Exchange Rate Variability in Nigeria: Drivers and Remedial Monetary Policy

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Exchange Rate Variability in Nigeria: Drivers and Remedial Monetary Policy[&]

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Abstract

In this study, we examine the drivers of persistent exchange rate depreciation in Nigeria and suggest remedial monetary policy actions based on inference from the results. Using time series data from January 2008 to June 2023, the following potential drivers were examined: price level differential, interest rate differential, terms of trade, stock market performance, oil price and central bank forex supply to the FX market. While the Naira/USD exchange rate is a daily observation data, potential drivers are majorly available on a monthly basis. On this note, we employ the GARCH variant of the Mixed Data Sampling (GARCH-MIDAS) technique. For robustness purposes, we employ conduct modelling with fixed window and rolling window data sampling techniques. Notable model selection criteria such as the Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC) and Logarithmic Likelihood (LogL) are utilized to determine the optimal model. Our results reveal that foreign exchange market inefficiency, high inflation, low interest rate, dwindling oil price, adverse stock market performance, and low CBN FX supply to the forex market are major drivers of exchange rate variability in Nigeria. The results are robust to alternative data sampling techniques. Additional results of this study suggest that improvement in macroeconomic performance and adverse financial market performance can reduce the long-term volatility persistence of the exchange rate in Nigeria. Based on intuition from these findings, remedial monetary policy actions proposed by this study include improvement in forex market efficiency, promotion of productivity and export of tradeable goods and services, reduction in macroeconomic uncertainties, and policy consistency in exchange rate and macroeconomic management. In addition, we conclude that monetary authorities need not introduce hostile financial market policies to reduce exchange rate variability; rather, they should embark on policies to enhance macroeconomic performance.

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1. INTRODUCTION

The significance of exchange rate stability for a nation's economic growth and development cannot be over-emphasized. The exchange rate is the relative price of foreign currency in terms of domestic currency. As no economy can produce all it needs, economic agents would need to procure foreign currency using their domestic currency to buy goods and services produced by other countries. High exchange rate variability would imply high uncertainty around the price of foreign currency in the domestic economy, which may trigger uncertainty around international trade, policies, and private and public finance. More so, this would have favourable or unfavourable effects on foreign exchange traders, foreign and local investors and balance of payment (Salisu, 2011). Oaikhenan and Aigheyisi (2015) noted that exchange rate volatility would reduce investors' confidence, adversely affect domestic and foreign investment, and stimulate huge business and investment risks. While maintaining exchange rate stability is one of the core mandates of central banks globally, achieving this objective has been very challenging for monetary authorities in some countries, including Nigeria.

Despite the frequent supply of US dollars by the monetary authority to the Nigerian foreign exchange market, the Naira/US dollar exchange rate has persistently depreciated. In the last two decades, the Naira/US dollar exchange rate has depreciated at a rate higher than 630%. Before the spillover effect of the Global Financial Crisis (GFC) became evident in Nigeria, the rate of depreciation of Naira/US dollar exchange rate was minimal, as Naira fairly depreciated from ₦113.12/US dollar in December 2001 to ₦129.07/US dollar in December 2008. With the combined effects of devaluation and depreciation of currency, the Naira/US dollar exchange rate became ₦156.64/US dollar in December 2011, after the GFC. Naira/US dollar exchange rate was fairly stable in the post GFC period as the rate hovers between ₦155/US dollar and ₦156/US dollar to remain at ₦155.76/US dollar in October 2014. The rapid Naira/US dollar fall from this fairly stable price to N197/US dollar in May 2016 and N305.22/US dollar in December 2016 has been attributed to an oil price crash. During this period, the Central Bank of

Nigeria's (CBN) responses include restricting 43 items from accessing foreign exchange (forex) from the official market. After this period, the Naira/US dollar exchange rate fell to ₦446.47/US dollar in December 2022 and fell rapidly to ₦832/US dollar in October 2023.

This Naira/US dollar exchange rate trend tends to portray the case of insatiable foreign exchange demand or insufficient market supply of forex in Nigeria. Different opinions have emanated. While some attribute high Naira/US dollar exchange rate variability and persistent depreciation to the problem of high dependence on imported goods, some believe it is due to market speculation; others opine that forex supply by the monetary authority is insufficient, while some believe that it is caused by the variability of foreign exchange inflow due to oil dependence and capital outflow due to dwindling returns on capital. This problem of persistent exchange rate depreciation problem has generated research interest among academic and policy-based researchers interested in not only identifying the drivers of the awkward movement in the exchange rate but also keen on suggesting ways to stabilize the exchange rate to the monetary authorities in Nigeria. Following this background, this study seeks to answer the following research questions: First, what are the causes of exchange rate volatility persistence in Nigeria? Second, how would different exchange rate stabilization policy options affect exchange rate volatility?

