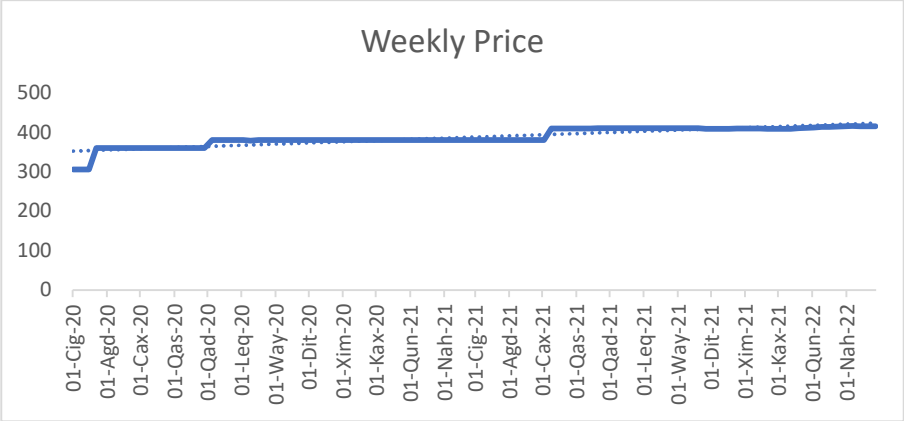

Fig. 4.5

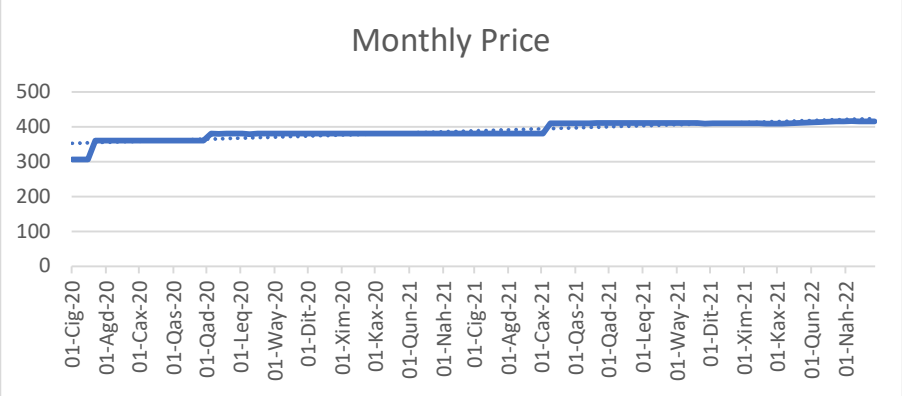

Fig. 4.6

Figures 4.4, 4.4 and 4.6: Graphs of Exchange rate Price in COVID-19 Period

4.2: Summary of Statistics

Tables 4.1 and 4.2 below depict the summary of statistics describing the distributional characteristics of exchange rate data of various intervals (daily, weekly, and monthly) for both periods. In table 1, pre-COVID-19 period, the average (mean) of various intervals of exchange rate price of the Naira to the US Dollar are 306.3, 306.4 and 305.8 respectively for the period, with respective standard deviation of 1.7, 1.5 and 0.4, an indication that the movement in exchange rate between the Naira and US Dollar was volatile in the pre-COVID period, mostly on daily and weekly basis. The difference between the maximum and minimum is high on the same basis as that of standard deviation of exchange rate price, confirming volatility in the exchange rate price within the period. All the intervals (daily, weekly, and monthly) recorded positive skewness, indicating that all price distributions are skewed to the right of their mean with long right tail and have the tendencies that large positive prices could occur more than large negative price in the foreign exchange markets. This shows that large movements in exchange rate price do not follow with the same magnitude of negative movement. In the same vein, all the intervals had excess kurtosis (leptokurtic distributions), suggesting the tendency of exchange rate prices distribution exhibit fat tails and excess peakedness at the mean (Brooks, 2008). The values of the skewness and Kurtosis signpost presence of asymmetry and volatility clustering in the exchange rate prices. This showed the features of data that are clearly observed. Jarque-Bera zero probability values for daily and weekly prices showed abnormality of the distribution of exchange rate price, with exception of monthly price that exhibited normal distribution.

