Money and Foreign Exchange Markets Dynamics in Nigeria: A Multivariate GARCH Approach

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This study examines money market and foreign exchange market dynamics in Nigeria by estimating the dynamic correlation and volatility spillovers between Nigeria Naira/US Dollar Bureau De Change (BDC) exchange rate and interbank call rate with data from January 2007 to August 2019. The study employs a dynamic conditional correlation form of GARCH model (DCC-GARCH) to access the nature of correlation, while an unrestricted bivariate BEKK-GARCH (1, 1) form of multivariate GARCH model is utilized to investigate shocks and volatility spillover of the rates. The estimated DCC-GARCH (1, 1) reveals that interest rate and exchange rate are dynamically linked negatively, suggesting that exchange rate (or interest rate) is inversely sensitive to interest rate (or exchange rate) in Nigeria. This result was substantiated by the estimated BEKK-GARCH(1, 1) model. Furthermore, the effects of news (shocks spillover) are bi-directional across the markets. However, volatility spillover is unidirectional, from exchange rate to interest rate, suggesting that, calming the volatility in foreign exchange market does guarantee moderation of volatility in the money market, whereas reverse is not the case. The results underscore the growing influence of foreign exchange market in the financial space of the Nigerian economy. Thus, the study recommends that foreign exchange policies aimed at maintaining exchange rate stability should be sustained, having found exchange rate to be more effective in moderating interest rate volatility in Nigeria.

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1.0 Introduction

Money and foreign exchange markets are vital parts of financial system in promoting financial intermediation and stability. Economic managers and investors depend on the activities of these markets by focusing on the behaviour of the key elements of the markets: interest rate and exchange rate to make informed macroeconomic and optimum portfolio management decisions. The behaviour of the rates can be driven by the forces of demand and supply in the markets. That means, if at any given time, the demand for funds or foreign exchange is

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higher than the supply, the rates could increase; and reverse is the case when supply is higher. The changes in these rates over time can be measured in terms of volatility.

Exchange rate (or interest rate) volatility has the tendency of driving interest rate (exchange rate) volatility either positively or negatively given that foreign exchange market and money market tend to co-move (Geisslreither & Gros, 2004). The nature of the co-movement over time is equally important to investors. If the correlation (co-movement) and volatilities are changing, then investors hedge ratio can adjust to account for the most recent information. It is based on the understanding of correlation as well as volatility spillover between exchange rate and interest rate that most monetary authorities of emerging markets tend to adopt contractionary monetary policy stance to calm fluctuations in exchange rate (Sitikantha & Arghya, 2001; Taha & Kadir, 2016).

Assessing exchange rate and interest rate volatility in the Nigeria financial market is pertinent as, the Nigeria Naira to United State Dollar (₦/$) exchange rate and the interbank interest rate had witnessed significant fluctuations over time. For instance, in the Bureau De Change (BDC) window of the foreign exchange market, the exchange rate depreciated from ₦154.57/1$ in December 2010 to ₦163.3/1$ in 2011, while interbank call rate rose from 8.03 per cent to 15.5 per cent during the same period. As at December 2015, the exchange rate has depreciated significantly to ₦258.3/1$ as the interbank call rate plunged to 0.77 per cent. The level of volatility in the markets persisted throughout the period of this study, but the nature of correlation and volatility spillover appears unclear.

In 2016, the monetary authority implemented foreign exchange policy that further liberalised the foreign exchange rate market to deepen the market and mitigate market fluctuations. This was achieved by closing the retail window of exchange rate transactions, introducing the investors and exporters (I&E) window for foreign exchange (forex) transaction as well as allowing the authorized dealers in the market to sell foreign currency accruing from inward money remittances to licensed BDCs[3]. Notwithstanding the immediate relative stability in exchange rate due to the policy, the volatility continued as the BDC exchange rate reached N363.46 per US Dollar in December 2018. Furthermore, the CBN adopted contractionary and expansionary policies alongside symmetric and asymmetric corridors to realign interest

[3]Circular on the Sale of foreign currency proceeds of International Money Transfers to BDCs. Source: https://www.cbn.gov.ng/Out/2016/TED/FX%20Sales%20BDCs.1.pdf

rates in the money market. Evidently, the Central Bank of Nigeria (CBN, 2018) reported that money market rates rose generally in 2017, which reflected the non-expansionary policy stance of the Bank; and foreign exchange intervention was one of the factors that contributed to the rise. Such policies intended to moderate exchange rate and interest rate volatility can be undermined by volatility spillover from any of the rates if the nature of the co-movement and spillover are not properly identified.

Theories, such as herding behaviour and portfolio channel have been used to explain foreign exchange market and money market volatility spillovers. Herding behaviour theory hypothesised that, due to risk in one market, participants will re-evaluate other markets based on the available limited information (Cipriani and Guarino, 2008; Cheng *et al.*, 2009). Portfolio channel theory explains the investors' reactions when one market is affected by idiosyncratic shocks (Kodres & Pritsked, 2002). Under such circumstances, investors tend to rebalance portfolios from the alternative market to mitigate total portfolio risk. In general, the use of interest rate as a defence for exchange rate volatility, and vice versa is contentious between monetarist and revisionist schools of thought. The Monetarists posit negative relationship between interest rate and exchange rate. This means that contractionary monetary policy through increase in interest rate leads to exchange rate appreciation. On the other hand, the Revisionist do not support the use of interest rate in stabilising exchange rate volatility, arguing that contractionary monetary policy stance can be counterproductive in an unhealthy financial environment (Radelet & Sachs, 1998; Stiglitz, 1998; Gümüş, 2002).

Empirical studies have investigated interest rate and exchange rate nexus on the foundation of these theories. These studies focus on the correlation between the duo, and the impact of one on the other. The extant empirical findings are mixed. For instance, Kayhan, Bayat, and Uğur (2013), Shodipe (2018), Capasso, *et al.* (2019), Nnamani and Anyanwaokoro (2019) and Adeshola *et al.* (2020) find positive impact of interest rate on exchange rate, while Babatunde and Olufemi (2014) and Kisaka and Ouma (2017) established negative relationship. However, some studies could not find significant dynamic linkage between interest rate and exchange rate (Choi & Park, 2008; Lungu & Johannes, 2014). The theoretical cum empirical controversy is investigated in this current study at the level of second moment to understand the school of thought that the two markets in Nigeria support.

Further, most of the existing studies do not simultaneously capture the ups and downs (dynamics) of this relationship because the method employed are based on a linear framework of ordinary least squares (OLS). Investors are interested in the information relating to simultaneous reaction of markets to help reduce portfolio risk. Similarly, a typical central bank is worried about the persistent fluctuations of these rates because a sustained volatility of any of the rates could undermine the price stability goal of the monetary authorities due to the spillover effects each market could have on the other. Unfortunately, OLS neither captures this co-movement nor the dynamics of the conditional variances and conditional covariances. Engle and Kroner (1995) and Bauwens *et al.* (2006) suggest that such dynamics can be investigated directly by applying a multivariate generalised autoregressive conditionally heteroskedastic (MGARCH) model.