The problem of exchange rate variability is not peculiar to Nigeria, as different researchers have investigated its causes in developed and emerging countries. Notably, the drivers of exchange rate variability have been investigated by Dell'Ariccia (1999) for the case of Poland, Kisaka and Ouma (2017) and Abdi et al. (2020) for Kenya; Jara and Pina (2023) for Chile; Joof and Jallow (2020) for Gambia; Kaur and Kulaar (2022) for India; Kilicarslan (2018) for Turkey; Kuncoro (2020) and Khaliq (2022) for Indonesia; Aftab and Mehmood (2023) for Asian Emerging Markets; Agosin and Diaz-Maureira (2023) for emerging markets; Aworinde et al (2021) for advanced economies and Nigeria among others. Meanwhile, despite increasing remedial policy recommendations from the existing studies on drivers of exchange rate variability in Nigeria (see Adeoye and

Atanda, 2012; Oaikhenan and Aigheyisi, 2015; Hassan et al., 2017), the problem of persistent exchange rate variability remains. This has continued to have devastating effects on foreign investors' confidence, financial inflows, and economic development (Oloko, 2018). The massive migration of Nigerian youth in recent years, which poses a threat to the country's labour supply sustainability, may not be unattributed to the exchange rate's persistent depreciation, as this reduces the real income in Nigeria. The Nigerian monetary authorities have attempted various policies with no significant improvement in the variability condition. This study seeks to investigate further the drivers of persistent exchange rate variability in Nigeria to provide renewed remedial monetary policy recommendations to resolve this problem.

This study contributes to the literature on determinants of exchange rate variability in three distinct ways. It employs the recently developed Mixed Data Sampling Generalized Autoregressive Conditional Heteroscedasticity (GARCH-MIDAS) model by Engle et al., 2013. This method more pragmatically models the exchange rate market, where low-frequency macroeconomic and financial variables determine high-frequency currency prices. Due to the effectiveness of GARCH models in describing the dynamics of volatile series, various GARCH-type models have been used in explaining exchange rate variability. This ranges from the simple GARCH (1,1)/EGARCH model (Bartsch, 2018; Cai, 2022; Zhou and Zhang, 2023) to GARCH-X (see Isah and Ekeocha, 2023), DCC-GARCH (see Sakaki, 2017), BEKK-GARCH (AGARCH) (see Kim, and Jung, 2018; Chowdhury and Garg, 2022), Copula-GARCH (He and Hamori, 2019) and Markov Switching GARCH (see Jara and Pina, 2023). However, these methods do not appeal to the nature of macroeconomic variables whose frequencies are low. This may lead to biased results. Hence, this study follows recent studies like You and Liu (2022) and Salisu et al. (2022). However, while these studies focus on short-run modelling by fitting or determining the fitness of the exchange rate variability model, this study uses the model to determine drivers of exchange rate variability, which is a long-run model.

Second, this study explores the case of Nigeria, which has one of the weakest currencies in the world and is the African country with the largest number of citizens in the diaspora. A weak currency is expected to encourage exports and discourage imports. However, this has not reduced Nigerian imports, causing prices of domestic goods to increase and pushing people to emigration. Earlier studies on Nigeria's exchange rate variability have been narrow in consideration of drivers of exchange rate variability, which constraints monetary policy recommendation. For instance, Musa and Sanusi (2020) and Babalola (2021) observed that central banks-determined interest rate is a crucial predictor of the nominal Naira exchange rate. Gidigbi et al. (2018) found that Nigerian inflation also plays a significant role. Also, Isah and Ekeocha (2023) explain that crude oil price affects Naira's nominal rate variability. This study examines Nigeria's peculiar case, thus considering a wider range of drivers, including price level differential, interest rate differential, terms of trade, crude oil price, stock market performance and CBN forex supply to the exchange rate market. While Hassan et al. (2017) similarly consider numbers relevant drivers, they employ an Autoregressive Distributed Lag (ARDL), which averages the exchange rates over a month and distorts the data-generating process of the exchange rate, which may bias the results.