In table 4.2, COVID-19 period, from the values of standard deviation from all the intervals show that exchange rate movement between the Naira and US Dollar was highly volatile. The high difference between the maximum and minimum up to the value ₦100 for various intervals of exchange rate price affirmed high volatility in exchange rate price within the COVI9-19 period. The negative skewness exhibited in the various intervals, pointed out that it is negatively skewed suggesting the distributions have long left tail. This means large negative movements in exchange rate are not normally followed by the same magnitude of positive movement. Monthly exchange rate price has less than normal Kurtosis (platykurtic), whereas daily and weekly have excess kurtosis (leptokurtic distributions) suggesting features of data are clearly monitored. Therefore, the exchange rate price index depreciates more than it appreciates, and there are more data extremes. Jarque-Bera zero probability values confirm abnormality of the distribution of exchange rate price, except monthly interval.

Table 4.1: Descriptive Statistics of Daily EXCR in Pre-COVID 19 Period

Estimators	Daily Price	Weekly Price	Monthly Price
Mean	306.3130	306.4957	305.8283
Median	305.9500	306.4000	305.9000
Maximum	315.2500	315.2500	307.0000
Minimum	304.7000	304.9000	304.8800
Std. Dev.	1.735539	1.553571	0.481751
Skewness	4.423407	4.612618	0.246798
Kurtosis	22.14927	25.57130	3.530404
Jarque-Bera	9696.433	2576.464	0.524966
Probability	0.000000	0.000000	0.769140
Sum	160201.7	31875.55	7339.880
Sum Sq. Dev.	1572.313	248.5990	5.337933
Observations	523	104	24

Table 4.2: Descriptive Statistics of Daily EXCR in COVID 19 Period

Estimators	Daily Price	Weekly Price	Monthly Price
Mean	387.2576	388.2451	390.0763
Median	380.7000	380.7000	380.7000
Maximum	416.5100	416.5100	415.5200
Minimum	305.9000	306.5000	360.0000
Std. Dev.	23.98502	23.50671	19.96242
Skewness	-1.094166	-1.063886	-0.086152
Kurtosis	4.985440	4.960440	1.600918
Jarque-Bera	189.5304	36.62201	1.987120
Probability	0.000000	0.000000	0.370256
Sum	201761.2	40765.74	9361.830
Sum Sq. Dev.	299146.3	57466.80	9165.454
Observations	521	105	24

4.3 Testing for ARCH Effects

In the ARCH models estimation, it is important to first know if there is presence of ARCH effect or heteroscedasticity in the data series. To do that heteroskedasticity test is adopted as seen below in table 4.3.

Table 4.3: Heteroskedasticity Test: ARCH

ARCH Test	PRE COVID			COVID-19		
	Daily	Weekly	Monthly	Daily	Weekly	Monthly
F-statistic	0.0000	0.0010	0.6725	0.9723	0.8745	0.6718
Obs*R-squared	0.0000	0.0012	0.6542	0.9722	0.8730	0.6535

The results of the Engle (1982) ARCH-LM test statistic on pre-COVID-19 and COVI-19 periods in table 4.3 above shows exchange rate price changes with signs of heteroskedasticity in the daily and weekly interval of pre-COVID-19, but not available in monthly of pre-COVID-19 and in all intervals in COVID-19. This suggests the need to use other ARCH family for daily and weekly pre-COVID-19 only, while all intervals in COVID-19 are to be exempted from the analysis since data exhibited no serial correlation and no ARCH effect. It could be concluded that ordinary least square (OLS) method fits the data of COVID-19 period and no further ARCH family volatility models are to be performed on the COVID-19 period.

4.4: Check of Volatility Clustering

This section is to know if the exchange rate prices in the pre-OVID-19 period have the feature of volatility pooling. That is if large price changes (of either sign) are expected to follow large changes, and small changes (of either sign) to follow small changes.

