ESTIMATING THE TIME-VARIANT CO-MOVEMENT OF EXCHANGE RATE VOLATILITY AND CONSUMER PRICE RETURNS IN NIGERIA

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ABSTRACT

This study examined the dynamic co-movement between the exchange rate volatility and consumer price returns (inflation) in Nigeria. The study adopted DCC-GARCH approach to observe if there exist variations in the correlation between the two variables over different periods using a monthly time series data spanning the period of 2009M1 - 2024M12. The results indicate that the constant mean in the conditional mean equation of $\Delta NEXR$ is statistically insignificant. Likewise, the constant of conditional variance equation of ΔCPI. However, the parameters in both the mean and the variance equations of the two variables are statistically significant at least at 10 percent level, including the ARCH and the GARCH terms in the two equations. Equally, the sums of $\alpha+\beta$ in both conditional variance equations are almost 1.2 indicating a somewhat low persistence in the conditional variances. For the dynamic correlation, its mean-value is estimated to be around 0.105 which shows an unconditional positive, although weak, correlation between returns on exchange rate and inflation in Nigeria over the study period. However, the results of parameter constancy test, χ^2-statistic, indicates strong evidence against the hypothesis of a constant conditional coefficient. The result shows that R_t is different from R at 1 percent level. Thus, we conclude that there is evidence of dynamism in the conditional correlation between the variables. Depicting the dynamism, we observed that periods of 2011M1, 2019M1 and 2020M8 recorded the lowest correlation (the lowest level of pass-through), while 2011M3 and 2012M6 witnessed a somewhat highest correlation between the two volatilities, until Retail DAS (RDAS) was re-implemented towards the end of July 2013. The paper therefore recommends auction of sufficient foreign exchange by the CBN and unification of exchange rates for adequate predictability of inflation rates by the monetary authority.

Keywords: *Exchange rate, Inflation, Volatility, Dynamic Correlation, Nigeria*
JEL Classification: *F31, E31, E44*

1.0 INTRODUCTION

Price stability has been recognized in economic literature as one of the major macroeconomic goals of all national economies. Hence, the objective of monetary, fiscal and exchange rate policies alike must be geared towards achieving sustainable price stability in the economy. In particular, a good exchange rate policy is expected to, among others, maintain stability in the external relative value of the national currency

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as well as domestic prices of imports and exports. This in fact becomes necessary to avoid inflation as economy opens up to global market. The need arises because in seasons of depreciating exchange rate, the value of national currency drops, the implication of this is that increase in the exchange rate has been passed to the consumer (Jian, 2008) via fall in purchasing power of domestic currency and ultimately inflation.

Recently, the level of inflation in Nigeria had been awful, even though we concede that inflation has never been stable in the country since 1986. Evidences have shown a sharp rise in domestic prices of consumer and producer goods. As at December 2024, inflation rate stood at 34.80 percent – one of the worse in the world (NBS, 2025). By December 2025 – a year later, the rate crashed to 15.15 percent due largely to the change in the computational methodology and the base-year period. The rate declined further to 15.1 percent in January 2026 (NBS, 2026). Notwithstanding the debasement, the inflation rate is still a cause for concern as it continues to erode purchasing power, year in, year out.

Just like inflation, exchange rate has not been stable in Nigeria since implementation of the Structural Adjustment Programme (SAP) and adaptation of the foreign exchange market (FEM) in 1986 (Abdullahi & Aliyu, 2023). According to Alao (2010), during the transition in 1986, the exchange rate of naira to US dollar was only ₦2.0206. Nevertheless, by the first half of 2023 the official exchange rate had woefully fallen to around ₦460 per dollar (CBN, 2023). Yet, with the unification attempt of various exchange rates in June 2023, the CBN embarked on the imperfect free floating exchange rate system. As a result, the exchange rate of naira depreciated to an average of over ₦1,535 per dollar in 2024, placing it among the 10 weakest currencies on the Continent (World Bank, 2025). It is therefore not a mere coincidence that inflation rate reached the said 34.80 percent during the same period. It actually testifies to the correlational nature of the two variables in Nigeria. However, naira gets stronger recently, with the rates trending around ₦1,370, ending its poor performance string in the market (CBN, 2026); and perhaps one of the reasons why inflation rates also subsided. Indeed, the monetary authority intervenes now and then through various measures to ensure a relative stability in the value of naira to reduce inflation, which is typical of developing economy; however, the level of fluctuation is still alarming.

One discernible fact in Nigeria had been the co-movement between prices and exchange rates; what is termed as exchange rate pass-through (ERPT) in the literature. However, previous studies on ERPT in Nigeria adopted dynamic analyses that only estimate time-invariant parameters, which often miss the impact of context—such as exchange-rate regime shift in the context of this research [Abdullahi & Aliyu (2023); Adedokun, Ogbaekirigwe & Tiamiyu (2022); Adeyemi & Samuel (2013)]. Another methodological challenge is capturing volatility in these variables.