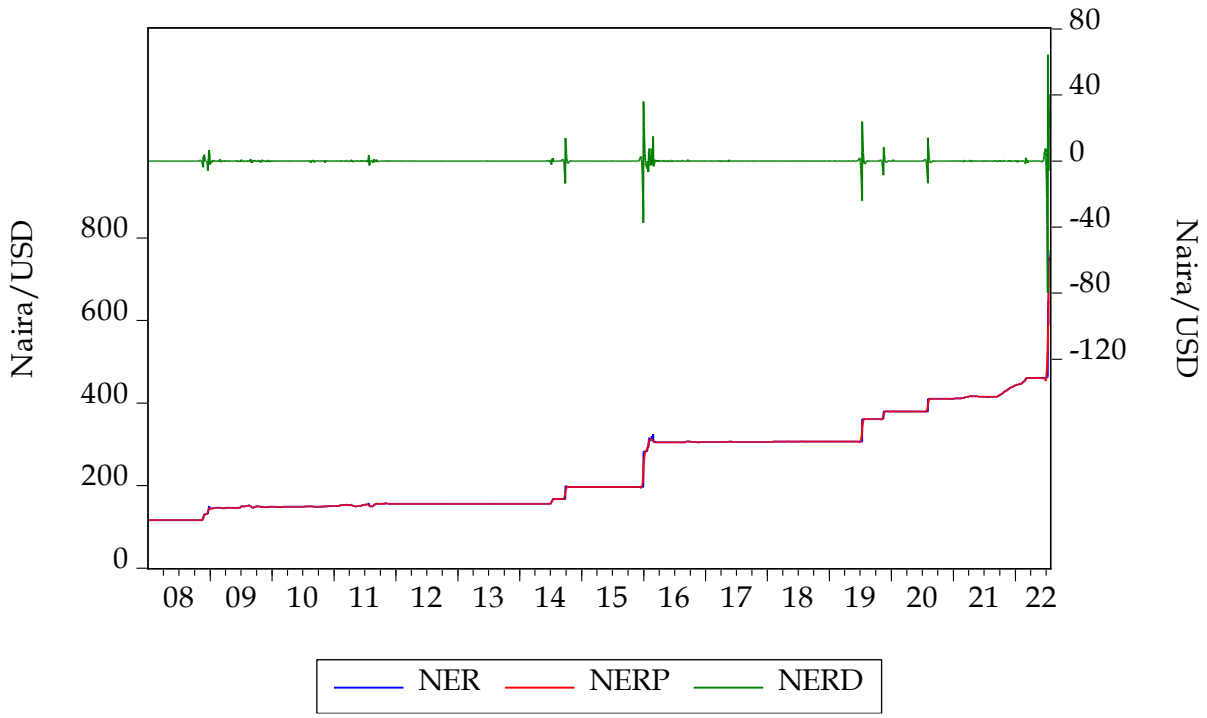
Third, we conduct further empirical analysis by employing Principal Component Analysis (PCA) to combine macroeconomic and financial factors (see Salisu et al., 2019). This is to help policymakers in setting priorities when choosing between stabilization policies for the macroeconomic or financial sector. To the best of our knowledge, this study is about the foremost in distinguishing between macroeconomic and financial drivers of exchange rate variability. In addition, with the failure of realized volatility, observed volatility, and GARCH-based volatility of the Nigerian Naira-USD exchange rate to satisfy the stylized facts of ARCH and no unit root, this study employs the Hodrick filter approach as a measure of variability. Foreshadowing our results, we find that foreign exchange market inefficiency, high inflation, low interest rate, dwindling oil price, adverse stock market performance, and low CBN FX supply to the forex market

are major drivers of exchange rate variability in Nigeria. Following this introduction, the section presents data issues and preliminary analysis. A literature review was discussed in section 3, and the methodological framework was presented in section 4. Results presentation and discussion were done in section 5, and section 6 concludes.

2. DATA ISSUES AND PRELIMINARY ANALYSIS

This study employs time series analysis to investigate Nigeria's exchange rate variability drivers. The dependent variable is exchange rate variability, expressed as the exchange rate deviation from its potential. This is calculated using the Hodrick-Prescott filter approach. The daily Naira/USD exchange rate data was downloaded from the website of the Central Bank of Nigeria (CBN). The start period for the analysis is January 2008, and the end period is June 2023. This captures the GFC and post-GFC periods where persistent Naira/USD exchange rate depreciation occurred. Figure 1 presents the graphical representation of the actual, potential and variation. The actual Naira/USD exchange rate (NER) and the potential Naira/USD exchange rate (NERP) are presented on the left axis, while the Naira/USD exchange rate deviation (NERD) is presented on the right axis.

Figure 1: Trends in Exchange Rate and Exchange Rate Variability



Evidently, the rising trend of NER reveals that Naira consistently depreciates against the US dollar in the period under review. From about ₦129.07/US dollar in December 2008, the Naira/US dollar exchange rate became ₦156.64/US dollar in December 2011 and ₦155.76/US dollar in October 2014. The rapid fall in Naira/US dollar from this value to ₦197/US dollar in May 2016 and N305.22/US dollar in December 2016 has been attributed to the oil price crash. During this period, the Central Bank of Nigeria's (CBN) responses include restricting 43 items from accessing foreign exchange (forex) from the official market. After this period, the Naira/US dollar exchange rate fell to ₦446.47/US dollar in December 2022 and rapidly to ₦770.88/US dollar in June 2023. The trend in exchange rate deviation reveals some long spikes, suggesting large variability at intermittent periods.

Table 1 shows the descriptive statistics for NER, NERP, and NERD, as well as the explanatory factors considered. The table shows that the average value of Naira USD over the period of our analysis is ₦245.78/USD, and the maximum value is ₦770.88/USD.