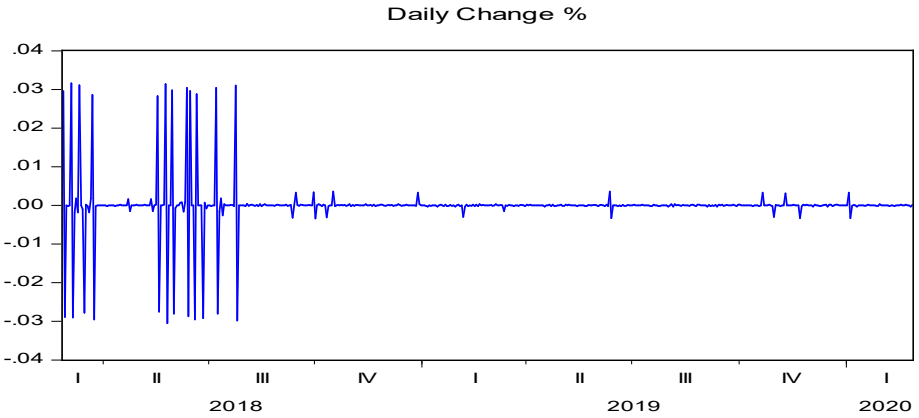

Fig. 4.7

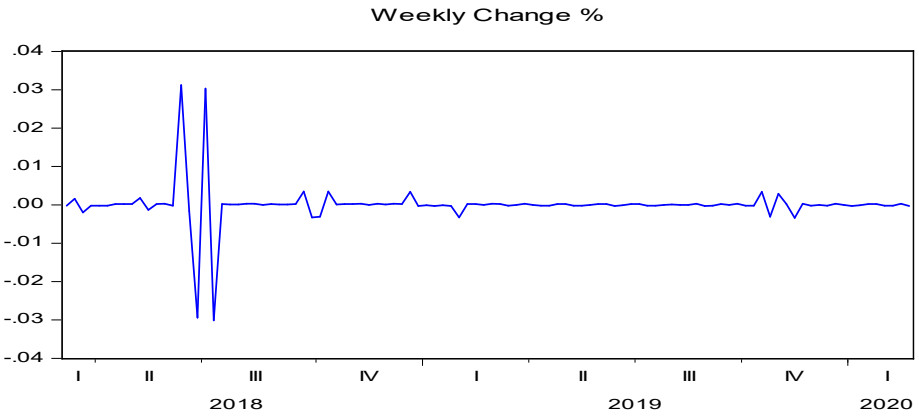

Fig. 4.8

Figures 4.7 and 4.8: Volatility Clustering Test for *Exchange rate Price in Pre-COVID 19 period*

A close look at figures 4.7 and 4.8 above revealed high fluctuations in the first quarter of 2018 followed by period of calmness between first quarter and second quarter. Again, short swings were witnessed from second quarter to third quarter of 2018, suggesting that periods of high volatility are followed be the same magnitude of volatility for a short period. Last quarter of 2018 exhibited a period of relative tranquillity, intercepted with very low volatility until 2020. This shows relatively calmness with very low volatility, indicating low volatility caused by small positive and negative changes in prices. The implication of the above stylized movements is that the pre-COVID-19 period exhibited property of exchange rate prices distribution known as volatility clustering or volatility pooling, a kind of heteroscedasticity. This means that volatility shocks at the current period influence the expectation of volatility in some periods in the future.

4.5. Estimation of Models for Pre-COVID-19 Period

To model the ARCH effects exhibited in the daily and weekly intervals of pre-COVID-19 period, the researchers used variants of ARCH (ARCH, GARCH and EGARCH) to capture the effect of serial correlation of volatility in the time series data.

Table 4.4 Estimation of models using ARCH.

Parameter Estimates	**Daily**	**Weekly**
	Coefficient	Coefficient
μ	-0.155005 **0.0649	-0.357663 **0.0616
ω	2.52E-05 **0.5888	0.000427 **0.7180
α_1	7.48E-07 **0.0000	1.93E-05 **0.0027
α_2	0.968334 **0.0000	0.447514 **0.0050
α_3	0.036899 **0.0000	0.514158 **0.4778
α_4	0.211061 **0.0001	-0.382818 **0.4973
α_5	-0.255695 **0.0728	0.286600 **0.8113
Log likelihood	2707.541	433.4433
Dw Stat	2.595967	2.509848
AIC	-10.34690	-8.280452
SIC	-10.28980	-8.101392
ARCH-LM Test-		
F-statistic	0.6826	0.9654
Obs*R-squared	0.6819	0.9650

**Probability values

Table 4.5 Estimation of models using GARCH.