To overcome these dual challenges therefore, this paper takes a step forward to employ the Dynamic Conditional Correlation—Generalized Autoregressive Conditional Heteroskedastic (DCC-GARCH) technique to determine the co-movement between domestic prices and exchange rates in the presence of volatility which, to the best of our knowledge, has not been done in Nigeria. DCC-GARCH model as suggested by Engle (2002), incorporates modeling both DCC and GARCH as first specified by Bolerslev (1986). Thus, the model is considered effective in dealing with over-time variations in both the mean and variance of the time series data set. Moreover, this GARCH-type model has additional advantage of the fact that detection of possible changes in conditional correlations over time is data dependent (Lee, 2006). The approach represents a significant departure from the traditional methods used in the studies of pass-through in Nigeria, and allows us to capture regime-specific co-movement of the two variables, thereby offering suggestion on the relative sensitivity of inflation to the different exchange rate regimes in Nigeria. Previously, there is no study that attempted to check the time-variant (regime-specific) mean and variance of exchange rate and domestic prices in Nigeria. Moreover, the research work employs monthly series, between 2009M1 - 2024M12 (192 observations), as oppose to previous studies which mostly used annual to quarterly series. The higher frequency data allows for the detection of volatility in the variables.

The paper is organised in five sections including the Introduction. Section two related literature, while section three discusses the methodology used to achieve the objectives of the paper. Section four presents and discusses the empirical findings. Finally, section five concludes the paper and recommendations are offered.

2.0 LITERATURE REVIEW

Generally, Nigeria has adopted various exchange rate regimes over years, in its bid to achieve exchange rate stability which is *sine qua non* to macroeconomic stability. The country has transited from fixed exchange rate regime in the 1960s to pegged regime between the 1970s and the early1980s and finally, to the various forms of floating exchange rate regime since 1986, following adoption of the SAP. Obviously, fixed exchange rate system prevailed in the country between the period of 1960 and 1986 with relative flexibility after 1970. The foreign exchange market in the fixed exchange rate period was characterized by high demand for foreign exchange which cannot be adequately met with the supply of foreign exchange by the CBN. The fixed exchange rate period was also characterized by sharp practices perpetrated by dealers and end-users of foreign exchange Sanusi (2004). The inadequate supply of foreign exchange by the CBN promoted the parallel market for foreign exchange and created uncertainty in foreign exchange rates (Onya, Ojimadu & Ogu, 2013).

A managed floating exchange rate regime, without any strong commitment to defending any particular parity, has been the most predominant of the floating system in Nigeria since introduction of the SAP, with exception of periods of 1984-85 and 1993-98 (Nnanna, 2002). First, it was dual exchange rate system under the Second-Tier Foreign Exchange Market (SFEM) in which naira was allowed to float in two-tier rates. Transitional transaction items, such as debt service payments and official unilateral transfers, were settled at the first-tier rate. The SFEM rate was determined under an auction system in which bidding was done weekly. In July 1987 a unified exchange rate system, Foreign Exchange Market (FEM), was adopted following the integration of the first and second-tier markets that were under SFEM. Under FEM banks were allowed to transact official exchange business among themselves and an autonomous market for private dealers emerged with its different quotations. This according to Nnanna (2002) increased demand for foreign currencies and depreciated further the value of naira.

Dutch Auction System (DAS) was adopted between March 1987 and December 1988 owing to the downward trend of exchange rate experienced under SFEM. Under DAS the frequency of bidding was change from weekly base to fortnightly. The financial recklessness and inability of the then military administration to maintain fiscal discipline overshot the price of US dollar vis-à-vis the naira. For instance, the average naira-dollar exchange rate was ₦4.02/$ in 1987, but by 1989 the rate increased to ₦7.39/$, an approximate depreciation of 84 percent in the naira value (CBN, 2002).

Following this setback, the autonomous foreign exchange market (AFEM) was introduced in 1995. The introduction of AFEM was to provide for the window to redress the market distortions created by the fixed exchange rate regime re-introduced by the then military administration. AFEM operated alongside official exchange rate which was fixed. Although the official rate was stable over the period however the naira value remained volatile in the parallel market. Inter-bank exchange rate market (IFEM) was adopted to replace AFEM in October 1999. Under IFEM, CBN was the main source of foreign exchange and licenses were issued to authorized dealers who purchased on behalf of their customers at a rate determined by the CBN. Although relative stability was restored at the inception, however, volatility resurfaced thereafter prompted by excessive liquidity and increasing government expenditure (Obadan, 2002).

Following the failure of the variants of the flexible exchange rate mechanism to ensure exchange rate stability, the DAS was re-introduced on July 22, 2002. The DAS was to serve the triple purposes of reducing the parallel market premium, conserve the dwindling external reserves and achieve a realistic exchange rate for the naira (Sanusi, 2004). The DAS helped to stabilize the naira exchange rate, reduce the widening premium, conserve external reserves, and minimize speculative tendencies of authorized dealers. The foreign exchange market has been relatively stabilized since 2003. The conditions that facilitated the re-introduction of DAS were basically, the external reserve position which could guarantee

adequate funding of the market by the CBN; reduce inflationary pressures; instrument autonomy of the CBN and its prompt deployment of monetary control instruments in support of the DAS as well as the bi-weekly auctions as against the previous fortnightly auctions, thus, assuring a steady supply of foreign exchange which stabilizes the naira value (Mordi, 2006). Specifically, the naira has fluctuated within a single digit band since the DAS was re-introduced in 2002 (Sanusi, 2004).

