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Exchange Rate Volatility and Consumer Price Index in Nigeria: An ARDL Analysis

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Abstract
This study investigated the volatility of exchange rate and consumer price index in Nigeria using monthly series from 2010M1 to 2022M10. The GARCH (1,1) framework and a standard GARCH test in an ARIMA framework were used to check the volatility clustering. The Johansen System cointegration test and Block exogeneity test confirm a long run relationship degree and direction of causality between exchange rate volatility and consumer price volatility. Again, a long run cointegrating unidirectional causality running from consumer price index volatility to exchange rate volatility without feedback, was found. Further findings arising from the study showed that exchange rate and consumer price index exhibited volatility properties in the Nigerian economic environment. Also, a reasonably size correlational coefficient was documented which is connotative of a linear association between exchange rate volatility and price volatility. This study recommends wholistic and system-based approach to policy formulation given the likelihood of transmission effect from the volatility of consumer price index to exchange rate.

Keywords: *Exchange Rate Volatility, Consumers Price Index, ARDL, ARIMA, Nigeria*
JEL Classification Code: *B41, C1, D12, E31, F31*

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I. Introduction

Following the collapse of the gold standard system in 1971, most countries abandoned fixed exchange rates for floating systems, which in turn lead to an increased volatility in exchange rates. Besides, transmission of various endogenous and exogenous economic shocks to macroeconomic variables has increased. Statistically, volatility is often regarded as variance and it is a measure of the dispersion of a random variable from its mean value. Thus, Exchange volatility relates to the fluctuations (or instability) in a chosen measure of foreign exchange or exchange rate (Omotosho & Doguwa 2012). Inflation volatility relates to the fluctuations (or instability) in a chosen measure of inflation. In Nigeria, for instance, monthly headline inflation is measured in terms of the year-on-year percentage change in the all-items Consumer Price Index (CPI) compiled by the National Bureau of Statistics (NBS) and fluctuations in such a measure characterizes inflation volatility in the country (Judson & Orphanides, 1999).

Globally, one of the key challenges to economic policy management all over the world and particularly in emerging and developing economies has been the effect of changes in exchange rates on inflation and economic activities. It is believed that exchange rate movements would create domestic economic distortions and affect a country's economic competitiveness. The deleterious effect of exchange rate misalignment is well documented in literature and there is often reluctance on the side of policy makers to adjust exchange rates due to perceived negative effect on the economy, mainly due to pass-through effects.

Similarly, one of the most serious challenges facing Nigeria and most developing economies is inflationary pressure coupled with exchange rate volatility. The adverse or consequences of inflationary pressure arising from exchange rate volatility have been a serious concern for financial economists, policy makers, and researchers. In Nigeria, the Central Bank is saddled with the responsibility of maintaining stable exchange rate and price stability in the economy and, this is done by ensuring that the rate of inflation is kept within a certain bound (Nuhu, 2021). Furthermore, the central bank maintains the stability of the Naira exchange rate in order to achieve its objective of maintaining price stability as domestic prices respond to exchange rate fluctuations.

According to Ubi, Effiom, and Eyo (2012), in countries where exchange rate volatility tends to have adverse effects on inflationary pressure, more stable exchange rate through central bank intervention in the foreign exchange market is required in order to stabilize the economy. The Central bank uses its monetary policy such as monetary policy rate, interest rate, open market operation, and other weapons to stabilize the economy with a view to achieving some specified macroeconomic policy objectives and to counter undesirable

trends in the economy such as unemployment, inflationary pressures, sluggish economic growth and external sector instability.

Literature has underscored the importance of exchange rate as a veritable tool for achieving overall economic progress. This is based on the link between exchange rate and other economic variables including inflation. The crucial role of exchange rate in monetary policy formulation is also emphasized, as it serves as an essential part of signaling channel of the transmission of policy decisions to achieve the desired macroeconomic objectives. It has therefore placed responsibility on this study to establish a clear relationship between volatility in exchange rate and volatility in inflation rate measured in Consumer Price Index. Hence, an in-depth understanding of the effect of exchange rate volatility on Consumers Price Index in Nigeria is essential for policy formulation and implementation.

II. Theoretical framework

Various theories of exchange rate, monetary policy and inflation relate to this study. These include the classical theory, monetarist's theory, Keynesians theory and the Purchasing Power Parity. First, the classical theory or Quantity theory of money (QTM) propounded by Irving Fisher in 1956 postulates a direct and proportional relationship between money supply and the price level. That is, change in the supply of money causes a proportional change in the price level. Algebraically, it is expressed as follows: MV = PT 1 where: M is the total money supply, V is the velocity of money in circulation and T is the volume of transactions. From the equation, the total money supply (MV) equals total value of output (PT) in the economy. Assuming V (the velocity of money) and T (the total output) to be constant, a change in the supply of money (M) causes a proportional change in the price level. The variable M is the policy variable, which is exogenously determined by the monetary authorities (Nuhu, 2021).