Parameter Estimates	**Daily**	**Weekly**
	Coefficient	Coefficient
Mean Eqn		
ω	3.59E-07 **0.9774	1.41E-05 **0.0093
Variance Eqn		
ω	1.46E-08 **0.0000	1.10E-06 **0.0047
α	0.059262 **0.0000	1.615414 **0.4101
β	0.749987 **0.0000	0.034426 **0.5004
$\alpha + \beta$	0.809249	1.64984
GED r	1.101871 **0.0000	0.380227 **0.0000
Log likelihood	2972.521	590.2868
Dw Stat	2.263174	2.930079
AIC	-11.36598	-11.34537
SIC	-11.31704	-11.19189
ARCHLM Test		
F-statistic	0.9565	0.9076
Obs*R-squared	0.9564	0.9064

**Probability values

Table 4.6 Estimation of models using EGARCH.

Parameter Estimates	Daily	Weekly
	Coefficient	Coefficient
Mean Eqn		
b_2	-47.70669 **0.0000	-13.42344 **0.1896
b_1	0.013921 **0.0000	-0.096129 **0.0000
ω	0.000134 **0.0000	4.56E-05 **0.0021
Variance Eqn		
ω	-7.596682 **0.0000	-6.034997 **0.0001
α	-1.222590 **0.0000	0.640009 **0.0023
γ	-0.049595 **0.0000	-0.419787 **0.0097
β	-0.033558 **0.0000	0.562365 **0.0000
Log likelihood	3755.895	581.8536
Dw Stat	2.033423	3.070235
AIC	-14.35975	-11.14279
SIC	-14.29450	-10.93815
ARCH LM Test		
F-statistic	0.8198	0.9001
Obs*R-squared	0.8194	0.8989

**Probability values

Table 4.4 above shows the results of the estimated parameters and associated probability values for daily and weekly intervals. The lags (α_1 to α_5) are the conditional volatility dynamics indicating all lags from α_1 to α_5 are significant at 5% level, except lag 5 that is significant at 10% level, implying that the ARCH (5) model is properly fitted on daily basis. The presence of serial correlation was noticed on both daily and weekly intervals, hence ARCH model is unreliable for policy formulation. In table 4.5 above, the model is estimated based on the assumption that errors have a Generalized Error Distribution (GED). The need of GED for the asymmetric GARCH model is due to the excess kurtosis seen in the exchange rate prices. It was then found that GED tail parameter, r is less than 2 and significant for all the intervals under study, suggesting that the errors have a fat-tailed distribution. Under the theoretical assumption, GED is normally distributed if r = 2, otherwise a fat-tailed distribution if r $<$ 2. The outputs of the GARCH models in Tables 4.5 reveals that the daily coefficients of conditional variance equations parameters (ω, α, β) are found to be significant at 5% significance level as measured by t-statistic, thereby satisfy the non-negativity restrictions of the models. Again, the ARCH effect (α_i) for the daily interval at 5% significant level, suggesting that news about volatility from past has the capacity to predict current volatility. The daily and weekly coefficients of β(lagged conditional variance) are significantly different from zero indicating volatility clustering in the exchange rate price series. It is good to note that since GARCH output for all price series coefficients of variance equations are statistically significant, showing presence of volatility clustering. Since the variance equation of both ARCH (α) and GARCH (β) terms are positive and highly significant, indicating that conditional variance of exchange rate market in Nigeria are generated by an ARCH/GARCH process. It is also observed that the daily persistence parameter, which is the sum of the ARCH and GARCH parameters (α +β) are very close to unity or 1, indicating shocks to the conditional variance are highly persistent (volatility is highly persistent) and shocks die or fizzle out very slowly in all the exchange rate market in Nigeria. It is also discovered that (α +β) are greater than 1 on weekly basis, suggesting that shocks to the conditional variance are explosive on weekly basis. It therefore confirms the long-term characteristics of the foreign exchange markets, though eventually reverts to its long run average. That means that prolonged changes in exchange rate prices tend to be followed by prolonged changes and mild changes also tend to be followed by mild changes, implying that volatility in exchange rate prices occur in clusters and are predictable in the pre-COVID-19 period. In Table 4.6 above, the outcome of the estimation revealed that coefficient of the conditional volatility (b_2) (capturing the exchange rate price-volatility relationship) for daily exchange rate price is negative and significant, while insignificant on weekly basis within the pre-COVID period of the study, contradicting the expected positive and significant relationship for risk averse investors who requires higher reward for higher risk. This shows that investors or speculators in the