While contributing to the existing debate, this study deviates from extant literature by applying Engle (2002) Dynamic Conditional Correlation (DCC) and Baba, Engle, Kraft and Kroner (BEKK) forms of MGARCH model to examine the dynamic relationship and transmission channel of money market and foreign exchange market volatilities in Nigeria. Unlike other forms of volatility models, DCC and BEKK models allow spillover across assets under study. The study is unaware of any other study that empirically establishes this linkage using DCC-GARCH and a full or unrestricted BEKK-GARCH forms of multivariate GARCH model in Nigeria. Deebom and Tuaneh (2019) attempted modelling exchange rate and deposit money bank interest rate in Nigeria using a diagonal form of trivariate BEKK-GARCH model. The full BEKK adopted in this study is unique to diagonal BEKK employed by Deebom and Tuaneh (2019) and other variants of MGARCH as full BEKK ensures positive definiteness of the variance-covariance matrix and allows volatility dependence across markets or assets (Engle & Kroner, 1995; Brooks, 2014; Shiyun, 2015).

In view of the methodological gap in literature and the possible implications of exchange rate and interest rate volatility spillovers, the study seeks to: (i) assess the nature of correlation between interbank interest and Naira/US Dollar Bureau De Change (BDC) exchange rates over time (ii) investigate the spillover of market shocks between BDC exchange rates and interbank interest, and (iii) examine the volatility transmission channel of BDC exchange rates and interbank interest in Nigeria. The study outcome provides useful policy advice to the monetary authority on the appropriateness of interest rate in moderating volatility in the foreign exchange market, and vice versa. Investors could also leverage on the outcome of this study to rebalance portfolio and minimize investment risks that could arise from the volatility in any of the markets.

The remainder of this study is structured thus: following this introduction is Section 2, which discusses relevant theoretical and empirical literature as well as conceptual review. Section 3 outlines the methodology adopted, while Section 4 presents the results and discussion. Section 5 concludes the study with some policy recommendations arising from the study results.

2.0 Literature Review

2.1 Theoretical Literature

The theoretical perspective of the relationship between exchange rate and interest rate can be extricated from the Frenkel (1976) monetary model or Dornbusch (1976) assets view of exchange rate determination. Frenkel (1976) argues that the rate of increase in money supply brings an equi-proportionate contemporaneous rate at which domestic currency depreciates. This implies that as the supply of money increases through the reduction in interest rate, exchange rate and domestic prices tend to rise.

Furthermore, Frenkel (1976) argues that expectations tend to dominate the liquidity effect in a hyperinflation situation, thus leading to a positive relationship between exchange rate and interest rate. As presented by Belke, Geisslreither and Gros (2004), interest rate volatility should increase when exchange rate volatility is checked. Relying on this postulation, most monetary authorities in emerging economies intervene in the money market to tame the fluctuation in the foreign exchange market. For instance, most Asian central banks adopted contractionary monetary policy to address the 1997 currency crisis. The hypothesised negative relationship is further elucidated by the asset approach with short run liquidity effect of changes in money supply being accommodated. Thus, in the short run, a higher interest rate induces an appreciation of the currency (Dornbusch, 1976). However, there are other opposing arguments that support a positive relationship. Furman and Stiglitz (1998) opine that increasing interest rates can depreciate the domestic currency in an economy with high default risk and the unhealthy financial and corporate sectors.

The conflicting theories, which are based on macroeconomic fundamentals appear not to sufficiently meet the expectations of investors and macroeconomic managers. Information required by stakeholders in the financial markets are asymmetric in nature, which can be effectively assessed by a simultaneous examination of markets in a nonlinear framework. According to Pericoli and Sbracia, (2003), asymmetric behaviour cannot be explained by macroeconomic fundamentals. In fact, since the findings of Meese and Rogoff (1983), it is becoming generally acceptable that structural models are no longer effective for exchange rate determination. Economists have used the concept of volatility or financial contagion and assets co-movement to examine asymmetric relation of financial assets such as interest rate and exchange rate. Theories, such as Herding behaviour theory, wake-up call hypothesis or information correlation theory and portfolio channel theory have been proposed for examining volatility and co-movement of financial assets.

Herding behaviour theory is premised on the assumption that asymmetric information is available to market participants, meaning that once risk is identified in one market, market participants would tend to re-evaluate other markets based on the available limited information (Cipriani & Guarino, 2008; Cheng *et al.*, 2009). The wake-up call hypothesis or information correlation theory explains that instability in one market portends uncertainty in another market. Thus, with the disruption in one market, investors tend to develop expectations that could cause aspersion in the other market in the short term. Portfolio channel theory, according to Kodres and Pritsked (2002), explains the investors' reaction when one market is affected by idiosyncratic shocks. Thus portfolio rebalancing takes place through the alternative market.

2.2 Empirical Literature

There are vast empirical works on the relationship between exchange rate and interest rate in finance and economic literature. While some of the studies support the hypothesised negative relationship of the Monetarists, others found evidence to support a positive relationship between exchange rate and interest rate. However, a few others are found in-between the two-opposing stances in literature. This section of the study is approached in accordance with the stances in empirical literature.

Eichenbaum and Evans (1995) investigate the effects of United States monetary policy shocks on exchange rates by employing dynamic vector autoregressive framework. The study reveals a significant evidence in support of monetary policy and exchange rates linkage and stresses that a tight monetary policy shock causes persistent and significant appreciations of U. S.

nominal and real exchange rates. Kisaka and Ouma (2017) examine the presence of the forward premium puzzle in the foreign exchange market in Kenya. Using monthly data from 1994 to 2016, exchange rate, Kenyan, and US governments' 91-day treasury bills rate were found to be cointegrated. By applying error correction method, results suggest the presence of the forward premium puzzle in the foreign exchange market in Kenya, implying that a higher interest rate relative to foreign interest rate appreciates the value of domestic currency.

Among the related studies done on Nigeria, the closest to ours, in terms transmission of own shocks and volatility, is Deebom and Tuaneh (2019). They investigated the linkage among the returns of Naira to Dollar exchange rate, maximum and prime lending rates in a VECM framework with monthly data from 1997 to 2017. The study compared the VECM estimates with the results from an estimated trivariate diagonal BEKK-GARCH form of MGARCH. The trivariate diagonal BEKK-GARCH model was preferred. From the estimated diagonal BEKK-GARCH model, own shocks had effect on the current volatility of the money market indicator; while own volatility had effect on the current volatility of exchange rate and the money market rates. The study could not ascertain shocks and volatility spillover across the variables due to the restrictions placed on the diagonal BEKK-GARCH model applied. In our study, we applied the full BEKK instead of the diagonal BEKK to allows shocks and volatility dependence across markets.