Secondly, the monetarists led by Milton Friedman posit that money exerts significant influence on aggregate demand, price level and output (Ufoeze, et al 2018). The monetarists are of the view that changes in money supply determine the nominal price level and output. The Thirdly, Keynesian economic theory posit that expansionary monetary policy increases the supply of loanable funds available through banking system, causing interest rates to fall. With the lower interest rates, aggregate investment increases, causing real gross domestic product to rise (Chukwuemeka, 2018; Nwoko, Ihemeje, & Anumadu, 2016). Keynes contends that monetary policy affects real output indirectly. Keynes did not support the idea that the relationship between money and price is direct and proportional, rather Keynes contends that a change in the supply of money has an indirect and non-proportional relationship with economic variables such as interest rate, investment, aggregate demand, level of employment, output and income.

Fourthly, Mundell- Fleming Theory of Exchange rate determination on the other hand, is an extension of the IS-LM framework which deals with equilibrium in the product market and money market. In the Mundell-Fleming theory, the balance of payments is considered another equilibrium condition in addition to the product market and money market equilibrium. The Mundell-Fleming theory posits that expansionary monetary policy increases the supply of loanable funds available through banking system, causing interest rates to fall. The fall in interest rates leads to fall in capital inflows which results to capital account deficit leading to further pressure on domestic currency thereby causing depreciation of the exchange rate. The depreciation in currency stimulates domestic production causing IS curve and balance of payments (BP) curve to shift to the right (Chukwuemeka, 2018; Nwoko et al., 2016). The IS represents the investment and savings equilibrium in the product market while the LM represents the liquidity preference and money supply equilibrium in the money market (Nuhu, 2021)

Finally, the purchasing power parity (PPP) theory was developed by Swedish economist Gustav Cassel. This theory posits that the exchange rate between countries is determined by their relative price level. It explains how the exchange rate volatility affects inflation rates (Jhingan, 2011). This study is principally underpinned by the purchasing power parity theory.

2.2 Empirical review

Empirical literatures exist on the relationship between exchange rate volatility and Consumers Price Index in empirical works carried out in Nigeria and other countries. In Nigeria, Yakub et al. (2019) investigated the impact of exchange rate volatility on trade flows in Nigeria using annual time series data for the period 1997-2016. A GARCH model was used to generate the nominal exchange rate volatility series. To detect the long-run relationship among variables, the ARDL bounds test approach was employed. Also, the Granger causality test was applied to ascertain the direction of causality among the variables. The study found that exchange rate volatility affected Nigeria's trade flows negatively in the short-run but does not in the long-run.

Nkoro & Uko (2016) investigated the effect of exchange rate volatility on inflation in Nigeria, using quarterly time series data from 1986QI-2012Q4 sourced from the CBN Statistical Bulletin and National Bureau of Statistics. The study employed GARCH model. Findings from the study revealed a persistent volatility in

exchange rate and inflation rate in the Nigeria. Obiekwe and Osabunhien (2016) examined the effect of exchange rate volatility on inflation in Nigeria using annual time series data from 2006 to 2015. The study employed the GARCH technique to test for volatility in exchange rate in Nigeria. The study applied the ARCH model in its analysis. The result revealed that volatility in exchange rate significantly influenced inflation rate in Nigeria.

Besides, Ajao and Igbekoyi (2013) investigated the determinants of real exchange rate volatility in Nigeria using annual time series data from 1981 to 2008. Using Generalized Auto-regressive Conditional Heteroskedasticity (GARCH) techniques and the Error Correction Model (ECM). The results revealed that trade openness, government expenditures, interest rate and the lagged exchange rate had positive and significant effect on real exchange rate volatility during the period under investigation.

Similarly, Dickson and Andrew (2013) analyzed the impact of exchange rate fluctuations on trade variations in Nigeria for the period 1970 - 2010. The study employed the error correction and GARCH model for the analysis and results of the study showed that exchange rate volatility was not significant in explaining variations in import, but was found to be positive and significant in accounting for variations in export. Joseph (2011) investigated the impact of real exchange rate volatility on economic growth in Nigeria from 1970-2009. The study used the GARCH model for the analysis. Results indicated that a negative and insignificant transmission existed between exchange rate volatility and economic growth. Aliyu (2010) analysed the impact of exchange rate volatility on Nigeria's non-oil exports using quarterly data from 1986 - 2006. Using vector error correction and the VAR model. The results revealed a long-run stable and negative relationship between Naira exchange rate and non-oil exports in Nigeria.

Reviewing empirical works from other countries or cross countries analyses have some variations. Achouak, Ousama, and Mourad (2018) examined the impact of exchange rate volatility on economic growth in a sample of 45 developing and emerging countries over the period 1985-2015. The study employed generalized autoregressive conditional heteroskedasticity (GARCH) model for the analysis. Findings revealed that nominal and real exchange rate volatilities had negative and significant impact on economic growth. In a study on the effect of exchange rate volatility on inflation in Switzerland using Structural Vector Auto regressive (SVAR) technique, Zidek and Suterova (2017) found that exchange rate volatility caused inflationary pressure in the study area. On their part, Viola, et al (2017) explored the effect of exchange rate volatility on inflation in Brazil using annual time series data from 1980-2015 sourced from Central Bank of Brazil. Findings from the study revealed that GARCH (1,1) and the EGARCH (1,1) showed high persistence of volatility in the exchange rate.