The CBN introduced the Wholesale Dutch Auction System (WDAS) on February 20, 2006. This was meant to consolidate the gains of the retail Dutch Auction System as well as deepen the foreign exchange market in order to evolve a realistic exchange rate of the naira. Under this arrangement, the authorized dealers were permitted to deal in foreign exchange on their own accounts for onward sale to their customers. Since then there has been changes in the policy prescriptions and modalities under this system. There was relative stability in the value of naira against that of the US dollar immediately after WDAS was adopted. In fact, the exchange rate of naira to dollar strengthened from the last quarter of 2007 through the entire 2008, to the extent that naira appreciated from about ₦130/$ in 2005 to₦117/$ (10 percent appreciation) in the third quarter of 2008.

However, the fall in the demand for crude oil in the global market, which was caused by global financial crisis, resulted in downward trend in the value of naira from the beginning of 2009. Since then exchange rate of naira has been on its falling trend from ₦147.72/$ in 2009 to over ₦150/$ in 2010. Such depreciation continued in 2011, 2012 and 2013 when the value stood at ₦157.27/$. This development compelled the CBN to suspend WDAS and re-introduce retail DAS with effect from October 2, 2013. RDAS is the direct sale of foreign exchange to end-users through commercial banks during an auction which was done bi-weekly. Subsequently however, the value of naira against US dollar worsened. For instance, in the last quarter of 2014 naira was officially exchanged at ₦169.07 per dollar.

As a policy response, the CBN scrapped direct sale of foreign exchange to end-users which is used to be case under RDAS on February 17, 2015. Users of foreign exchange were thus referred to inter-bank market for transactions. This according to the CBN was done to eliminate the gap between the RDAS and the inter-bank rates which was caused by round-tripping, speculative activities, rent seeking and spurious demand. Unfortunately, even with this measure, exchange rate of naira deteriorated further in 2015 as US dollar exchanged for over ₦197 in the inter-bank market and over ₦300 in black market. Incidentally, authorities blamed falling crude oil price for this setback.

In 2016, the exchange rate was liberalised following the closure of the RDAS due to recession occasioned by the drop in global oil price which depleted the foreign exchange reserves of the economy. To stabilise the market, several policies were implemented which included restrictions of some commodities from accessing interbank foreign exchange rate, limiting withdrawals from naira ATM cards to US$300, and

the use of naira denominated cards abroad. This new foreign exchange regime moved to a more flexible exchange rate, and the exchange rate stabilised at an about N231.76 and N351.82 in June 2016 at the interbank and parallel market segments, representing depreciation of 14.9 and 4.2 percent, respectively (CBN, 2024).

By April 2017, the Investors and Exporters (I&E) window was introduced to deepen the forex market and increase liquidity. According to the CBN, this new policy had stimulated a greater transparency in the operations of the foreign exchange market through the two-way quote and the trading platform. However, the apex bank admitted that foreign exchange had remained scarce even with the policy.

Between 2018 and 2022 CBN implemented a managed floating system aimed at maintaining stability in the relative official exchange rate, while managing shortages in foreign exchange rate supply even with the depleted reserves. The period saw different and varying exchange rates, including the I&E window, the parallel market, and CBN intervention rates. Notwithstanding the stabilization efforts, the official rate of naira weakened to ₦446/US$ around December 2022.

From June 2023, exchange rate management in Nigeria experienced drastic transformations, moving away from managed-floating system to free floating regime. During such period, the rates were highly volatile with rapid naira depreciation. The CBN announced the unification of foreign exchange windows, allowing market forces to dictate the rates. The reform continued throughout the year 2024, and there was easing on hitherto restrictive forex access. This period witnessed the worst performance of naira in recent times as naira depreciated to over N1800 to a dollar in the market (World Bank, 2025).

Post-2024, the CBN strived for the stabilization of the rates through building strong forex reserves and other reforms aimed at encouraging capital importation through foreign portfolio inflows. By 2025, the naira saw its strongest performance in over a decade, appreciating to around N1,530-N1,560 per dollar by November 2025 (CBN, 2026). These events with some remarks are summarised in Table 1 below.

Table 1: Scheme of Events in Exchange Rate Management in Nigeria

S/NO	***YEAR***	***EVENT***	***REMARK***
1	1959-1967	Fixed parity solely with the British pounds	Suspended in 1972
2	1968-1972	Included the US Dollar in the parity exchange	Aftermath of the 1967 devaluation of the pound and the emergence of a strong US Dollar
3	1973	Revert to fixed parity with the British pounds	Devaluation of the US Dollar
4	1974	Parity to both the pounds and US dollar	To minimize the effect of devaluation of the individual currency
5	1978	Trade-weighted basket of currency approach	Tied to currencies: British Pounds, US Dollar, German