In another study, Babatunde and Olufemi (2014) examined the behaviour of monetary policy shocks and exchange rate volatility. The study employed OLS to investigate the short run impact of monetary policy determinants of exchange rate volatility as well as Engle-Granger technique to evaluate the long-run interaction among the variables. Results suggest a causal relationship between the past values of monetary policy variables, particularly interest rate and the exchange rate. The study concludes that interest rate is crucial for exchange rate management in Nigeria. Ajao and Igbekoyi (2013) utilise GARCH (1,1) techniques to extract the conditional variance of real exchange rate and investigate its determinants in an error correction framework. Interest rate was found to be one of the significant determinants of real exchange rate volatility in Nigeria. The study suggests that the monetary authority should institute policies that will stabilise exchange rate. By implication, the authors could be referring to the use of interest rate, being the main monetary policy tool to stem the exchange rate volatility. Again, Effiong (2014) uses a cointegrated SVAR technique to investigate the validity of the monetary exchange rate model in Nigeria in the short run and long run with data from 1987:Q1 to 2011:Q4. Findings from the study reveal that interest rate differential is the only significant variable and explains significant proportion of variations in the nominal exchange rate in the short-run.

Studies supporting positive relationship in advanced and emerging economies include Chen (2006), who employs Markov switching approach to investigate interest rate–exchange rate nexus by pinning down on the effectiveness of interest rate in the defence of exchange rate in Indonesia, Mexico, Philippines, South Korea, Thailand and Turkey. The result confirms a positive relationship between interest rate and exchange rate and emphasises that a contractionary monetary policy deepens foreign exchange crisis. The study refutes the argument that a high interest rate policy is a defensive mechanism for exchange rate in the countries studied. Kayhan, Bayat, and Uğur (2013) investigate the dynamic relationship between real interest rate and real exchange rate in Brazil, Russia, India, China and Turkey by utilizing a nonlinear causality test and frequency domain causality test techniques to capture the asymmetric properties of the relationship. The results indicate that, in the long run, interest rate affects exchange rate positively in China only, while exchange rate shocks induce positive changes in interest rate in the short run. The study concludes that stakeholders should consider interest rate behaviour to circumvent probable risk emanating from exchange rate shock.

Using two stage least squares, Shodipe (2018) provides evidence to support positive relationship between real interest rate and real exchange rate in Japan. The study argues that continuous decrease in monetary policy rate will cause domestic currency to lose its competitiveness, especially when its rivals adjust to macroeconomic dynamics and investors become more responsive to higher returns on investments. Belke, Geisslreither and Gros (2004) examine exchange rate volatility and interest rate volatility interactions in the MERCOSUR (Mercado Común del Sur) countries by utilising models that explain systematic correlations between the movements of the variables at the level of second moments. The empirical work controls for monetary volatility, financial stress, and exchange rate misalignment. The model results reveal a co-movement of interest rates and exchange rates in the MERCOSUR countries, independent of the control variables. Capasso *et al.* (2019) examine the long-term interrelationship between interest rate and exchange rate in Mexico using a nonlinear autoregressive distributed lags (NARDL) model. The study confirms asymmetry; further results show that the exchange rate has significant effects on the interest rate, but interest rate exerts no statistically significant impact on the exchange rate in the long run. The study relates the results to monetary authorities' reluctance to free float.

In Nigeria, Nnamani and Anyanwaokoro (2019) investigate the effect of monetary policy rate on the exchange rate using autoregressive distributed lag (ARDL) model. The results suggest that monetary policy rate has a positive and significant effect on the exchange rate. Similarly, Adeshola *et al.* (2020) employed the same method as in Nnamani and Anyanwaokoro (2019) to investigate the impact of interest rates (deposit and lending) on exchange rate in Nigeria from 1981-2018. The result depicts a positive relationship that increase in lending rate depreciates the Naira to Dollar exchange rate significantly, but the exchange rate appears insensitive to increase in deposit interest rate.

It is interesting to find that some studies could not align with any of the opposing stances in literature. Choi and Park (2008) employ VAR causality technique to examine the suitability of contractionary monetary policy in calming exchange rates fluctuations in Indonesia, Korea, Malaysia and Thailand in the long run and short run. The study found no evidence to suggest that interest rate differentials affect spot exchange rates at all horizons, except for some subsample for Malaysia. Similarly, Lungu and Johannes (2014) examine the behaviour of interest rate and exchange rate in Namibia from 1993:Q1 to 2012:Q4. The cointegration test result fails to establish a long run relationship; and the impulse response function could not identify any systematic relationship between the two variables. Using data from Indonesia, Korea, Philippines and Thailand to estimate a bivariate VAR-GARCH model, Kwan and Kim (2004) examine the behaviour of exchange rates and interest rate alongside the evolution of their dynamics following the post-Asia crisis. The study found no reason to support the use of interest rate in stabilising exchange rates fluctuations in these countries. Furthermore, the results reveal no strong evidence to suggest volatility spillover of interest rate and exchange rate. The result of the most closely related work to this study also lies in both sides of the divide.

However, there are evidence that the dynamic relationship could change over time. In that regard, some studies tend to support both opposing theories, depending on the time horizon. Hacker *et al.* (2010) examine the relationship between spot exchange rate and interest rate differential between Sweden and seven other nations: United States, Japan, European Union, United Kingdom, Switzerland, Norway and South Korea. In the short run, the results reveal a negative relationship between exchange rate and interest rate differential, while positive relationship is established in the long run. The authors argue that the sticky-price model of exchange rate determination is confirmed in the short run while flexible-price models explain the sign of the relationship better in the long run. In Nigeria, Oke, Bokana and Shobande (2017) employ Johansen cointegration and vector error correction mechanism approaches to examine the relationship between exchange rate, domestic and foreign interest rate. Inflation, money supply and national output were included in the model as control variables. The study established a bi-directional relationship among the variables but argues that growth-enhancing contractionary monetary policy is necessary for appropriate exchange rate; but cautioned that increase in these variables must be moderate in order not to plunge foreign exchange market into crisis.

From the reviewed literature, it is evident that the relationship between interest rate and exchange rate is well documented, although with mixed findings. None of the studies strictly investigated the volatility spillover of the two variables. Only the study by Kwan and Kim (2004) for four Asian economies, Belke, Geisslreither and Gros (2004) for MERCOSUR countries and Deebom and Tuaneh (2019) for Nigeria methodologically delve into the subject, but sources of spillover were not identified in the studies. Also, in Nigeria, the study by Ajao and Igbekoyi (2013) and Babatunde and Olufemi (2014) relates interest rate with exchange rate volatility, but with an approach that does not convey the feedback effect of exchange rate volatility. Another important feature of these studies is the use of monetary models of exchange rate determination in investigating interest rate and exchange rate dynamics. Since the work of Meese and Rogoff (1983a, 1983b), that could not find any monetary model of exchange rate that outperforms a random walk (MGARCH foundation), most of the empirical works that relied on monetary models suffered from endogeneity problem and persistence of the explanatory variables in the regression (Neely & Sarno, 2002). The inadequacies of these models could stem from the changing dynamics of capital account transactions and payment system arising from increasing liberalization of most economies that allows freer and faster flow of capital across national boundaries leading to more volatility in interest rates and exchange rates. These deficiencies form part of the motivation for this current study as it applies a time varying volatility model that accounts for feedback on the variables of interest and identifies the sources of volatility.