Also, Serenis and Tsounis (2014) investigated the effect of exchange rate volatility on two small countries, Croatia and Cyprus on aggregate exports using annual time series data for the period 1990 to 2012. Autoregressive distributed lag (ARDL) model was employed for the analysis and results revealed a positive and significant effect of exchange rate volatility on exports of Croatia and Cyprus. Vieira, et al (2013) analysed the impact of exchange rate volatility on economic growth on a sample of 82 developed and emerging countries over the period of 1970-2009. The study employed generalized autoregressive conditional heteroskedasticity (GARCH) model for the analysis. Findings revealed that nominal and real exchange rate volatilities had negative and significant impact on economic growth in the sampled countries.

Besides, Mori, et al (2012) investigated the effects of the exchange rate volatility on economic growth in Malaysia during the period 1971- 2009. The variables employed include; GDP, real exchange rate and nominal exchange rate. The study employed Autoregressive Distributed Lag approach for the analysis. Results revealed that both nominal and real exchange rates had a positive and significant effect on economic growth in Malaysia.

From the literature reviewed, it is clear that studies that examined the relationship between exchange rate volatility and Consumer Price Index (CPI) in Nigeria were few. This study is one of few studies that would examine the impact of exchange rate volatility on Consumer Price Index in Nigeria, particularly using the ARDL approach. This study will contribute to the existing literature in terms of methodology used and variables employed in the study.

III. Methodology

3.1 Data and Method

The data for this study are extracted from the Central Bank statistical bulletin covering the period 2010M1 to 2022M10. It is a monthly series given the fact that high frequency data like monthly data are efficient in measuring volatility.

First, the collected data were described using basic descriptive statistics, test for correlation, graphs and descriptive charts. Prior to the description, the volatility profile of the datasets was shown using a GARCH (1,1) model as:

$$Y_t = X_t^{'}\theta + \epsilon_t$$ ……. eqn (1)

$$\sigma_t^2 = \omega + \alpha\epsilon_{t-1}^2 + \beta\sigma_{t-1}^2$$ ……eqn (2)

Where:

The mean equation given in eqn (1) is written as a function of exogenous variables with an error term. Since σ_t^2 is the one-period ahead forecast variance based on past information, it is called the *conditional variance*. The conditional variance equation specified in eqn (2) is a function of three terms:

• A constant term: ω News about volatility from the previous period, measured as the lag of the squared residual from the mean equation: ϵ_{t-1}^2 (the ARCH term). Last period's forecast variance: σ_{t-1}^2 (the GARCH term). The (1, 1) in GARCH (1, 1) refers to the presence of a first-order autoregressive GARCH term (the first term in parentheses) and a first-order moving average ARCH term (the second term in parentheses). The conditional variance residual series of the volatile variables are identified as the series for the measurement of volatility for both CPI and Exchange Rate.

Second, the graph of the residual series as well as their test for heteroscedasticity were used to confirm their volatility properties which is the first objective of this study. Evidently, a graph that shows periods of low volatility succeeded the period of low volatility and high volatility going along the same line form empirical evidence of existence of volatility clustering.

Third, the volatility series and other moderating variables are used to determine the long run cointegrating relationship of the series in a Johansen type cointegrating system equation. Also, the block exogeneity test is used to measure the direct and reverse causal interaction among the variables under investigation. All inferences were based on the 0.05 level of significance.

IV. Presentation of Data and Results

4.1: Presentation of exchange rate and consumer price index monthly data from 2010 to 2022 in Nigeria

Year	CPI	LCPI	LUSDEXR	USDEXR
2010M01	103.13	4.635990328327978	5.016219672390156	150.84
2010M02	105.04	4.654341229994541	5.013032418695978	150.36
2010M03	104.9	4.653007515402251	5.010968571886377	150.05
2010M04	105.72	4.660794089736088	5.010968571886377	150.05
2010M05	105.68	4.660415660214069	5.02157523413459	151.65
2010M06	108.76	4.68914361976427	5.010635294096256	150
2010M07	109.94	4.699934762432514	5.010635294096256	150
2010M08	111.87	4.717337482858839	5.022893191491757	151.85
2010M09	112.38	4.721885985684052	5.040194096337801	154.5
2010M10	112.72	4.724906867590425	5.016285965605071	150.85
2010M11	112.77	4.725350346244197	5.016285965605071	150.85
2010M12	114.22	4.738126413236717	5.023880520846276	152
2011M01	115.59	4.750049447306176	5.025195445427586	152.2
2011M02	116.7	4.75960653929251	5.032722890560261	153.35
2011M03	118.3	4.773223770984341	5.044843465425993	155.22
2011M04	117.66	4.76779910943631	5.041617031704984	154.72
2011M05	118.73	4.776852007677701	5.052416828111211	156.4
2011M06	119.89	4.786574655719562	5.027295734989363	152.52
2011M07	120.27	4.789739215322525	5.030437921392435	153
2011M08	122.27	4.806231714156099	5.043425116919247	155
2011M09	124	4.820281565605037	5.072670685015709	159.6
2011M10	124.6	4.825108606353353	5.071103040863346	159.35
2011M11	124.65	4.825509809969568	5.082645830072528	161.2
2011M12	125.97	4.836043783364212	5.073297055220967	159.7
2012M01	130.19	4.868994921909306	5.082397660323147	161.16
2012M02	130.55	4.871756295145138	5.061011501421323	157.75