			Mark, French Franc, Japanese Yen, Dutch Guilder, Swiss Franc
6	1985	Reference on the US dollar	To prevent arbitrage prevalent in the basket of currency
7	1986	Adoption of Second-tier foreign exchange market (SFEM)	Deregulation of the economy
8	1987	Merger of first and second-tier markets and adoption of Foreign Exchange Market (FEM)	Merger of Rates
9	1987-1988	Introduction of Dutch Auction System (DAS)	Retail sale of foreign exchange by CBN
10	1988	Introduction of Inter-bank foreign exchange market (IFEM)	Merger between Autonomous and FEM rates
11	1994	Fixed exchange rate regime	Regulation of the economy
12	1995	Introduction of Autonomous foreign exchange market (AFEM)	Guided deregulation/dual market
13	1999	Re-introduction of the IFEM	Merger of the dual exchange rates following the abolition of the official exchange rate from January 1, 1999
14	2002	Re-introduction of the DAS	Retail DAS was implemented at first instant with CBN selling to end-users through the authorized dealers (banks)
15	2006	Introduction of Wholesale Dutch Auction System (WDAS)	Further liberalized the market
16	2013	Re-introduction of Retail DAS (RDAS)	Selling to end-users to avoid speculative activities of the authorized dealers
17	2015	CBN abolished RDAS/WDAS	CBN scrapped direct sale to end-users and referred them back to inter-bank market (IFEM)
18	2016-2017	CBN closed RDAS due to low forex reserve occasioned by drop in global oil price	Investors and Exporters (I&E) window was introduced to deepen the forex market and increase liquidity
19	2018-2022	CBN adopted Managed Floating system	Multiple Windows and CBN Interventions leading to gradual depreciation
20	2023-2024	Strong commitment for the Unification of various rates	CBN adopts free Floating (Market) rates and rapid depreciation
21	2025	Efforts for Stabilization	Market-based rates with active FX reserve building, leading to Relative Stability

Source: Compiled from Various CBN Publications.

2.2 Empirical Literature

The relationship between exchange rate volatility and inflation rate, the level of ERPT to prices, has been studied extensively in various jurisdictions using varying methods and techniques. The findings also vary considerably among these studies.

Much earlier studies mostly focused on microeconomic impacts or relationships, focusing mostly on specific industry or a particular commodity, such as: Feenstra (1989); Knetter (1989); Martson (1990); Feenstra, Gagnon & Knetter (1993). However, as from the late 1990s, macroeconomic studies dominate the literature on ERPT, both in Nigeria and elsewhere. These include: Choudhri & Hakura (2003); Bailliu & Fujii (2004); Oladipo (2006); Ca'zorzi et al (2007); Stulz (2007); Aliyu et al (2008); Takhtamanova (2008); Mihaljek & Klau (2008); Oyinlola & Babatunde (2009); Adetiloye (2010); Al Yahyaei (2011); Yunculer (2011); Boamah (2012); Adebiyi & Mordi (2012); Adelowokan (2012); Adeyemi & Samuel (2013); Zubair, Okorie & Sanusi (2013); Bada, et al (2016); Musti & Siddiki (2018); Bello & Sanusi (2019); Adedokun et al (2022); Abdullahi & Aliyu, (2023); Salisu et al. (2024); Adewole et al. (2025).

Likewise, these researches employed diverse techniques of analysis to explore the relationship. Some of the researchers used univariate models such as OLS, WLS, GLS and ARDL e.g. Feenstra (1989), Ca' Zorzi, et al (2007), and Stulz (2007); Abdullahi & Aliyu, (2023); Salisu et al. (2024); Adewole et al. (2025); Enueshike & Harrison (2026). Others employ the use of multivariate techniques such as Vector Autoregression (VAR) and vector error correction (VECM). Some of them include: Yüncüler (2011), Boamah (2012), Adebiyi and Mordi (2012), Adelowokan (2012), Adeyemi & Samuel (2013), Zubair, Okorie & Sanusi (2013); Bada, et al (2016); Bala & Muhammad (2019). Recently, Abel et al (2025) have used structural equation model (SEM) to investigate the magnitude of the pass-through effect in South African countries, and the paper reported complex dynamics in the relationship.

Few studies have also been carried out on the dynamism in the relationship between exchange rate volatility and inflation as well as the impact of exchange rate regime shifts on inflation. For instance, Adeyemi (2024) has concluded that managed flexible exchange rate regime is more impacted positively than fixed exchange rate regime in Nigeria. Also, Nadani and Yusuf (2025) used Markov-switching model to investigate the impact of exchange rate regime shift on inflation in Nigeria. They concluded that the correlation between inflation and exchange rate volatility in the low and high volatility systems is statistically insignificant one, even as the volatility impacts on output. This result is quite doubtful; hence, the decision to review the findings using different techniques.

The major gap identified in the literature is the virtual absence of studies that looked into the time-variant conditional correlation between the two variables of interest, which incorporates the impact of volatility, mostly caused by policy innovations and changing market conditions in Nigeria. Agboola and Olusegun (2017) have used similar model to estimate the time-variant co-movement between stock market and inflation in Nigeria. Also, Nortey et al. (2015) in Ghana have all used DCC-GARCH approach to study the time-variant co-movement between the exchange rate volatility and inflation returns. This paper replicates the approach using monthly time series data of exchange rates and consumer prices Nigeria.