2.3 Conceptual Review

2.3.1 Money Market and Interest Rate Dynamics

Money market is seen as an aspect of financial market designed to facilitate trading in short term debt instruments to meet short-term needs. The distinctive features of this market lie on the instruments and participants. The life span of money market instruments such as treasury bill, commercial papers, bankers' acceptances, and certificate of deposit ranges from few hours to one year. Participants in the market are mostly, the central banks, commercial banks corporate organisations and individuals. Money market instruments are largely offered by central banks for the control of money supply in the economy, while companies offer short-term instruments principally to source for capital.

Money market and the banking system are instrumental for transmission of monetary policy. The efficiency of the central banks' monetary policy and the transmission of its impulses into the real economy are enhanced by well developed, active and efficient interbank system and money market operations (Warjiyo & Juhro, 2019). In other words, the progress of the financial intermediation is smoothened by the development of money market, which serves as an important parameter for measuring the level of financial development of the economy.

There is always a price for the release of funds in exchange for short-term money market instrument. This price or interest rate, which is a return from lending out money or cost of borrowing money determines the amount of liquidity and volume of activities in the market. The dynamics of interest rate can affect the activities in other facets of financial market and the overall economy. For example, a low interest rate may cause depreciation of exchange rate, which can make exports cheaper and increase aggregate demand for an exporting country. Hence, understanding the behaviour of interest rate could help keep track of the economy.

2.3.2 Foreign Exchange Market and Exchange Rate Dynamics

Foreign exchange market is a platform where foreign currencies are traded. The major operators in the foreign exchange market are central banks, commercial banks, merchant banks, and bureau de change (BDC). The central bank is a wholesale dealer while the other banks and BDC are retail dealers. The rate at which one currency exchange for another on the foreign exchange market is the exchange rate.

In an economy, exchange rate functions as key price variable. It performs the role of maintaining international competitiveness of a domestic currency. Often, exchange rate management keeps economic managers on their toes because of its volatile nature and sensitivity in the achievement of macroeconomic stability. Business entities also take exchange rates movements into consideration in making investment decisions.

The focus of economic managers has always been on the volatility of exchange rate and its impact on business cycles. This is because, exchange rate fluctuations can create inefficiency and distort price stability objective of monetary authorities. According to Ghiba, (2010), excessive exchange rate depreciation may jeopardize the financial soundness of banks and the borrower's ability to repay their loans. Munthali *et al.* (2010) provide evidence of high growth periods being associated with undervalued currencies.

In most monetary models of exchange rate determination, interest rate plays an important role. On the other hand, the role of exchange rate movement cannot be downplayed when examining interest rate dynamics. This implies that the fluctuations in the two variables can be separately examined endogenously and as being influenced by exogeneous factors. As noted by Belke, Geisslreither and Gros (2004), the two variables can move together given that the connection between them could be affected by other factors like the rates of money growth, capital flows or country risks, but the question on how exchange rate and interest rate volatilities co-move in emerging markets is not yet fully described in the literature. This further underscore the relevance of this current study.

2.3.3 Multivariate GARCH, Volatility Spillover and Co-movement

Multivariate GARCH models are volatility modelling techniques that simultaneously model the heteroskedasticity (conditional variance) and conditional covariance of two or more assets returns. They are structured to allow the conditional variances and covariances to depend on the information set in a vector autoregressive moving average (ARMA) framework and suitable for analysing dynamics of assets pricing. This class of models are extension of univariate GARCH models proposed by Bollerslev (1986). Given that volatilities of cointegrated markets co-move, it is important to simultaneously measure the volatility spillover (volatility transmission) of the assets returns in the markets as well as the channel of transmission.

There are many MGARCH variants, which include vector error conditional heteroscedastic

(VECH), constant conditional correlation (CCC), dynamic conditional correlation (DCC) and BEKK model proposed in Engle and Kroner (1995). To effectively examine the contagion between foreign exchange and money markets, it is expected that the variance-covariance matrix of MGARCH variants must be positive definite, that is, allowing volatilities to move across markets. The VECH and CCC fall short of this expectation. The DCC-GARCH and BEKK-GARCH model are forms of multivariate GARCH processes typically preferred in applications (Engel 2002 and Farid, Florian & Robert, 2011). It ensures positive definite variance-covariance matrix as well as keeping a reasonable number of parameters. These models parametrize the conditional correlations directly and at the same time estimate in two steps: a series of univariate GARCH parameters and the dynamic correlation (Engle, 2002).

3.0 Data and Methodology

3.1 Data

The data were sourced from the Central Bank of Nigeria Statistics Database, available online (http://statistics.cbn.gov.ng/cbn-onlinestats/DataBrowser.aspx). The study covers the period from January 2007 to August 2019. The period was carefully chosen to accommodate the monetary policy framework where monetary policy rate (MPR) is used as the anchor for short term money market rates.

The variables used are interbank call rate (IBR) and bureau de change (BDC) Naira/US Dollar exchange rate, representing money market and foreign exchange market, respectively. The interbank call rate is the interest rate at which banks borrow or lend among themselves in the interbank segment of the money market. Although there are other forms of interest rates, but interbank call rate is preferred in this study as it is a major rate in the money market with the highest volume of trading conducted with it. More so, the dynamics of monetary policy rate or decisions is more evident in the interbank segment of money market; hence the market is taken as the most vital in the transmission of monetary policy. Similarly, the exchange rate at the BDC window of the foreign exchange rate market is chosen for this study because it reflects the dynamics of the market fundamentals more than other exchange rates prevailing in different windows of the foreign exchange market.

The underlying series of the two financial assets are their log returns. The log returns (also known as continuously compounded one-period return) widely used in empirical studies (Fama, 1965; Ogum *et al.,* 2005; and Atoi, 2014) is applied in this study. The returns of asset prices are used in empirical applications primarily because returns account for the fluctuations in assets prices and are usually stationary. The continuously compounded one-period return, denoted as r_t is given as:

$$r_t = 100 * ln\left(\frac{P_t}{P_{t-1}}\right) \quad (1)$$

where ln is the natural log, P_t is the current asset price and P_{t-1} is the previous price of the asset. Applying this formalization, we derive the returns for IBR denoted as RIBR. In line with the concept of depreciation and appreciation computation of exchange rate in financial economics, equation 1 is inverted to generate the returns for BDC, denoted as RBDC.

3.2 Model Specification

The RBDC and RIBR are used to estimate the dynamic conditional correlation as well as spillover of exchange rate and interest rate through the frameworks of Dynamic Conditional Correlation and Multivariate GARCH Models. The specifications and their relevance are provided in this subsection.