foreign exchange market are not adequately rewarded for taking additional risk on daily basis in Nigeria within pre-COVID-19 period in this study. It was revealed that the leverage effect or asymmetry parameter γ are negative and significant for both intervals, suggesting presence of leverage effects in the foreign exchange market, implying that bad or negative news have the propensity to cause more volatility than good or positive news of the same magnitude. The persistent parameter β is significant, and is small for daily price, indicating that volatility is persistent, suggesting that volatility takes a short time to die following the crisis in the foreign exchange market. Magnitude effect ($\propto$) (volatility clustering) coefficient of EGARCH is significant for both daily and weekly interval. That means the conditional volatility will rise or fall when the absolute value of the standardized residual is larger (smaller). Tables 4.4, 4.5 and 4.6 above found that the ARCH-LM tests for the serial correlations were insignificant at 5% critical level for all the intervals under study, suggesting that the asymmetry models are sufficient in modelling the serial correlation structure in the conditional mean and variance. This indicates there is no further ARCH effect in the estimated ARCH-GARCH models, as well as suggests that the models are correctly specified. The AIC and SIC were found to maintain small criterion value for all the variants of ARCH in the intervals under study, affirming the suitability of the models. The Durbin-Watson (DW) statistics for Daily exchange rates show absence of autocorrelation in the model, indicating that daily exchange is suitable and reliable for drawing inference to make policy statements.

4.6 COVID 19 Period Estimation

Since no ARCH effects were not found in the COVID-19 period, it is advised to conclude with the ordinary least square (OLS) method. This is shown on table 4.7 below for both daily, weekly, and monthly intervals.

Table 4.7: Estimation using Ordinary Least Square (OLS) Method

OLS test Estimators	Daily	Weekly	Monthly
Coefficient	-0.124039 **0.0046	-0.026492 **0.7895	-0.052987 **0.6210
C	0.000716 **0.1173	0.003182 **0.1055	0.007178 **0.1217
R^2	0.015386	0.000702	0.011847
Adjusted R^2	0.013485	-0.009095	-0.035208
F-statistic	8.094295 **0.004616	0.071633 **0.789514	0.251773 **0.621049
Durbin-Watson stat	2.004544	2.001121	2.111120

**Probability values

Table 4.7 above reveals significant relationship between the successive variables (prices regressed on their lagged value), i.e., the coefficients of the regression are significantly different from zero and associated probability value is significant at 5% level for daily interval only. This suggests that there is a significant relationship between the price series and their lagged values, indicating that historical exchange rate prices on daily interval could be used to predict current and future prices in the foreign exchange market.

5. Summary, Conclusion and Recommendations

This study examined the relationship between Conditional Variance and Exchange rate Market within the Pre-COVID-19 period and COVID-19 period of the pandemic in Nigeria using different estimation intervals (daily, weekly, and monthly) of exchange rate price computed from the exchange rate price between the United State of America Dollars and the Nigeria Naira. After empirical analysis of the models in this study, the following were adduced; in the pre-COVID-19 period, it was discovered that high volatility heralded the exchange rate market. It was also found that the pre-COVID-19 period, conditional volatility (capturing the exchange-volatility relationship) was found to be negative and significant. Volatility persistence (the period required or expected for the volatility in the market to decay or dissipate) were persistent for daily and weekly intervals. The asymmetry parameter was found to be positive and significant level for daily and negative for weekly exchange rates, suggesting presence of leverage effects in the foreign exchange market in Nigeria within the scope of the study. It was also found that the conditional volatility (capturing the exchange rate-volatility relationship) for daily exchange rate was negative and significant, while insignificant on weekly basis. This shows that investors or speculators in the foreign exchange market are not adequately rewarded for taking additional risk in the pre-COVID-19 period. The persistent parameter was found to be significant for all the intervals, suggesting volatility