2.3 Theoretical Framework

The theoretical link between exchange rate and domestic prices is traced to the studies of scholars of the University of Salamanca in Spain in the fifteenth and sixteenth centuries (Eun & Resnick, 2009; Al Yahyaei, 2011). During such period, Spain experienced a major influx of gold following the conquest of the Americas. This phenomenon resulted in domestic inflation and depreciation of the Spanish escudo against foreign currencies; the scenario that served as the backdrop of what is now known as purchasing power parity (PPP). The idea was subsequently synthesized by classical economists like David Ricardo. However, it was Gustav Cassel, a Swedish economist, who resurrected and popularized the PPP theory in 1921 as a guide for the industrialized economies to adjust their gold parity when the First World War ended (Dornbusch, 1987; Eun & Resnick, 2009). PPP is an offshoot of the Law of One Price (LOP) which "suggests an identical product sell for the same common-currency price in different countries" (Goldberg & Knetter, 1997). In other words, the LOP states that the price of identical/homogenous basket of tradable goods should be at far when converted to common currency at the market exchange rate (McDonald, 2007).

$$P_t = E_t P_t^* \quad (1)$$

Where P_t stands for the domestic price of imports, E_t is the market exchange rate, and P_t^* stands for the world/foreign exports price. Thus, a complete pass-through is said to be holding if the ratio of the two prices is exactly equal to the market exchange rate between currencies of the trading countries as in equation 2.

$$E_t = \frac{P_t}{P_t^*} \quad (2)$$

In the context of ERPT, both the LOP and PPP imply that any change in exchange rate movement will definitely translate into proportionate changes of domestic price level. Hence, one can vividly view here that LOP and PPP suggest complete pass-through of exchange rate to domestic prices; hence, incomplete pass-through replicates deviation from the PPP theory.

However, from theoretical viewpoint, both LOP and PPP suffer major setback because of the unrealistic strong assumptions or rather conditions enumerated above. Rogoff (1996) argues that the assumption of distortion-free trade without any impediments coupled with that of homogeneity of tradable goods render LOP unrealistic. In contrast, different countries may have different evaluating and weighing schemes for the commodities. Moreover, the assumptions of perfect competition and absence of capital flows invalidate further, both LOP and PPP as such conditions may not necessarily hold in reality (Goldberg and Knetter, 1997).

In response to the shortcomings of what may be called 'absolute' PPP theory, a weaker version is considered by Pakko and Pollard (1996) known as the relative PPP theory. The theory states that

difference in the domestic price spreads (inflation rates) between two countries is adjusted by changes in exchange rate between them. In other words, relative PPP suggests that changes in domestic price levels will be closely, but not absolutely, related to changes in exchange rates. Hence, a period of high inflation rates will experience a depreciating exchange of domestic currency, and vice versa. Consider equation 3 below:

$$\%\Delta E = \left[\frac{\%\Delta P_t - \%\Delta P_t^*}{1 + \%\Delta P_t^*}\right] \approx \%\Delta P_t - \%\Delta P_t^* \quad (3)$$

Where %Δ represents percentage change. Equation 3 represents the relative PPP theory which is said to hold if inflation differential in the two countries is approximately equal to the change in exchange rate. One can infer from the equation that 2 percent depreciation in a domestic country's currency, ceteris paribus, will result in 2 percent inflation in the country. This version of PPP theory seems less restrictive compared to the absolute version as it only relates inflation differentials of two countries to changes in exchange rate between them (Eun and Resnick, 2009; Al Yahyaei, 2011). Thus, complete pass-through can hold even though the LOP fails.

3.0 METHODOLOGY

3.1 Research Design

This research work is basically designed to measure the time-variant co-movement between the volatility in exchange rate and volatility in domestic prices in Nigeria measure in CPI. Hence, the design is basically correlational. Conventionally, for a macroeconomic study of this nature, time series secondary data is employed for the purpose of analysis. The analysis is based on time series econometric modeling which establishes volatility link between the variables of interest.

3.2 Type and Sources of Data

For a time series study, secondary data is normally employed to establish the necessary link or otherwise among the variables of interest; hence, this study is not an exception. Specifically, monthly time series data between 2009M01 and 2024M12 (192 observations) is sought for, from the National Bureau of Statistics (NBS) database, and the Central Bank of Nigeria (CBN). The choice of the timeframe is informed by the CPI reference period to 2009 which has now been changed to December 2024. The CPI basket is updated periodically to reflect the evolving consumption pattern in the economy by adding new items. By 2025, the CPI weight reference period has been changed to 2023, and the price reference period (base year) also to December 2024. So, the paper settles for the said period to avoid such significant distortion in the CPI series. Moreover, the researcher employs monthly data particularly for this test to allow us observe the dynamism of clustering correlation. Obviously, in a financial time series analysis higher frequency data is always preferable, and the highest frequency data obtained from the CBN/NBS on the variables of interest is monthly data.