3.2.1 Dynamic Conditional Correlation of RBDC and RIBR

Bollerslev (1990) assumes that the conditional variance-covariance matrix is given by:

$$H_t = F_t G F_t \quad (2)$$

where $F_t$is the diagonal matrix consisting of the conditional standard deviation of error terms, $\sqrt{h_{11,t}}$ and $\sqrt{h_{22,t}}$ for the case of two assets (in our case, RBDC and RIBR). G is time invariant conditional matrix of correlation, thus making equation 2 to be constant conditional variance-covariance matrix. The assumption that G is time invariant is unrealistic because the correlation between asset returns is expected to vary over time. Hence Engle (2002) respecify time varying version of equation 2 by allowing G to vary over time. Thus we have:

$$G_t = \begin{bmatrix} 1 & \rho_{12,t} \\ \rho_{21,t} & 1 \end{bmatrix} \quad (3)$$

where $\rho_{12,t}$ and $\rho_{21,t}$ are time varying conditional correlations. Here, G_t is now a Dynamic Conditional Correlation (DCC) model. To circumvent the challenges of parameterization of the conditional correlation, the time varying conditional correlations are assumed to follow a structure similar to GARCH (1, 1) standardized model. The time varying conditional correlations are expected to fall between -1 and 1. To ensure that $\rho_{21,t} = [-1, 1]$we follow the transformation of $\rho_{21,t}$in Tsay (2005) such that:

$$\rho_{21,t} = \frac{\exp(q_t) - 1}{\exp(q_t) + 1} \tag{4}$$

where q_t is defined as:

$$q_t = \omega_0 + \omega_1 \rho_{21,t-1} + \omega_2 \frac{\mu_{1,t-1}}{h_{11,t-1}} \frac{\mu_{2,t-1}}{h_{22,t-1}} \tag{5}$$

Equation 5 modells the correlation coefficient in terms of its past value and the cross-product of the standardized shocks, which is a GARCH (1, 1) model for correlation coefficient. Thus, the dynamic analysis of RBDC and RIBR is examined from the behaviour of $\rho_{21,t}$, that is, the extent $\rho_{21,t}$ is close to -1 or +1 at any given time. Where $\rho_{21,t}$is greater than or equal to -0.5 in most of the sample period, it suggests that exchange rate and interest rate in Nigeria are negatively and dynamically linked (or co-move negatively), but positively and dynamically linked (or co-move positively) if greater than or equal to +0.5. Having established the dynamic nature, we also evaluate the volatility spillovers across the returns. The DCC model is competitive with multivariate GARCH specifications and superior to moving average methods (Engle, 2002).

3.2.2 Multivariate GARCH Models for Volatility Spillover

Conventionally, volatility modelling starts with the estimation of the mean equation. The following mean equations are specified for RBDC and RIBR.

$$\text{RBDC}_t = k_1 + \varphi_i \mu_{1,t-1} + \mu_{1,t} \tag{6}$$

$$\text{RIBR}_t = k_2 + \varphi_i \mu_{2,t-1} + \mu_{2,t} \tag{7}$$

where: RBDC_t and RIBR_t are monthly returns in foreign exchange and money market at time t and $\mu_{i,t}|\bigcup_{t-1} \sim N(0, H_t)$ is a random noise from each market at time t assumed to follow a students' t distribution. Financial returns series possess fat tail, which is not accommodated in a normal distribution, thus Bollerslev (1986) recommended student t assumption for volatility modelling. $\bigcup_{t-1}$ denotes the market information that is available up to time t-1 alongside the 2×2 conditional variance-covariance matrix, H_t, which is modelled with an MGARCH process.

The unrestricted BEKK multivariate GARCH model proposed in Engle and Kroner (1995) is utilized in this study. It stands unique among other variants of multivariate GARCH models because it ensures positive definiteness of the variance-covariance matrix (H_t), which allows volatility dependence across markets. To keep overparameterization burden low, a full bivariate BEKK GARCH (1, 1) process of H_t is specified as:

$$\begin{bmatrix} h_{11,t} & h_{12,t} \\ h_{21,t} & h_{22,t} \end{bmatrix} = \begin{bmatrix} w_{11} & w_{12} \\ w_{21} & w_{22} \end{bmatrix} + \begin{bmatrix} \alpha_{11} & \alpha_{12} \\ \alpha_{21} & \alpha_{22} \end{bmatrix}' \begin{bmatrix} \mu_{1,t-1}^2 & \mu_{1,t-1}\mu_{2,t-1} \\ \mu_{1,t-1}\mu_{2,t-1} & \mu_{2,t-1}^2 \end{bmatrix} \begin{bmatrix} \alpha_{11} & \alpha_{12} \\ \alpha_{21} & \alpha_{22} \end{bmatrix}$$
$$+ \begin{bmatrix} \beta_{11} & \beta_{12} \\ \beta_{21} & \beta_{22} \end{bmatrix}' \begin{bmatrix} h_{11,t-1} & h_{12,t-1} \\ h_{21,t-1} & h_{22,t-1} \end{bmatrix} \begin{bmatrix} \beta_{11} & \beta_{12} \\ \beta_{21} & \beta_{22} \end{bmatrix} \quad (8)$$

where $h_{11,t}$ represents the conditional variance of RBDC and $h_{22,t}$ is the conditional variance of RIBR. $h_{12,t}$ = $h_{21,t}$ is the conditional covariance between RBDC and RIBR. The parameters to be estimated are w_{11}, w_{22}, $w_{12}(w_{21})$, α_{11}, α_{12}, α_{21}, α_{22}, β_{11}, β_{12}, β_{21} and β_{22}.

$$H_t = \begin{bmatrix} h_{11,t} & h_{12,t} \\ h_{21,t} & h_{22,t} \end{bmatrix}; W = \begin{bmatrix} w_{11} & w_{12} \\ w_{21} & w_{22} \end{bmatrix}; A = \begin{bmatrix} \alpha_{11} & \alpha_{12} \\ \alpha_{21} & \alpha_{22} \end{bmatrix} \text{ and } B = \begin{bmatrix} \beta_{11} & \beta_{12} \\ \beta_{21} & \beta_{22} \end{bmatrix}$$

In equation 8, positive definiteness of H_t is guaranteed by including the quadratic terms on the right-hand side of the specification. Matrices A and B diagonal parameters (α_{ii} *and* β_{ii}) measure the effects of own past shocks and past volatility in each market on its conditional variance. The matrices A and B off-diagonal (lower diagonal) parameters (α_{ij} and β_{ji}) are used for testing the null hypotheses by measuring the spillover effects across the two markets.W is a 2×2 matrice of the constant terms of variance and co-variance of the markets.

In examining the volatility spillover between the two markets, we first investigate the existence of direct relationship between RBDC and RIBR. If no relationship exists, that is α_{12}, α_{21}, β_{12} , and $\beta_{21}$are not significantly different from zero, then the conditional variance of interbank interest rate and BDC exchange rate returns volatilities can only be determined by their own past values. Where dynamic relation is established, we examine the volatility spillover from BDC exchange rate return to interbank interest rate return, which amounts to probing whether β_{12} and α_{12} are significantly different from zero; and determine the effect of interbank interest rate return volatility on BDC exchange rate return volatility, which implies examining if β_{21} and α_{21} are not significantly different from zero. Thus, in line with the objectives of this study, the null hypotheses are represented as:

Ho: $\alpha_{12} = \beta_{12} = 0$,

Ho: $\alpha_{21} = \beta_{21} = 0$.