2012M03	132.63	4.887563296506261	5.060821309009427	157.72
2012M04	132.8	4.888844237042334	5.058790335983303	157.4
2012M05	133.8	4.896346147694128	5.074235875505851	159.85
2012M06	135.34	4.90779013080408	5.092829531722242	162.85
2012M07	135.66	4.910151755517934	5.079850363117729	160.75
2012M08	136.57	4.916837303690334	5.063670403975397	158.17
2012M09	137.95	4.926891300663294	5.057773300553659	157.24
2012M10	139.17	4.935696207431762	5.056627897946728	157.06
2012M11	140.01	4.941713848629834	5.058790335983303	157.4
2012M12	141.06	4.949185331780032	5.05783689558055	157.25
2013M01	141.94	4.955404433096837	5.057518879995106	157.2
2013M02	143	4.962844630259907	5.066385309200747	158.6
2013M03	144.02	4.969952178820721	5.066574446420364	158.63
2013M04	144.82	4.975491591960675	5.061961921261596	157.9
2013M05	145.79	4.982167230116731	5.063227744215426	158.1
2013M06	146.65	4.988048795423461	5.091293197113711	162.6
2013M07	147.44	4.993421313361567	5.078605420535523	160.55
2013M08	147.81	4.995927665223982	5.086978860683589	161.9
2013M09	148.9	5.003274939689963	5.079228085561868	160.65
2013M10	150	5.010635294096256	5.067960360715525	158.85
2013M11	151.1	5.017941869278694	5.065880768322234	158.52
2013M12	152.29	5.025786597863599	5.074548619839908	159.9
2014M01	153.26	5.032135825542258	5.090678001769792	162.5
2014M02	154.03	5.037147388636367	5.104125637183594	164.7
2014M03	155.23	5.044907888038351	5.105339229565553	164.9
2014M04	156.19	5.051073214869631	5.079103583569675	160.63
2014M05	157.4	5.058790335983303	5.092092385672523	162.73
2014M06	158.62	5.066511404655174	5.093443405283571	162.95
2014M07	159.65	5.072983919160791	5.086978860683589	161.9
2014M08	160.42	5.077795375938779	5.090062427727578	162.4
2014M09	161.31	5.083327979489696	5.098035484377089	163.7
2014M10	162.13	5.088398482561977	5.109273263993256	165.55
2014M11	163.1	5.094363509626968	5.175019150203542	176.8
2014M12	164.4	5.10230248262208	5.192956850890211	180
2015M01	165.77	5.110601285436774	5.221436322212079	185.2
2015M02	166.9	5.117394830667789	5.288267030694535	198
2015M03	168.4	5.126342101808226	5.283203728737989	197
2015M04	169.7	5.134032172240181	5.283203728737989	197
2015M05	171.58	5.145049630144819	5.283203728737989	197
2015M06	173.17	5.154273770964059	5.282949889416914	196.95
2015M07	174.37	5.161179478329403	5.283203728737989	197
2015M08	175.4	5.167069079938083	5.283203728737989	197
2015M09	176.5	5.173320876373351	5.283203728737989	197
2015M10	177.2	5.177279038170981	5.283203728737989	197
2015M11	178.37	5.183860044570212	5.283203728737989	197
2015M12	180.15	5.193789837194103	5.283203728737989	197
2016M01	181.7	5.202356975402125	5.283203728737989	197
2016M02	185.9	5.225208894727398	5.283203728737989	197
2016M03	189.94	5.246708232814806	5.283203728737989	197
2016M04	192.99	5.262638374091019	5.283203728737989	197
2016M05	198.3	5.28978103552575	5.283203728737989	197
2016M06	201.7	5.306781444960166	5.645446897643238	283
2016M07	204.23	5.319246809729067	5.746203190540153	313
2016M08	206.29	5.329282945804916	5.723585101952381	306
2016M09	207.96	5.337345753515515	5.721131112990814	305.25
2016M10	209.68	5.345582559015151	5.720311776607411	305
2016M11	211.33	5.353420892774061	5.720311776607411	305
2016M12	213.56	5.363917823631986	5.720311776607411	305