3.3 Dynamic Conditional Correlation-GARCH Model

The two major methodological challenges of time series studies are time-varying relationships and volatility (Lebo & Box-Steffensmeier, 2008). To overcome these dual challenges therefore, this study employs DCC-GARCH model suggested by Engle (2002), which incorporates modeling both DCC and GARCH as first specified by Bolerslev (1986). According to Lee (2005), this GARCH-type model has additional advantage of the fact that detection of possible changes in conditional correlations over time is data dependent.

The analytical framework for the specification of DCC-GARCH in the study of pass-through is the relative PPP hypothesis of Pakko and Pollard (1996) presented earlier as Equation (3). The theory suggests that difference in the domestic price spreads between two countries is adjusted by changes in exchange rate between them. Hence, inflation rate (returns on prices) is expected to be closely related to returns on exchange rates. Holding foreign price (P_t^*) constant allows us to link directly domestic prices (P_t) and exchange rate (E_t). The framework suggested by Engle (2002) is specified below to model the dynamic processes of conditional correlations and conditional volatilities between the two variables. Let $x_t \equiv [x_{1t}\ x_{2t}]'$ be a 2 × 1 vector containing the returns on domestic prices and returns on exchange rate series in a conditional mean equation. Let represent the conditional mean equation as:

$$y_t = \alpha + \sum_{i=1}^{k} \theta x_{t-i} + \varepsilon_t \quad (4)$$

where $\varepsilon_t \sim N(0, H_t)$ for $t = 1, \ldots, T$ (5)

y_t is the dependent variable and stands for domestic prices represented by ΔCPI, x_{t-i} is the vector of lagged endogenous variable (represented by ΔNEXR), θ represents vector of unknown parameter, and α is the constant mean-inflation (ΔCPI) if endogenous variables are assumed to be zero. ε_t is the error term which is assumed to be normally distributed with zero mean and conditional variance-covariance matrix $H_t \equiv \{h_i\}_t$, for $i = 1, 2$.

Let formulate the GARCH component of the model by first representing the conditional variance-covariance matrix as:

$$H_t = D_t R_t D_t \quad (6)$$

Where R_t is 2×2 time-varying correlation matrix which is represented as $\rho_{ij,}$ for $i \neq j$ or simply $i, j = 1, 2$. D_t is a 2×2 diagonal matrix of conditional standardized residuals $\{\sqrt{h_{it}}\}$, which follow the univariate GARCH (P, Q) processes as in equation 7 below:

$$h_{it} = \vartheta_i + \sum_{p=1}^{P_i} \alpha_{ip} \varepsilon_{it-p}^2 + \sum_{q=1}^{Q_i} \beta_{iq}\, h_{it-q} \quad \text{for } \forall i = 1, 2 \quad (7)$$

Where h_{it} is the variance generated from the mean equation (which is the price volatility); ε_{it-p}^2 is the news about volatility from the previous period, measured as the lag of the squared residual from the mean

equation (the ARCH term); h_{it-q} is the previous forecast variance (the GARCH term); and ϑ_i is the constant.

Secondly, we formulate the bivariate DCC component of the model of the order $M \times N$ as in equation 8 below:

$$R_t = Q_t^{*-1} Q_t Q_t^{*-1} \quad (8)$$

Where:

$$Q_t = (1 - \sum_{m=1}^{M} a_m - \sum_{n=1}^{N} b_n) \bar{Q} + \sum_{m=1}^{M} a_m (\varepsilon_{t-m} \varepsilon'_{t-m}) + \sum_{n=1}^{N} b_n Q_{t-n} \quad (9)$$

Where $Q_t \equiv \{q_{ij}\}_t$ is the conditional covariance matrix of residuals, and $\bar{Q}$ is the unconditional covariance of these standardized disturbances which is specified in equation 10 below as:

$$\bar{Q} = cov(\varepsilon_t \varepsilon'_t) = E[\varepsilon_t \varepsilon'_t] \quad (10)$$

and $Q^* = diag\left\{\sqrt{q_{ii}}\right\}$ is a 2 × 2 diagonal matrix containing the square root of the diagonal elements of Q_t, while *a* and *b* are scalars to estimated.