3.3 Estimation Procedures

The estimation procedure starts with the generation of interest rate and exchange rate returns as well as examination of the stylized fact of the level and return series. Statistical properties of the return series are discussed by examining the descriptive statistics in order to have an a-priori knowledge of the financial series. Furthermore, the series are subjected to unit root test to determine the order of integration. Appropriateness of the multivariate GARCH models is tested by conducting Engle (1982) pre-ARCH-effects test. If the presence of ARCH-effect is confirmed, the DCC-GARCH (1, 1) and BEKK-GARCH (1, 1) bivariate model are estimated alongside their mean equations using maximum likelihood method in Eviews 11[4] to ascertain the co-movement and volatility spillovers across the two markets. Assuming a first order GARCH (1, 1) model is informed by its wide acceptability in financial time series volatility modelling (Hsieh, 1991; Bera & Higgins 1993; Hansen & Lunda 2004; Hojatallah & Ramanarayanan, 2011), which could be due to its tractability. Besides, higher lag lengths engender overparametrization (Atoi, 2014), and its implementation in a full multivariate BEKK model could be cumbersome. Finally, the post ARCH-effect test is conducted on the estimated BEKK-GARCH (1, 1) bivariate model to know if the heteroscedasticity has been adequately accounted for in the model.

4.0 Results and Discussion

4.1 Stylized Facts

Figure 1 shows the movements in BDC exchange rate and interbank interest rate in Nigeria. In 2007, BDC exchange rate averaged N126.50 to 1$ (one US dollar) when interbank interest rate was about 8.00%. However, during the 2008/2009 global financial crisis (GFC), the exchange rate depreciated to N141.09 per US$ as interest rate inched up to 11.86%. The two rates were relatively stable after the crisis period, though interest rate appears to fluctuate more. At the build-up of general election in Nigeria in 2015, exchange rate depreciated further as interest rate became more volatile.

[4]The EViews code was programmed to follow a Gaussian process.

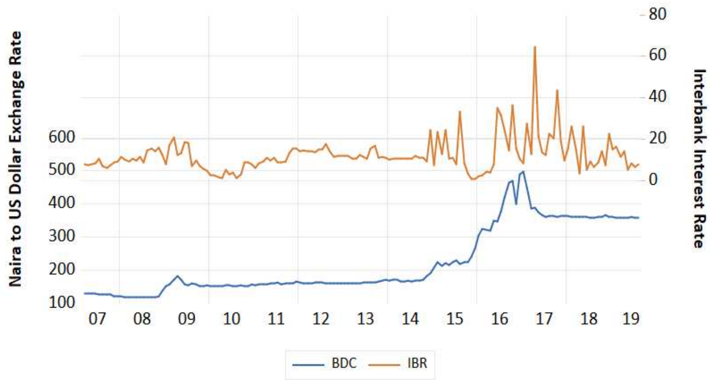

Figure 1: BDC Exchange Rate and Interbank Interest Rate

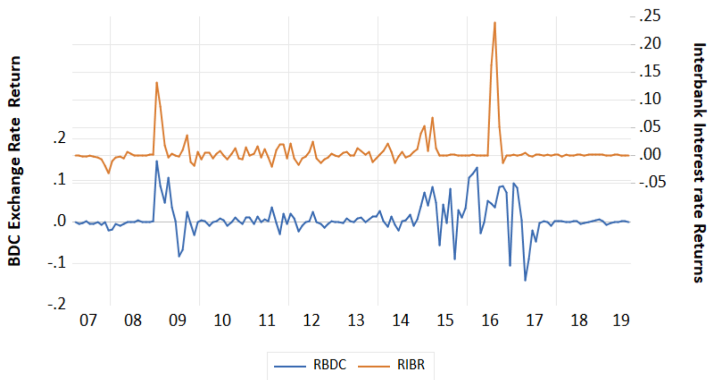

Figure 2: BDC Exchange Rate and Interbank Interest rate Returns

Furthermore, the two rates witnessed intense fluctuations during the period of economic recession in Nigeria in 2016 and 2017, which coincided with CBN policy of further foreign exchange market deregulation in June 2016. In fact, exchange rate depreciated from an average of ₦226.04 in 2015 to ₦361.51 per US$ in 2017 and interest rate moved up from 11.93% to 13.29%. Over the observation period, there seem to be evidence of correlation between the two markets. In Figure 2, similar features were observed in the return series. Intense fluctuations were again recorded during the GFC and economic recession. Two main stylized facts are observed in the return series, which are mean reversion and volatility clustering. These two features respectively imply that fluctuations in return series revolves around the mean values and period of high fluctuations are followed by periods of low fluctuations.

Table 1: Descriptive Statistics

	BDC	RBDC	IBR	RIBR
Mean	223.22	0.01	12.28	0.01
SD	102.82	0.04	8.28	0.03
Skew	0.92	0.40	2.57	5.40
Kurtosis	2.39	6.77	14.15	37.71
J-B	23.44	92.72	941.47	8259.81
Prob	0.00	0.00	0.00	0.00
Obs	150	150	150	150

Table 1 describes the summary statistics of the level series (BDC and IBR) and the return series (RBDC and RIBR). The table reveals a wide difference in the mean of the level series, but the means of return series are approximately zero (an indication of mean reversion). Similar characteristic is observed for the values of standard deviation (SD). However, the values of SD suggest that foreign exchange market is more volatile and could be riskier since higher volatility implies higher risk. The skewness of the level series and return series is higher than that of a normal distribution, suggesting that the series are not from a normal population. The very high Jarque-Bera (J-B) statistic and the small p-values further validate this claim on the normality of the series.

Table 2a: ADF Unit Root Test

	RBDC		RIBR	
	C	C & T	C	C & T
Test statistic	-8.155***	-8.167***	-8.651***	-8.628***
1% level	-3.475	-4.021	-3.474	-4.020
5% level	-2.881	-3.440	-2.881	-3.440
10% level	-2.577	-3.145	-2.577	-3.144

*** denote 1% level of significance.

Table 2b: PPP Unit Root Test

	RBDC		RIBR	
	C	C & T	C	C & T
Test statistic	-6.521***	-6.488***	-8.778***	-8.756***
1% level	-3.474	-4.020	-3.474	-4.020
5% level	-2.881	-3.440	-2.881	-3.440
10% level	-2.577	-3.144	-2.577	-3.144

*** denote 1% level of significance.

The Augmented Dicky-Fuller (ADF) and Philip-Perron (PP) unit root test techniques are employed to determine the order of integration of the return series (RBDC and RIBR). The procedure was conducted by first accommodating constant (C) term and then constant and trend (C & T) in each of ADF and PP technique. The results are reported in Table 2. Judging from the test-statistic of each approach and the corresponding significance level, there is strong evidence to conclude that the returns series are stationary at 1% level. This is expected in returns, being a first order differenced series.

4.2 Pre-Arch Effect Test

Table 3 show the results of pre-ARCH effect test, testing the null hypothesis that the variance is homoscedastic. Given the high values of the F and R-squared statistic and their corresponding small p-values, there is evidence not to accept the null hypotheses of constant variance, which denotes ARCH effect presence in the return series. This provides justification for applying DCC and BEKK-GARCH models to account for the heteroscedasticity in the series (Atoi, 2014; Shiyun, 2015). It is important to use appropriate volatility model to account for the heteroscedasticity because the presence of ARCH effect could reduce the efficiency of the volatility model.