2017M01	215.72	5.373981270469026	5.721131112990814	305.25
2017M02	218.95	5.388843393247407	5.72194977861165	305.5
2017M03	222.71	5.405870476712758	5.724728239171664	306.35
2017M04	226.27	5.421728976463236	5.723094785688574	305.85
2017M05	230.53	5.440381005811504	5.721622392784532	305.4
2017M06	234.17	5.456047347313921	5.723258251156858	305.9
2017M07	237.02	5.468144525760303	5.722604228896789	305.7
2017M08	239.32	5.477801568521831	5.723094785688574	305.85
2017M09	241.19	5.48558500462375	5.722767774567281	305.75
2017M10	243.03	5.493184892510509	5.722931293494961	305.8
2017M11	244.93	5.50097245543491	5.723585101952381	306
2017M12	246.38	5.506875059533828	5.723585101952381	306
2018M01	248.35	5.514839041553359	5.722604228896789	305.7
2018M02	250.32	5.522740099360627	5.723258251156858	305.9
2018M03	252.41	5.531054749533568	5.722440656474735	305.65
2018M04	254.52	5.539379418364591	5.722604228896789	305.7
2018M05	257.29	5.550203853394458	5.72342168990855	305.95
2018M06	260.47	5.562487691413844	5.722767774567281	305.75
2018M07	263.42	5.573749716570901	5.723258251156858	305.9
2018M08	266.18	5.58417277165841	5.724075177923964	306.15
2018M09	268.41	5.592515662227614	5.724728239171664	306.35
2018M10	270.39	5.599865361236428	5.724728239171664	306.35
2018M11	272.56	5.607858773352711	5.726196069493101	306.8
2018M12	274.57	5.615206237547758	5.726847747587196	307
2019M01	276.6	5.622572419230658	5.72603308359102	306.75
2019M02	278.62	5.629848846278079	5.726098281139616	306.77
2019M03	280.81	5.637678284053157	5.726587127309465	306.92
2019M04	283.46	5.64707101973876	5.726717445938696	306.96
2019M05	286.61	5.658122406620676	5.726684867873505	306.95
2019M06	289.69	5.668811385712149	5.72652196162569	306.9
2019M07	292.62	5.678874838950016	5.726359028835106	306.85
2019M08	295.51	5.688702677221108	5.726847747587196	307
2019M09	298.59	5.699071394926082	5.726847747587196	307
2019M10	301.78	5.709698275085505	5.726847747587196	307
2019M11	304.87	5.719885456237599	5.726847747587196	307
2019M12	307.47	5.728377521511581	5.726847747587196	307
2020M01	310.16	5.737088293362674	5.726847747587196	307
2020M02	312.61	5.74495640723899	5.726684867873505	306.95
2020M03	315.23	5.753302531119593	5.88887795833288	361
2020M04	318.45	5.763465476817375	5.88887795833288	361
2020M05	322.17	5.775079356538235	5.88887795833288	361
2020M06	326.07	5.787112082243205	5.88887795833288	361
2020M07	330.14	5.799516806919395	5.942799375126701	381
2020M08	334.57	5.812846125238409	5.942799375126701	381
2020M09	339.52	5.827532855425618	5.942799375126701	381
2020M10	344.73	5.842761501937651	5.942799375126701	381
2020M11	350.26	5.858675735844519	5.942799375126701	381
2020M12	355.91	5.874677889901688	5.942799375126701	381
2021M01	361.23	5.889514874572237	5.942799375126701	381
2021M02	366.8	5.90481674038231	5.942799375126701	381
2021M03	372.51	5.920263883096861	5.942799375126701	381
2021M04	376.14	5.929961414513932	5.942799375126701	381
2021M05	379.94	5.940013345516904	6.016157159698354	410
2021M06	383.96	5.950538380495336	6.016547327475445	410.16
2021M07	387.51	5.959741654912034	6.016401032398014	410.1
2021M08	391.48	5.969934428557619	6.016937343081012	410.32
2021M09	395.98	5.981363704928552	6.018106478054404	410.8
2021M10	399.87	5.991139494284036	6.019809020117125	411.5

2021M11	404.18	6.001860323290102	6.016157159698354	410
2021M12	411.52	6.0198576216092	6.075346031088684	435
2022M01	417.58	6.034476142701229	6.021023349349526	412
2022M02	424.39	6.050652843785504	6.033086221798801	417
2022M03	431.8	6.067962518080706	6.030685260261264	416
2022M04	439.4	6.08541015995051	6.028278520230697	415
2022M05	447.23	6.103073003669565	6.033086221798801	417
2022M06	455.35	6.121066354013827	6.025865973825314	414
2022M07	463.63	6.139086820329655	6.054439346269371	426
2022M08	471.83	6.156618751217421	6.063785208687608	430
2022M09	478.24	6.170112698535628	6.063785208687608	430
2022M10	484.19	6.182477391667807	6.063785208687608	430

Source: Author compilation from Central Bank of Nigeria Statistical bulletin, 2022

4.2: A presentation of a graph of the level series of the CPI and EXR were firstly presented as Fig.1 and Fig.2