The minimum Naira/USD exchange rate deviation is 79.58 minus actual, and the maximum deviation is 64.36 plus actual. The Jarque-Bera statistics show that exchange rate variables are not normally distributed. However, while actual and potential exchange rates are positively skewed and platykurtic, exchange rate deviation is negatively skewed and leptokurtic. This suggests that exchange rate deviation contains some extreme values, which is one of the stylized facts for volatile series (see Salisu and Oloko, 2015). The formal test for volatility was conducted using the ARCH LM test by Engle (1982). The results show that the null hypothesis of no ARCH effect is significantly rejected for all three exchange rate variables. Similarly, the Q-statistic and squared Q-statistic tests for autocorrelation and higher-order autocorrelation show that the null hypothesis of no autocorrelation cannot also be rejected for the three indicators. However, the unit-roots results using the Augmented Dickey-Fuller (ADF) approach show that only exchange rate deviation is stationary. This is the only exchange rate indicator that fulfils the stylized facts of a volatile series; hence, it is the one used as the dependent variable in modelling exchange rate variability in the GARCH-MIDAS technique employed in this study.

Table 1: Descriptive Statistics

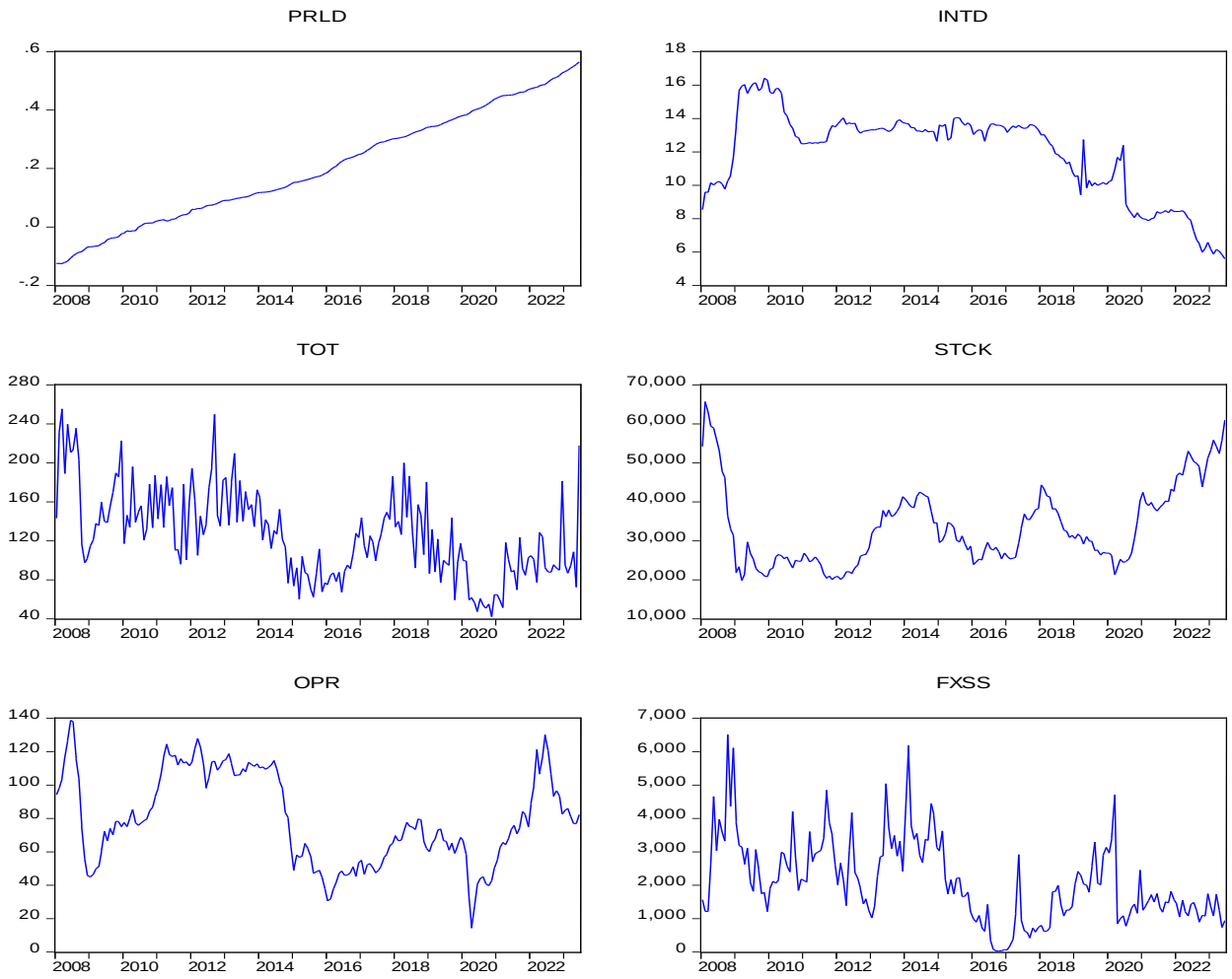
Statistics	NER	NERP	NERD	PRLD	INTD	TOT	STCK	OPR	FXSS
Mean	245.78	245.76	0.02	0.20	11.89	125.71	33603.76	79.44	2111.03
Median	197.00	197.00	0.00	0.17	13.02	121.65	31055.39	75.59	1866.41
Maximum	770.88	758.55	64.36	0.56	16.41	255.34	65652.38	138.74	6513.15
Minimum	116.55	116.16	-79.58	-0.13	5.60	42.08	19851.89	14.28	30.00
Std. Dev.	108.75	108.60	2.89	0.19	2.61	45.08	10248.41	27.25	1227.68
Skewness	0.67	0.65	-3.89	0.12	-0.66	0.53	0.89	0.14	0.82
Kurtosis	2.60	2.49	308.18	1.85	2.55	2.84	3.17	1.98	3.84
Jarque-Bera	305.84	307.96	1.47E+07	10.64	14.96	8.79	24.92	8.64	26.49
Probability	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.00
Residual Diagnostics									
ARCH(5)	177.5**	3789***	1134***						
ARCH(10)	120.5**	3784***	1174***						
LB-Q(5)	729.4**	14424**	365.53***						
LB-Q(10)	840.3**	18016**	601.74***						
LB-Q^2(5)	133.2**	12146**	1796.9***						
LB-Q^2(10)	141.3**	13431**	1889.0***						
ADF	2.6604[a]	2.5178[a]	-22.457[a]***						
Obs.	**3800**	**3800**	**3800**	**186**	**186**	**186**	**186**	**186**	**186**