Table 3: ARCH Effect (Heteroscedasticity) Test

	RBDC	RIBR
F-statistic	28.365	25.213
Prob. F(1,147)	0.000	0.000
Obs* R-squared	24.100	21.814
Prob. Chi-Square(1)	0.000***	0.000***

*** denotes 1% level of significance

4.3 Dynamic Conditional Correlation between Naira/US Dollar Bureau De Change exchange rate and Interbank Call rate

The correlation between BDC exchange rate and interbank interest rate was estimated with the DCC-GARCH (1, 1) model and the DCC is presented in Figure 3. The estimated GARCH (1, 1) parameters are reported in Table 4 while the conditional variances are shown in Figure 4. From Figure 3, most of the DCC fell between 0 and -0.2, while few positive correlations were observed to lie between 0 and +0.1. Given that the correlations are mostly negative, it can be inferred that the exchange rate and interest are negatively and dynamically linked, meaning that exchange rate (or interest rate) is negatively sensitive to interest rate (or exchange rate) in Nigeria.

The DCC approached highest negative (approximately -0.4) between 2008 and 2009, which coincided with the period when global financial markets collapsed, indicating that interest rate (or exchange rate) can act as a defence for exchange rate (or interest rate) fluctuations in crisis period. The intuition is that, interest rate increase can be an incentive to mitigate capital reversal and attract new capital inflow during crisis; thus, moderating volatility in exchange rate.

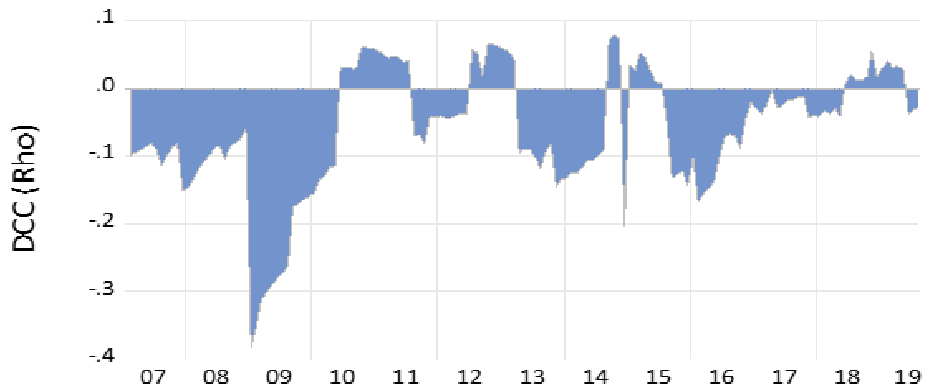

Figure 3: Bureau De Change Exchange Rate and Interbank Call Rate Dynamic Conditional Correlation

4.4 Naira/US Dollar Bureau De Change exchange rate and Interbank Call rate Volatility Spillovers

The estimated BEKK-GARCH (1, 1) model is decomposed into mean and conditional variance equations. The parameter estimates are reported in Table 4. In the mean equation, the estimated coefficient of the moving average terms φ_1 and φ_2 for exchange rate and interest rate returns is positive and significant at 1% level. From the variance equation, the estimated constant terms of exchange rate volatility (w_{11}) and co-variance (w_{21}) equations are statistically significant. Furthermore, the shock parameters of each market (α_{11} and α_{22}) are significant at 1% level, meaning that the volatility of each market is affected by its own past innovations. This corroborates the finding of Deebom and Tuaneh (2019). Similarly, lagged volatility persistence in foreign exchange market (β_{11}) has a positive effect on its own current volatility whereas lagged volatility of interbank interest rate (β_{22}) is negatively related to its own current volatility, but not statistically significant. From the estimated shock parameters, we find that the effects of own shocks and previous period volatility on current volatility of each market is higher in foreign exchange market than in money market.

Table 4: Estimated BEKK-GARCH (1, 1) Bivariate Model for BDC Exchange Rate and Interbank Interest Rate Returns

	Parameters	Coefficient	Std. Error	z-Statistic	Prob.
Mean Equation	k_1	-0.001	0.003	-0.265	0.791
	k_2	0.001	0.004	0.188	0.851
	φ_1	0.410***	0.050	8.175	0.000
	φ_2	0.495***	0.053	9.282	0.000
Variance Equations	w_{11}	0.014***	0.004	3.532	0.000
	w_{22}	0.000	134.850	0.000	1.000
	w_{21}	0.014***	0.003	4.959	0.000
	α_{11}	1.005***	0.160	6.268	0.000
	α_{22}	0.482***	0.122	3.946	0.000
	α_{12}	-0.304**	0.130	-2.337	0.019
	α_{21}	-0.392***	0.086	-4.530	0.000
	β_{11}	0.505***	0.099	5.101	0.000
	β_{22}	-0.409	0.325	-1.259	0.208
	β_{12}	0.504***	0.085	5.901	0.000
	β_{21}	0.062	0.310	0.199	0.842
	Log likelihood	759.354	Akaike info criterion		-9.925
	Avg. log likelihood	5.062	Schwarz criterion		-9.624
	Number of Coefs.	15	Hannan-Quinn criter.		-9.802

***,** and * denote significance at 1%, 5% and 10%, respectively

As earlier mentioned, the parameters, α_{ij} and β_{ji} measure the volatility spillover across the two markets. The volatility parameter (β_{21}) is not significant. However, at 1% level, the shock parameters (α_{12} and α_{21}) and the volatility parameter (β_{12}) across markets are statistically significant. This suggests that shocks and volatility spillover parameters are not all zero, implying that the volatility in the foreign exchange market and money market are dynamically linked, confirming the result of the estimated DCC-GARCH(1, 1) model. This co-movement is an attribute of an integrated market. This gives credence for testing the stated two formulated hypotheses.

The first null hypothesis Ho: $\alpha_{12} = \beta_{12} = 0$ is tested based on the statistical significance of the estimated parameters. The estimated parameter, α_{12} which measures the shocks spillover from foreign exchange market to money market is negative and statistically significant. This means that shock from foreign exchange market has negative spillover effects on the money market. This result corroborates the mostly negative DCC-GARCH correlation between the return series, but contradicts the findings of Kayhan, Bayat, and Uğur (2013) that exchange rate shocks induce positive changes in interest rate in BRIC-T countries, which is in tandem with the Monetarists' view that contractionary monetary policy through increase in interest rate leads to exchange rate appreciation, thus moderation in exchange rate volatility. However, the estimated parameter, β_{21} which measures the volatility spillover from money market to foreign exchange market is positive but not statistically significant, which supports the results of the estimated DCC-GARCH that show very few periods of low positive correlation. This means that news in the money market does not spillover to foreign exchange market. Like the theoretical position of the Revisionist group and the findings of Kwan and Kim (2004) and Capasso, *et al.* (2019), this result, though not significant, does not support the use of interest rate in stabilising exchange rates volatility in Nigeria.