in exchange rate price between Naira and US Dollar is persistent in the pre- COVID-19 period in Nigeria. It was also found that in the COVID-9 period there is a significant relationship between the price series and their lagged values, indicating that historical exchange rate prices on daily interval could be used to predict current and future prices in the foreign exchange market. Considering the findings, the researchers are of the opinion that:

i. There should be a prompt and proper dissemination of information by the regulatory authorities about the activities of exchange rate market to avert undue influences by operators aimed at making abnormal gains. This will reduce the escalation of bad news which increases volatility.
ii. Again, panic buying should be discouraged since the market volatility persistent takes a little time to decay.
iii. Economic agents should go about their normal transaction since what is playing out is leverage effect.
iv. The Central Bank of Nigeria (CBN) should initiate measures to forestall the persistent rise in the price of exchange rate to restore the evaporated trust and confidence in the foreign exchange market.
v. The CBN should always monitor the activities of the parallel market operators and the speculators in the foreign exchange market in order avert unnecessary tension in the market.
vi. The results found in this study are believed to have doused the tension that the continued spread of COVID-19 does significantly raise exchange rate volatility in Nigeria.

5.1 Implication

The crux of this study is to examine the movement and behaviour of exchange rate mostly in the face of COVID-19 and to achieve that, this study is dissected into two periods, period preceding the outbreak of COVID-19 pandemic and two years into the pandemic (COVID-19 period) in Nigeria. This is for strong inferences, adequate comparison and concrete policy recommendations that will guide investors and other economic agents. Therefore, the findings in this study have the following implications:

The result that negative and significant relationship exist between conditional variance and exchange rate movement in this study implies that volatility exerted negatively on the exchange rate movement in Nigeria prior to the announcement of the index case of COVID-19 pandemic. Though, theory predicts a positive relation between expected returns and volatility if investors are risk averse, suggesting more reward for taking more risk. The result in this study informs that there is less compensation for risk when volatility is relatively high. This shows that investors or speculators in the foreign market should not expect much return when exchange is riskier.

It was also discovered that volatility was persistent in the pre-COVID-19 era. This serves as veritable message for government qua the Central Bank of Nigeria to always monitor the operations of the foreign exchange market on perceived crisis or dwindling in the market for appropriate palliative measures or bail out plans. Again, a significant relationship between the price series and their lagged values was found in COVI-19 period under study, indicating that historical exchange rate prices on daily interval could be used to predict current and future prices in the foreign exchange market. For that, the CBN should initiate measures to forestall the persistent rise in the price of exchange rate experienced in COVID-19 period in the study which has made the exchange movement become volatile and predictable. If such measures are taken, it will restore the evaporated trust and confidence in the foreign exchange market.

It was revealed that the leverage effect or asymmetry parameter are negative and significant for both intervals, suggesting presence of leverage effects in the foreign exchange market, implying that bad or negative news have the propensity to cause more volatility than good or positive news of the same magnitude. The CBN should always monitor the activities of the parallel market operators and the speculators in the foreign exchange market because they create undue tension in the market to make undue profit.

In sum. presence of volatility as found in this study, if not monitored will always induce investor to demand a higher risk premium, hence create higher cost of capital which will impede investment and slows down economic development. This a general problem retarding growth of developing economies like Nigeria. Foreign exchange volatility has several implications, for example on consumer spending with inherent effect on the wealth of economic agents. A rise in an exchange rate price (depreciation) weakens consumer confidence, thus drive down consumer spending. This also directly affect investment and economic growth. A rise in foreign exchange market volatility could be seen as a rise in risk of investment and thus, a shift of funds to less risky assets. This drift could lead to rise in cost of funds to new firms and hence new firms might not bear this effect as investors will turn to assets of blue chip.

5.2 Limitations and Direction for Further Research

This study should be extended to other countries around the world. This will help to validate possible inferences, theories and policy making. The study is limited to foreign exchange market in Nigeria. The researchers had wished it was extended to other African countries and the globe but was hindered by the requirement of the funding.

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