Note: NER is Naira/USD exchange rate (Actual), NERP is the Potential Naira/USD exchange rate, NERD is Naira/USD exchange rate deviation, PRLD is the price level differential (Between Nigeria and US), TOT is a terms of trade (export/import), STCK is stock market index, OPR is crude oil price, and FXSS is foreign exchange supply by the CBN.

The descriptive statistics for explanatory variables considered in this study are also presented in Table 1. These variables are selected based on relevant economic theories and the economic condition of Nigeria. They are monthly data selected over the same sample period as the dependent variable: January 2008 to June 2023. The variables are the

price level differential between Nigeria and the US (PRLD), which measures the impact of relatively higher inflation in Nigeria than in the US, and the terms of trade (TOT), which measures the impact of the trade balance. High TOT implies a favourable trade balance, and lower TOT implies an unfavourable one. Another variable is a stock market index (STCK), which measures the impact of stock market performance. Higher STCK implies higher stock market returns or improved stock market performance, and lower STCK indicates lower stock market returns or adverse stock market performance. Others are crude oil price (OPR) and foreign exchange supply by the CBN (FXSS). Higher (lower) OPR and FXSS are expected to reduce (increase) exchange rate variability in Nigeria.

Figure 2: Trends in Drivers of Exchange Rate Variability



The trends in the explanatory variables are presented in Figure 2. The trends show that Nigeria's inflation has been consistently growing at a higher rate than that of the US. Nigeria's interest rate has been consistently falling as well. Nigeria's terms of trade fluctuate over time but have decreased gradually. Stock market performance has been below its pre-GFC performance until recently. Crude oil prices have fluctuated, and the CBN's foreign exchange supply to Nigeria's foreign exchange market has fluctuated and reduced significantly in the last three years. Table 1 shows that Nigeria has higher inflation and interest rates than the US on average. The terms of trade are favourable on average. The average stock market index between January 2008 and June 2023 is 33603.76; the average price of crude oil in the same period is $79/barrel, and the monthly average amount of FX supplied by the CBN is US$2111.03 million.

3. LITERATURE REVIEW

Exchange rate is an important factor international economics and determinants of its changes or variation has been widely investigated, theoretically and empirically. From the theoretical point of view, relevant theories include the monetary models of exchange rate, the asset-market models of exchange rate, and the balance of payment models. The monetary models include Cassel (1916)'s purchasing power parity (PPP) hypothesis, Dornbusch (1976)'s sticky price exchange rate model, and Frenkel (1976), Mussa (1976) and Bilson (1978)'s flexible price exchange rate model. The asset-market models include the portfolio balancing model (Branson, 1977; Kouri, 1976; Driskill and McCafferty, 1980; Dooley and Isard, 1983; and Branson and Henderson, 1985), Nurkse (1944)'s destabilizing speculation theory, Bacchetta and van Wincoop (2004)'s scapegoat model, and Fisher (1930)'s international fisher effect (IFE) theory. Similarly, the balance of payment models include the optimal currency area (OCA) hypothesis (Mundell, 1961; McKinnon, 1963; and Kenen, 1969) and the Devereux and Lane (2001)'s model of bilateral exchange rate volatility.