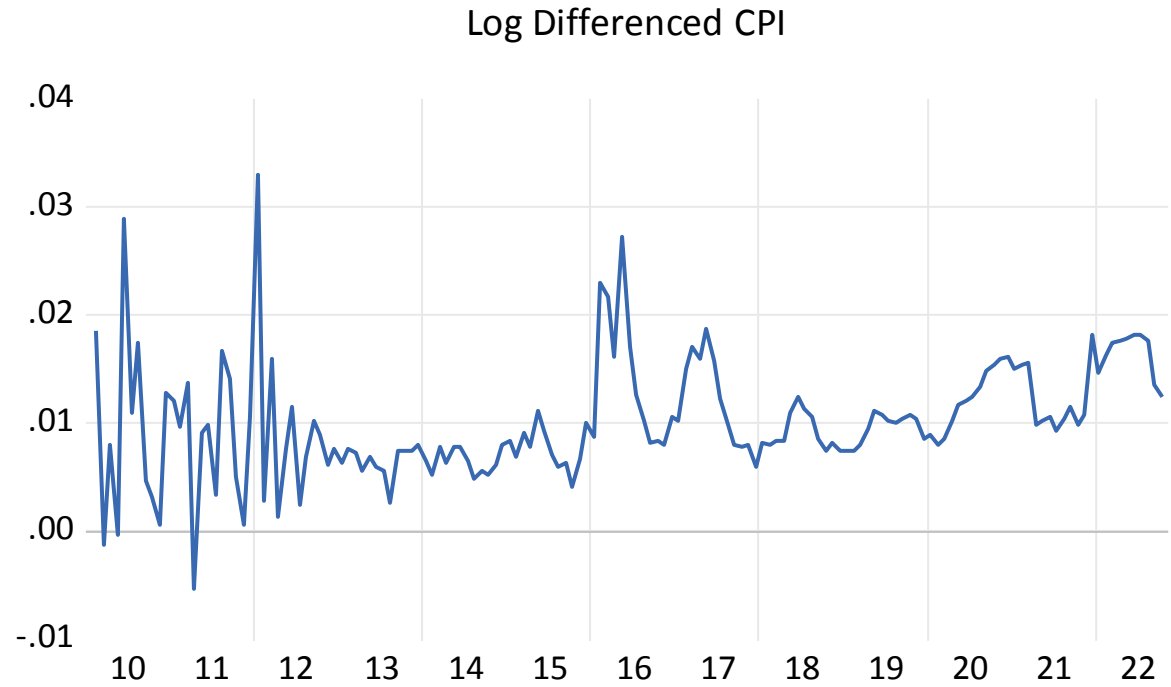

Fig. 1 – Log Differenced Line Graph of Monthly CPI series, 2010M1 to 2022M10.

There is an observance of oscillatory movement in the CPI series but this is not conclusive evidence as the GARCH residual series tests provide a confirmatory support to the initial observations.

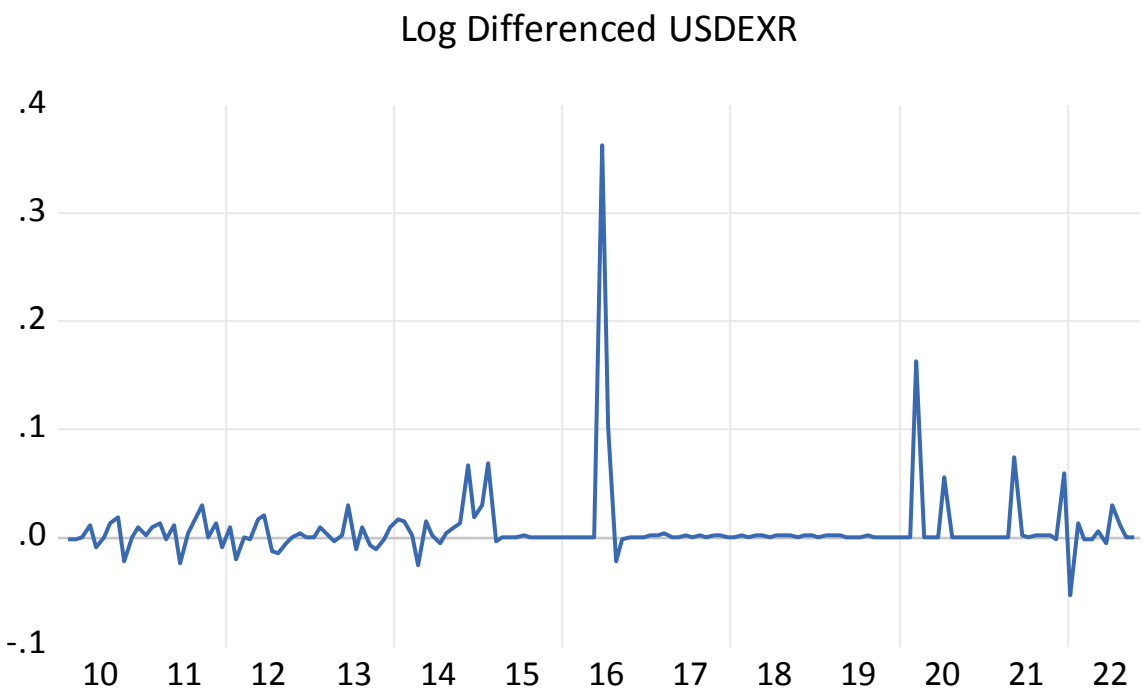

Fig. 2 – Log Differenced Line Graph of Monthly USD to Naira EXR series, 2010M1 to 2022M10

Following the GARCH (1,1) process described on section 3, the residual series are extracted and graphed of the form shown in Fig. 3 and Fig. 4.