The second null hypothesis Ho: $\alpha_{21} = \beta_{21} = 0$ is tested. The estimated coefficient of shocks from the money market, α_{21} which measures the spillover of shocks from money market to foreign exchange market volatility is negative and statistically significant at 1% level. This result is consistent with the time varying correlation estimated with DCC-GARCH model. This suggests that money market innovation has negative spillover effect on foreign exchange market volatility, meaning that volatility in foreign exchange market can be exacerbated by reducing the money market news. On the other hand, this finding also supports the hypothesized negative relationship between interest rate and exchange rate of the Monetarists, that contractionary monetary policy (increase in policy rate) could moderate exchange rate volatility. This result is contrary to the findings of Adeshola (2020) which showed that increase in interest rate on lending depreciates the exchange rate significantly. Again, the estimated parameter, β_{12} which measures the effect of foreign exchange market volatility on money market is positive and significant at 1% level, meaning that foreign exchange market volatility has positive spillover effects on money market volatility**.** This implies that calming volatility in foreign exchange market does guarantee moderation of volatility in the money market.

4.5 Model Diagnostics

To show that the estimated BEKK-GARCH(1, 1) has accounted for the heteroscedasticity in the returns series, the null hypothesis of no ARCH effect is not rejected at 1% level (see Table 5). Homoscedasticity is an evidence of robust estimated volatility model because ARCH effect has been adequately accounted for.

Table 5: ARCH Effect (Heteroscedasticity) Test

	RBDC	IBR
F-statistic	0.029	0.103
Prob. F(1,147)	0.865	0.748
Obs R-squared	0.030	0.105
Prob. Chi-Square(1)	0.863	0.746

Ho: Variance is homoscedastic

4.6 Analysis of Markets' Conditional Variance

Based on the estimated parameters in Table 4, the graphs in Figures 4 and 5 are plotted showing the conditional variance and conditional covariance of the two returns series over time. The two series exhibit high volatility in 2009 and from 2015 to 2017, coinciding with the 2008/2009 global financial crisis and economic recession as well as devaluation of exchange rate in 2016, respectively.

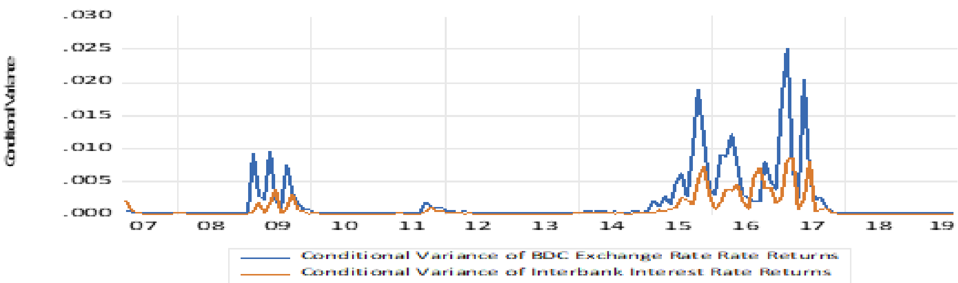

Figure 4: Conditional Variance of BDC Exchange Rate and Interbank Interest Rate Returns.

The BDC exchange rate volatility is higher than that of interest rate during the two periods of intense volatility (in consonance with the estimated model parameters). However, both display strong association and remain calm every other period. Interestingly, the conditional covariance (Figure 4) is very volatile and tends to decrease and increase during the two episodes. By visual inspection, Figures 3 and 4 provide strong evidence to suggest that the two financial returns series are dynamically connected (confirming the model results). Again, the two Figures suggest that economic recession and devaluation of exchange rate in 2016 had more effects on the volatility of the markets than the 2008/2009 global financial crisis.

Figure 5: Covariance of BDC Exchange Rate and Interbank Interest Rate Returns

5.0 Conclusion and Policy Recommendations

5.1 Conclusion

Money and foreign exchange markets are crucial for effective financial intermediation process and vital for monetary policy transmission. A firm understanding of the link between these markets could help the monetary authority on the appropriateness of using interest rate in moderating volatility in the foreign exchange market, and vice versa. Investors can also leverage on the knowledge of the link to rebalance portfolio and minimize risks. This study therefore examines the dynamic correlation and volatility spillovers between BDC Naira/US Dollar exchange rate and interbank call rate. The period of study covers January 2007 to August 2019. The study employs a dynamic conditional correlation form of GARCH to access the nature of correlation, while an unrestricted bivariate BEKK-GARCH form of multivariate GARCH model is utilized to investigate shocks and volatility spillovers of the two rates. The estimated model reveals interesting results.

The estimated DCC-GARCH (1, 1) reveals that interest rate and exchange rate are negatively and dynamically linked, suggesting that markets co-move, which means that exchange rate (or interest rate) is sensitive to interest rate (or exchange rate) in Nigeria. Further, the DCC-GARCH (1, 1) showed that highest point of correlation coincided with the period global financial markets collapsed (2008 and 2009) suggesting that interest rate (or exchange rate) can act as a defence for exchange rate (or interest rate) fluctuations in crisis period. This is supported with the monetarist view of exchange rate determination that, interest rate increase can attract new capital inflow during crisis; thus, moderating volatility in exchange rate.

The DCC-GARCH (1, 1) result was substantiated by the estimated bivariate BEKK-GARCH (1, 1) model. The result shows that the effects of own shocks and previous period volatility on current volatility of each market are higher in foreign exchange market than the money market. This implies that foreign exchange market is more prone to shocks. It further suggests that volatility in the foreign exchange market is more persistent than the money market. There is evidence of strong dynamic linkage of volatilities across the two markets. Further results reveal that shocks from foreign exchange market negatively transmits to the volatility of money market; and money market innovations also transmit to foreign exchange volatility with negative impact. This indicates a bi-directional shocks transmission across the markets. On the other hand, volatility in the money market does not spill over to foreign exchange market, but foreign exchange market volatility spills over to money market. This suggests a unidirectional transmission of volatilities across the markets. In other words, calming volatility in money market does not guarantee moderation of volatility in the foreign exchange market. The results underscore the growing influence of foreign exchange market in Nigerian. This finding also supports the view of the Monetarists in the literature that contractionary monetary policy (increase in policy rate) could moderate exchange rate volatility. In sum, exchange rate is found to exact more pressure on interest rate volatility suggesting that a policymaker confronted with two opposing choices between exchange rate and interest rate stabilization could opt for stable exchange rate.

5.2 Policy Recommendations

Based on the outcomes of the study, the following policy implications are provided. Given the overbearing influence of foreign exchange market, the policy of foreign exchange interventions aimed at keeping exchange rate within its long run path should be strengthened as it could be more effective in moderating interest rate volatility in Nigeria.

The use of interest rate to tame the fluctuation in the foreign exchange market may not yield expected results in Nigeria, given the outcome of the estimated volatility model which reveals that interest rate volatility does not spill over to foreign exchange market.

Given the level of volatility persistence in foreign exchange market, it goes to show the amount of risk in the market. Hence, strategies available to the monetary authority can be applied to moderate the volatility persistence in order not to erode the confidence of productive investors, who may consider the market too risky for investment.

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