The Purchasing Power Parity (PPP) model usually linked to Cassel (1916) explains that the value of a nation's domestic currency is perceived to be a sound reflection of the

purchasing power of the currency against other currencies. In essence, the model's prediction centres on the fact that for a currency to possess similar purchasing power elsewhere, the nominal exchange rate should equal a comparison of such country's aggregate price levels; known as the purchasing power rate (see Krugman and Obstfeld, 2009). While the model is keenly predicted on the law of one price, its central message is that there exist a proportional relationship between an economy's optimal exchange rate and such currency's purchasing power parity with other nations (see., Dornbusch, 1985; Aghevli, 1991; Froot and Rogoff, 1995; and many more). Furthermore, the relation of the PPP hypothesis as a monetary model is seen in the contributions of Thornton and Wheatley. For instance, while Thornton posits that price increases in nations with excess circulated currency will promote a proportional ascension in such economy's nominal exchange rate, Wheatley enunciated that nations nominal exchange rates in determined by relative prices, which in turn are subjected to variations in money supply (see Humphrey, 1979).

The sticky price model, alternatively referred to the exchange rate overshooting model has its root from the work of Dornbusch (1976), which attributed exchange rate over or under shooting from its market-clearing rate, to both the goods and money market recalibration pace. As such, the model's main message relays that monetary policy shocks will adduce greater effect on exchange rate movement in the short term than in the long term; a behavior described as overshooting. This situation is made possible via a short term price stickiness assumption in the goods market, which therefore implies short run exchange rate equilibrium on dynamics of the money market, therefore leading to an overreaction. Contrary to the sticky price model where the short term prices are assumed to be rigid, the flexible price exchange rate model credited to Frenkel (1976), Mussa (1976) and Bilson (1978), assumes a period of price flexibility in describing exchange rate dynamics. As such, the model links excess exchange rate fluctuations above the normally determined ones by the underlying fundamentals, to a rational framework of expectations formation. By this, the model's central paradigm is perceived to revolve

around a notion that the dynamics of a currency's exchange rate is keenly attributed to supply of such currency and more so, the perceived willingness to hold such magnitude (Mussa, 1976).

The portfolio balancing approach belongs to the Asset Market approach. It can be credited to the work of Branson (1977), perhaps with later extension from the likes of Kouri (1976), Driskill (1980), Dooley and Isard (1983) and Branson and Henderson (1985). Succinctly, the model being an extension of the monetary models to exchange rate, opines that the financial market determines fluctuation in an economy's exchange rate through the creation of demand for asset, in strict adherence to the magnitude of stock supplies (see Min and McDonald, 1993). To understand the model's main prediction, it is assumes that investors seeks to balance their portfolios as soon as the enforcement of changes in any of the three assets; that is, money, domestic and foreign stocks. As such, this recalibration thus adjusts the demand for assets; foreign and domestic, thereby causing significant changes along the exchange rate determination via the market forces paradigm.

From the empirical view, several studies have investigated the determinants of exchange rate variability using either the observed or the conditional volatility methods to deduced exchange rate variability. Number of studies in this regard can be categorized as the predictability-geared and structural model-informed criteria. Among the predictability-geared studies, evidence of interest rates towards nominal exchange rate volatility has been largely explained by studies like Hameed and Rose (2017), Thornton and Vasilakis (2019), Kuncoro, (2020), Mohammed et al., (2021), and others, while Kuncoro (2020) reported same evidence for the real exchange rate volatility. Again, Moazzam (2023) obtained public debt of Southern Asian economies to critically determine the variability of their exchange rate. Similarly, evidences of commodity prices, ranging from energy prices, food prices, factor input prices, and precious metal prices, as cogent predictors nominal exchange rate variability have been discovered (e.g., Kim and Jung, 2018; He and Hamori, 2019; Chowdhury and Garg, 2022; Geng and Guo, 2022; Isah and Ekeocha,

2023; Shang and Hamori, 2023), which was also reported for the real exchange rate volatility by Yildirim et al., (2022) in the case if Mexico, Indonesia, and Turkey.

More so, the economic policy uncertainty has likewise been detected in relation to the nominal exchange rate variability predictability (see., Blacilar et al., 2015; Bartsch, 2018; Juhro and Phan, 2018; Noria and Bush, 2019; Liming et al., 2020; Abid and Rault, 2020; Aworinde et al., 2021; Smales, 2021; Zhao and Cui, 2021; Abreu, 2021; Tumturk, 2022; Ruan, et al., 2023; Wang et al., 2023; Pastorek, 2023), with no evidence whatsoever in its relation with the real exchange rate volatility. Similarly, geopolitical risks have only been linked a crucial drivers of nominal exchange rate variability only (e.g., Khaliq, 2022; Iyke et al., 2022; Salisu et al., 2022), and not for volatility in the real exchange rate. Clearly, this trend has continued as evidences relating to real exchange rate volatility are relatively scarce, even as empirical discovery on the predictability role of central bank intervention in exchange rate variability is limited to the nominal exchange rate (see Jara and Pina, 2023 and Ramachandran, 2023; and others). Even as the predictability-geared studies have relatively intensified overtime, those of the structural model are likewise notable. Instances of these include studies of emerged economies that realised the determinants of exchange rate variability to include its implied volatility, money supply volatility, commodity prices, stock market, as well as both global economic activity and global economic policy uncertainty (see Plihal and Lyocsa, 2021; Chaturvedi and Kumar, 2022).