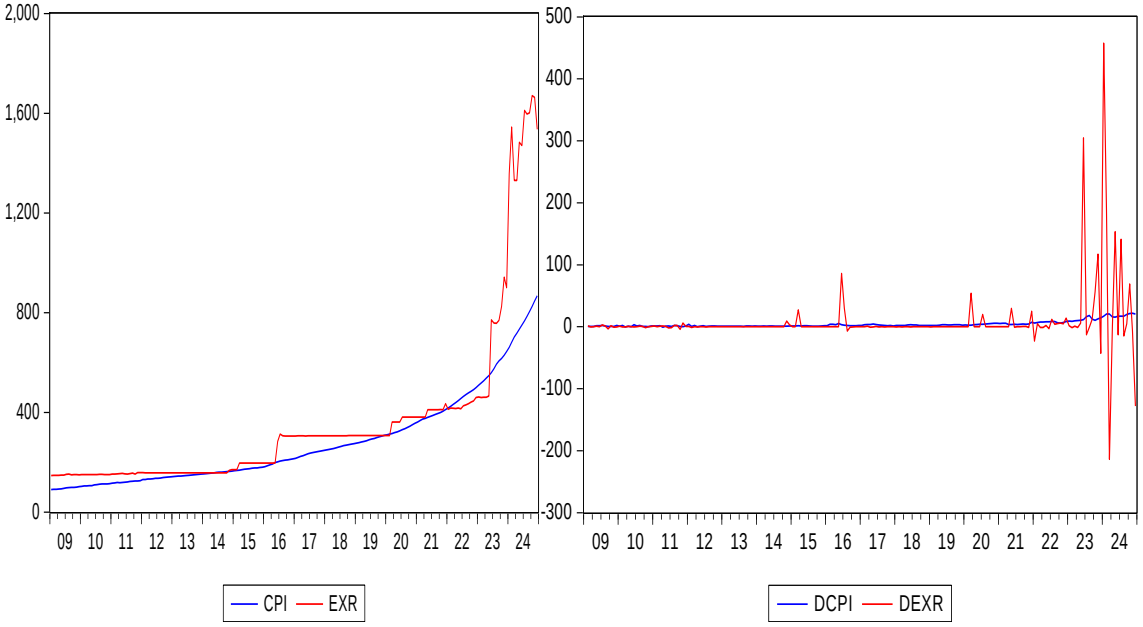
The major element of interest in R_t is $\rho_{12,t} = \frac{q_{12,t}}{\sqrt{q_{11,t}\ q_{22,t}}}$, which represents the conditional correlation between domestic prices and exchange rate volatility over time.

Finally, the bivariate DCC-GARCH structure expressed above will be applied to observe the conditional correlation between returns on consumer price index (inflation) and returns on nominal exchange rate in Nigeria. The software used in conducting this test is *OxMetrics*.

4.0 RESULTS AND DISCUSSIONS

This section presents the plots of the variables which is followed by the analysis of the findings. The section also provides for the discussion of the results obtained from the analysis. Figure 1A and 1B begin by depicting both the behaviour of the absolute values as well as that of the returns of the variables of interest (exchange rates and consumer prices).

Figure 1A & 1B: Plot of the monthly series of Absolute Values and Returns on CPI and NEXR



We first depict the plots of the absolute values of the CPI and NEXR and then the plots of the Returns of these two variables. In Figure 1A, one can observe similar trends in the two variables up until the mid-2023 when there was a significant innovation in the value of NEXR causing a serious break in the series. The same higher volatility in NEXR is observed in Figure 1B around 2023, which was occasioned by the free float exchange rate policy of CBN around that period. This may suggest that the conditional correlation between the two variables would vary over time, depending on the prevailing exchange rate regime as a specific period.

The results begin with the estimation of conditional means as specified in equation (4). The data for the DCC-GARCH estimation is essentially the residuals of the mean equation. The lag specification if one compares the log-likelihood discovers that GARCH (1, 1) best captures the data set used. The results of DCC (1, 1)—GARCH (1, 1) are presented in Table 2.

The Table displays the results of the model which indicate that the constant mean in the conditional mean equation of $\Delta NEXR$ is statistically insignificant. Likewise, the constant of conditional variance equation of ΔCPI. Other parameters in both the mean and the variance equations of the two variables are statistically significant at least at 10 percent level, including the ARCH and the GARCH terms in the two equations. Equally, the sums of $\alpha+\beta$ in both conditional variance equations are almost 1.2 indicating a somewhat low persistence in the conditional variances.

Table 2: DCC-GARCH model estimation results, 1999M1 – 2014M12

Parameter	Coefficient	Std. error	t-value	t-prob.
Cnst $(M)_1$	0.006367***	0.00021082	30.20	0.0000
Cnst $(M)_2$	0.000700	0.0013671	0.5120	0.6093
ϑ_1	-0.001736	0.0019690	-0.8817	0.3790
ϑ_2	0.839605*	0.42687	1.967	0.0507
α_{11}	0.484321*	0.25642	1.889	0.0605

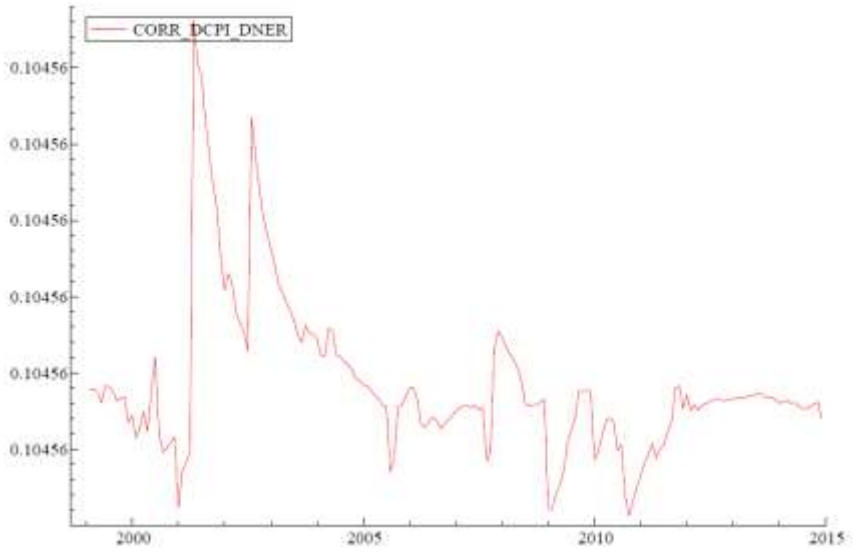
α_{22}	1.234928*	0.69287	1.782	0.0763
β_{11}	0.719965***	0.074231	9.699	0.0000
β_{22}	-0.006703***	0.0018385	-3.646	0.0003
a_1	0.000000	1.1485e-007	0.05318	0.9576
b_1	0.886483	0.68890	1.287	0.1997
$\rho_{1,2}$	0.104560			
Log-likelihood	1122.147			
χ^2-test: $R_t = R$	300.04***			0.0000