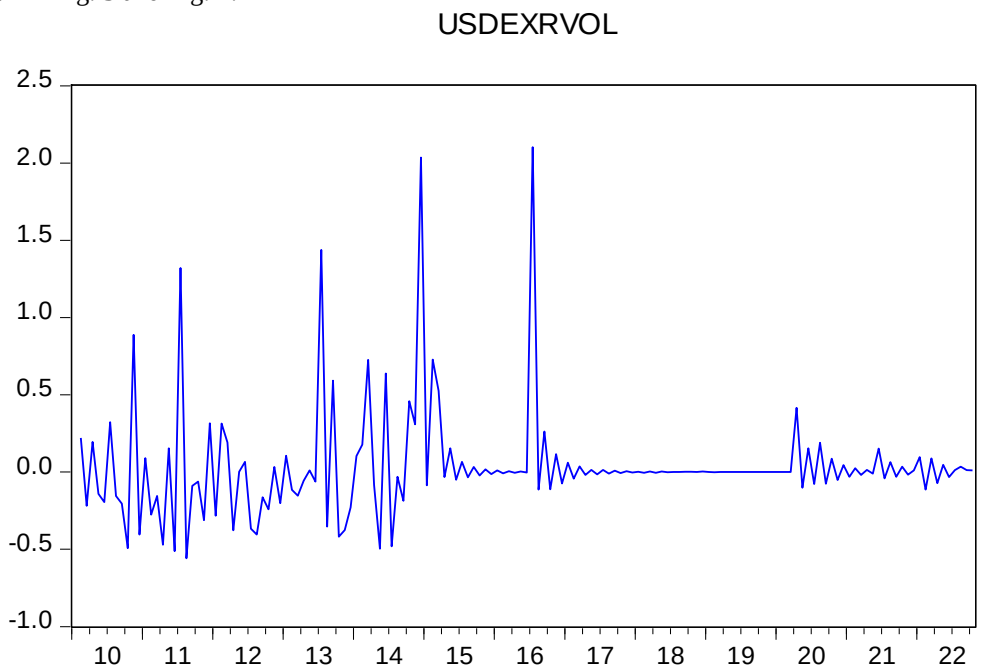

Fig.3: Graph of the residual of the conditional variance of Monthly USD to Naira EXR series, 2010M1 to 2022M10

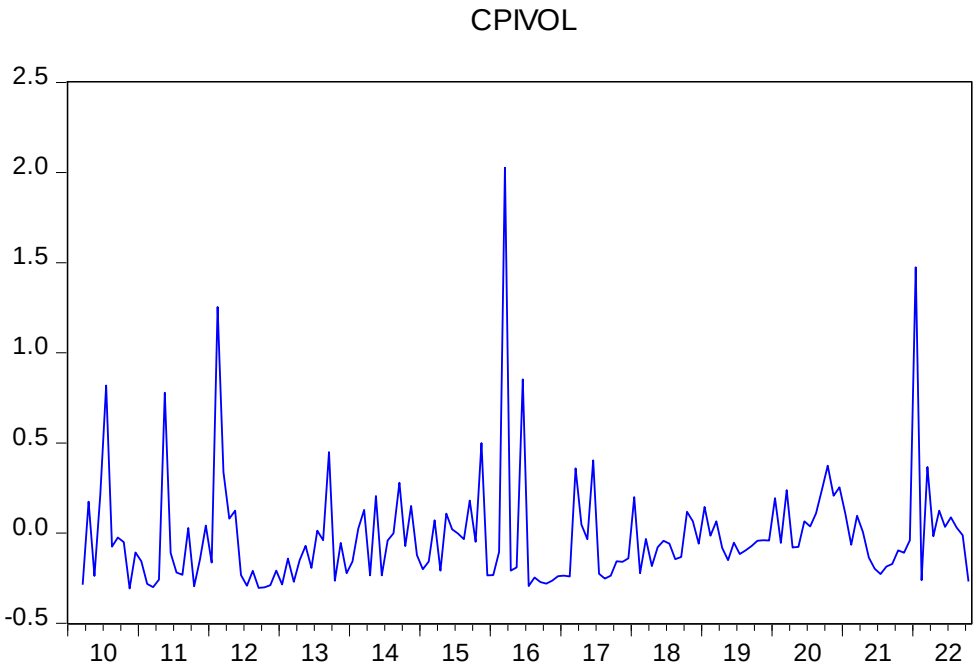

Fig.4: Graph of the residual of the conditional variance of Monthly series of CPI 2010M1 to 2022M10

It is concluded that CPI and EXR in the Nigerian economic space exhibited clear-cut volatility over the period 2010M1 to 2022M10. The volatility characteristics of these variables is further evaluated by the Autoregressive Conditional Heteroscedasticity (ARCH) tests reported in table 1 below:

Table 1: GARCH Test Results for CPI and EXR

Dependent Variable: LCPI

C	5.95E-07	3.24E-07	1.838898	0.0659
RESID(-1)^2	0.264555	0.108159	2.445990	0.0144
GARCH(-1)	0.732422	0.077262	9.479676	0.0000

Dependent Variable: LUSDEXR

C	4.69E-05	2.93E-05	1.602135	0.1091
RESID(-1)^2	0.585081	0.237904	2.459313	0.0139
GARCH(-1)	0.510368	0.179199	2.848047	0.0044

Source: Authors' Computation

The sum of the ARCH and GARCH terms are close to unity (1) in both the CPI and EXR. Also, the reported coefficient was significant at the 0.05 level of significance. This is clearly a proof of strong volatility in exchange rate and consumer price index in Nigeria over the studied period.