Similarly, a host of studies on emerging economies have realised the determinants of such economies' nominal exchange rate volatility to include interest rate, money supply, international reserves, market changes, inflation rates, balance of payment positions, fiscal balance, economic openness and activities, several policy uncertainty indices, and most especially central bank transparency (see Lim and Sek, 2014; Weber, 2017; Eichler and Littke, 2017; Hassan et al., 2017; Nwinee and Olulu-Briggs, 2022; Bonato et al., 2022; Aftab and Mehmood, 2023; Enumah and Adewinbi, 2023; Luo et al., 2023). On the determinants of real exchange rate volatility via this route, most of the studies have been on emerging nations as well whereby the detected drivers were found to include capital

flows, monetary aggregates, cross border investment magnitudes, economic activities, apex bank transparency, price level dynamics, net position of foreign asset and trade balance, as well as trade openness (see for instance., Weber, 2017; Kilicarslan, 2018; Kaur and Kulaar, 2022; Yang and Peng, 2023; Agosin and Diaz-Maureira, 2023).

The methodology for analyzing determinants of exchange rate variability starts from the determinations of measure of exchange rate variability to the empirical model combining the dependent and the independent variables. In terms of measures of exchange rate volatility, some studies measure this as observed volatility (for example, Khaliq, 2022; Iyke et al., 2022; Bonato et al., 2022; Geng and Guo, 2022; Wang et al., 2023; Yang and Peng, 2023; Agosin and Diaz-Maureira, 2023; Aftab and Mehmood, 2023; Enumah and Adewinbi, 2023; Moazzam, 2023; and others), while some others employ conditional volatility measure (see for instance Salisu et al., 2022; Yildirim et al., 2022; Ramachandran, 2023; Ruan et al., 2023; Nwinee and Olulu-Briggs, 2022; Luo et al., 2023; Pastorek, 2023; Jara and Pina, 2023; Isah and Ekeocha, 2023; Shang and Hamori, 2023).

The Generalized Autoregressive Conditional Heteroscedasticity (GARCH) type models have been the most prominently used method for analyzing volatility and volatility persistence. This ranges from simple GARCH (1,1) model to asymmetric GARCH and some other complex ones. Notable among the asymmetric GARCH models used in the analysis include exponential GARCH (EGARCH), Glosten–Jagannathan–Runkle GARCH (GJR-GARCH (1,1), integrated GARCH (I-GARCH), threshold GARCH (T-GARCH), and power asymmetric GARCH (A-PARCH). Likewise, proficiency in combining datasets of mixed frequencies have triggered the employment of several mixed data sampling GARCH approaches, such as GARCH-MIDAS and the FIGARCH-MIDAS methods; when the later additionally exerts efficiency in investigating the persistence of long term memory after the exclusion of several effects (Abreu, 2021; Chaturvedi and Kumar, 2022; Salisu et al., 2022; Luo et al., 2023; Yang et al., 2023; Wang et al., 2023). Other evident GARCH models on the debate therefore includes the BEKK-

GARCH (Kim and Jung, 2018), the multivariate GARCH (MGARCH) (see, Erdogan et al., 2020), DECO-GARCH (see, Hung et al., 2022), amidst others.

More so, Jara and Pina (2023) utilize the Markov switching – generalised autoregressive conditional heteroscedasticity (MS-GARCH) in extracting such time-varying evidence, while Sakaki (2017) stuck with the dynamic conditional correlation GARCH (DCC-GARCH) for the same purpose. Besides, the normal GARCH models have similarly featured pre-eminently in this debate, such as the symmetric ones like the basic GARCH, GARCH (1,1), GARCH-in-mean, copula-GARCH, among others (e.g., Bartsch, 2018; He and Hamori, 2019; Abdi et al., 2020; Cai, 2022; Demirbas and Can, 2022; Zhou and Zhang, 2023; Isah and Ekeocha, 2023; Zhou, 2023).

Other methods that have employed by previous studies the basic vector autoregressive model (VAR), perhaps, given its endogeneity tackle effectiveness and feedback allowance (see for example Yepez and Dzikpe, 2022; Chowdhury and Garg, 2022; Geng and Guo, 2022; Maio and Zeng, 2023; Armah et al., 2023). The structural VAR (SVAR) was used by Anwar et al., (2022) as a result of its efficiency in allowing feedback and dynamic interrelationship across all the variables in a system; and even avoids the need for structural modelling. Similarly, the Bayesian VAR (BVAR) was utilized by Ojeda-Joya and Romero (2023) and Aysun (2023). Certain studies have also prefer the linear autoregressive distributed lag (ARDL), since it excels in accommodating variables that are of diverse stationarity stance, whether I(0), I(1), or both; and even efficiently estimates long-run and short-run dynamics simultaneously, via bounds testing procedures (e.g., Aimer, 2021; Moldovan et al., 2021; Babalola, 2021; Mohammed et al., 2021; Poulakis and Tsaliki, 2022; Hlongwane, 2022; Kaur and Kulaar, 2022; Ashogbon et al., 2023; Yang and Peng, 2023). Similarly, Ahmed and Mazlan (2021) and AbdulSalam and Onipede (2023) combined both linear ARDL with the non-linear ARDL (NARDL) as the latter seamlessly dishes out asymmetric evidence (see also, Li et al., 2020; Zhang and Baek, 2021; Saidu et al., 2021; Kisswani and Elian, 2021; Long et al., 2022; Baek, 2022).