*****, **** and * indicate statistical significance at 1 percent, 5 percent and 10 percent respectively.
Source: Researcher's computation using OxMetrics. 2025

Most importantly, the mean value of the dynamic correlation ($\rho_{1,2}$) in the DCC equation is 0.105 which shows an unconditional positive, although weak, correlation between returns on exchange rate and inflation in Nigeria over the study period. Previously, Adetiloye (2010) found a similar correlation result between official exchange rate and CPI in Nigeria even though his paper only tested for time-invariant correlation.

Besides, the results of parameter constancy test, which is the χ^2-statistic as developed by Engle and Sheppard (2001), indicates strong evidence against the hypothesis of a constant conditional coefficient. The result shows that R_t is different from R even at 1 percent level. Thus, we conclude that there is evidence of dynamism in the conditional correlation between the variables. The dynamic correlation is depicted in figure 2.

Figure 2: Dynamic Conditional Correlation Plot



Source: Researcher's plot using OxMetrics

Figure 2 depicts the dynamism of the conditional correlation between consumer prices and exchange rates. Periods of 2011M1, 2019M1 and 2020M8 (coinciding with Covid-19 period) record the lowest correlation which means the lowest level of pass-through. 2011M1 was a period of relatively stable price, in fact, that very month recorded price-deflation but the exchange showed an upward trend. Similarly,

the first month of the 2019 was the verge of global Covid-19 pandemic crisis when there was drop in the demand for crude oil from most developed economies, or almost a shut-down of the global economy. In Nigeria, the level of supply quota of the OPEC+ was cut down 1.412 million bpd as oppose to the 1.829 million bpd in 2018 (Ibebuike & Amadi, 2020). The crude price also went as low as less than $20 per barrel, forcing Nigeria to review its budgeted crude price from $57 per barrel to $30 per barrel. This resulted in significant decline in the foreign exchange earning capacity of Nigeria, depleted its foreign exchange reserves, and depreciated the exchange rate. Conversely, since the end of lock-down policy, 2020M8 witnessed significant revamp of the economy which increased the inflation rates perhaps due to quantitative easing policy of the second quarter of the year, and a recession that set in during the third quarter of 2020. On the upper side of the correlation, 2011M3 and 2012M6 witnessed a somewhat relative low inflation and exchange rate stability. In fact, until Retail DAS (RDAS) was re-implemented towards the end of July 2013, exchange rate and consumer price depicted a very close co-movement with little or virtually zero changes. One can make much sense by arguing that the Dutch Auction System, both for retail and wholesale, as an exchange rate management policy (2009 to 2013), tied up exchange rates and domestic prices more than any other exchange rate regime in Nigeria. We can equally argue that since the liberalization of exchange rate in 2016, leading to the suspension of DAS regime, and the subsequent introduction of I&E window, the two variables drifted apart – showing a very weak correlation, perhaps due to prevalence of parallel/black market. But the recent free-floating regime has strengthened the correlation between the returns of the two variables.

5.0 CONCLUSION AND RECOMMENDATIONS

This paper investigated the time-variant correlation between exchange rate volatility and CPI fluctuations in Nigeria using monthly time series data spanning the period of 2009M1 – 2024M12. Dynamic Conditional Correlation—Generalized Autoregressive Conditional Heteroskedastic (DCC-GARCH) model was employed to determine the co-movement between domestic prices and exchange rates in the presence of volatility. The findings reveal that the correlation between exchange rate and domestic prices has been volatile but positive throughout the study period. Specifically, the dynamic conditional correlation between returns on exchange rate and inflation rate has been found to be an average of about 0.105, with the correlation reaching its peak at around 2011 and lowest in 2020. Thus, the paper concludes that the DAS regime tied exchange rate volatility and returns on CPI (inflation) more than flexible exchange rate system. It also concludes that, during shortages in exchange rate supply, the inflation rate is shaped by the parallel market rates rather than the official rates.

Thus, from the conclusion reached, the study recommends auction of sufficient foreign exchange by the CBN, whether directly to retailers or indirectly to wholesalers. This has become necessary so as to tie up

the consumer price movements with the official exchange rates in the economy. Exchange rate unification between the official and market rates is also of paramount importance for adequate predictability of inflation rates by the monetary authority.

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