Next, having established the volatility status of the series, the basic descriptive statistics are reported in table 2.

Table 2: Summary of Basic Descriptive Statistics

	CPI	LCPI	LUSDEXR	USDEXR
Mean	227.7429	5.332898	5.471940	255.5903
Median	200.0000	5.298281	5.466857	240.5000
Maximum	484.1900	6.182477	6.075346	435.0000
Minimum	103.1300	4.635990	5.010635	150.0000
Std. Dev.	102.0385	0.435224	0.380738	96.33019
Skewness	0.766725	0.220261	0.112745	0.349553
Kurtosis	2.540250	1.863067	1.369736	1.646370
Observations	154	154	154	154

Source: Authors' Computation

A comparism of the averages of the level series and the log transformed series provided justification for the use of the log transformed series in reducing data magnitude while ensuring linearity. All the variables become close-knit with reduced deviation around the mean when the log transformed series were used. The results further showed the linear association of the series by revealing the correlation matrix as reported in table 3.

Table 3: Correlational Matrix

	CPI	LCPI	LUSDEXR	USDEXR
LCPI	0.981041	1.000000		
	62.40925	-----		
	0.0000	-----		
LUSDEXR	0.937639	0.964956	1.000000	
	33.25556	45.33644	-----	
	0.0000	0.0000	-----	
USDEXR	0.960938	0.967230	0.992865	1.000000
	42.80605	46.96626	102.6568	-----
	0.0000	0.0000	0.0000	-----

Source: Authors' Computation

Positively significant correlation was found among all the investigated variables. The correlation coefficient that were appreciably high. And all the t-stats found to be significant at the 0.05 level of significance. This suggest positive comovement between EXR and CPI in the Nigerian economic space.

The possible cointegrating relationship between inflation and exchange rate was investigated and reported in table 4.2

Table 4: Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.445559	135.3236	47.85613	0.0000
At most 1 *	0.188099	46.85447	29.79707	0.0002
At most 2 *	0.080112	15.59791	15.49471	0.0483

Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.445559	88.46916	27.58434	0.0000
At most 1 *	0.188099	31.25656	21.13162	0.0014

Source: Authors' Computation

The trace test and maximum Eigen value test both confirm the existence of cointegration with the trace test reporting three cointegrating vectors and the Maxeigen statistics showing two cointegrating vectors. Summarily, it was found that exchange rate and consumer price index in Nigeria share a long run relationship.

Lastly, the direction of direction of the causal movement between exchange rate and consumer price index was shown in the block exogeneity tests reported from a Vector Error Correction framework as shown in table 5.

Table 5: VEC Granger Causality/Block Exogeneity Wald Tests

Dependent variable: D(CPIVOL)

Excluded	Chi-sq	Df	Prob.
D(LUSDEXR)	1.423069	2	0.4909
D(LCPI)	278.5380	2	0.0000
D(USDEXRVOL)	0.085372	2	0.9582

All	282.9401	6	0.0000

Dependent variable: D(USDEXRVOL)

Excluded	Chi-sq	Df	Prob.
D(LUSDEXR)	593.2955	2	0.0000
D(LCPI)	9.962668	2	0.0069
D(CPIVOL)	10.22667	2	0.0060
All	667.2286	6	0.0000

Source: Authors' Computation

Though all the variables showed block causality for the consumer price index volatility as well as exchange rate volatility, the study only found a unidirectional causality between exchange rate volatility and consumer price index volatility. The causality runs from consumer price index volatility to exchange rate volatility without feedback. This implies that the exchange rate volatility responded to the volatility of domestic inflation than exchange rate responds to the volatility of inflation.

V. Conclusions and Implications of the Study

This study examined the likelihood of volatility clustering in exchange rate and consumer price index in Nigeria using monthly series from 2010M1 to 2022M10. The volatility series were extracted using a GARCH (1,1) framework and a standard GARCH test in an ARIMA framework was conducted. Long run relationship was confirmed using the Johansen System cointegration test and Block exogeneity test used to determine the degree and direction of causality between exchange rate volatility and consumer price volatility. It is concluded that exchange rate and consumer price index exhibit volatility properties in the Nigerian economic environment. Also, a reasonably size correlational coefficient is documented which is connotative of a linear association between exchange rate volatility and price volatility. The Johansen's trace test and maxeigen value are in agreement as to the existence of a long run cointegrating relationship between exchange rate and consumer price index volatility. A unidirectional causality running from consumer price index volatility to exchange rate volatility without feedback, was found. This study recommended the need for a wholistic and system-based approach to policy formulation given the observed likelihood of transmission and spillover effect from the volatility of consumer price index to exchange rate. Also, exchange rate and inflation are among the key issues that monetary policy addresses in most economies including Nigeria; hence, the need for a balanced and all-inclusive monetary policy approach is emphasized by the outcome of this investigation.

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