This study contributes to literature on determinants of exchange rate variability in three distinct ways. It employs recently developed Mixed Data Sampling Generalized Autoregressive Conditional Heteroscedasticity (GARCH-MIDAS) model by Engle et al., 2013. This method models exchange rate market in a more pragmatic way, where high frequency currency price is determined by low frequency macroeconomic and financial variables. Second, this study explores the case of Nigeria which has one of the weakest currencies in the world and the African country with largest number of citizens in diaspora. Earlier studies on Nigeria exchange rate have been narrow in consideration of drivers of exchange rate variability, which constraints monetary policy recommendation variability (Musa and Sanusi, 2020; and Babalola, 2021; Isah and Ekeocha, 2023). This study examines the peculiar case of Nigeria, thus considers wider range of drivers including price level differential, interest rate differential, term of trade, crude oil price, stock market performance and CBN forex supply to the exchange rate market. While Hassan et al., (2017) similarly considers numbers relevant drivers, it employs an Autoregressive Distributed Lag (ARDL) which averaged exchange rate over a month and distorts the data generating process of exchange rate, which may bias the results.

4. METHODOLOGY

Exchange rate is a high frequency variable as much as its variability. However, some of its determinants are not. Specifically, while exchange rate is available on daily basis, relevant drivers such as inflation, interest rate, terms of trade, CBN FX supply, among others are only available on monthly basis. To analyze determinants of high frequency variable in such situation, Engle et al. (2013) develop the Mixed Data Sampling Generalized Autoregressive Conditional Heteroscedasticity (GARCH-MIDAS) model. The proficiency of this method in analyzing long term volatility and volatility persistence in high frequency data have been extensive discussed in the literature (see Oloko et al., 2022; Salisu et al., 2022; Tumala et al., 2023).

In this study, the dependent variable, exchange rate variability, is determined as the daily exchange rate deviation from its potential. This is calculated using Hodrick Prescott filter approach. The daily exchange rate variability series is denoted as r_{it} indicating exchange rate variability for day i in month t with $t = 1,...,T$ and $i = 1,...,N_t$ denoting the monthly and daily frequencies, respectively. In other words, N_t is the number of days in a given month t. To determine the effect of each explanatory variable, we compare the basic GARCH-MIDAS model (GARCH-MIDAS-RV) which takes realized volatility for the dependent variable as the explanatory variable with the GARCH-MIDAS-X which takes a particular macro-financial variable as the explanatory variable. We construct basic and augmented GARCH-MIDAS-X models, where RV is the exogenous variable in the basic model and each macro-financial variable is the exogenous variable in the augmented model. Essentially, there are two components involving the mean and conditional variance equations, while the latter is further divided into short- and long-run components to accommodate the predictor series.

$$r_{i,t} = \mu + \sqrt{\tau_t \times h_{i,t}} \times \varepsilon_{i,t}, \quad \varepsilon_{i,t} \left| \Phi_{i-1,t} \sim N(0,1), \quad \forall \ i = 1,...,N_t \right. \tag{1}$$

$$h_{i,t} = (1 - \alpha - \beta) + \alpha \frac{\left(r_{i-1,t} - \mu\right)^2}{\tau_t} + \beta h_{i-1,t} \tag{2}$$

$$\log(\tau_t) = m + \theta \sum_{k=1}^{K} \phi_k (w_1, w_2) X_{t-k} \tag{3}$$

where equation (1) defines the mean equation while equations (2) and (3) are for the conditional variance components specified, respectively, for short- and long-run components. In terms of the definition of parameters, μ is the unconditional mean of the exchange rate variability; $h_{i,t}$ is the short-run component of the high frequency (exchange rate variability) variable. This is specified following GARCH(1,1) process, where α and β are the ARCH and GARCH terms, respectively, conditioned to be positive and/or at least zero ($\alpha > 0$ and $\beta \geq 0$) and summed up to less than unity $(\alpha + \beta < 1)$. The summation of α and β in the model determines the degree of volatility persistence (high, low) and

whether volatility persistence is temporary or permanent. The exchange rate volatility persistence is temporary if $\alpha+\beta<1$ and permanent if $\alpha+\beta\geq 1$. More so, the volatility persistence is low if $\alpha+\beta<<1$ and high if $\alpha+\beta\approx 1$.

The term τ_t captures the long-run component, and this incorporates the role of exogenous variable (denoted by X), and it involves repeating the monthly value throughout the days in that month. Also, $\log(\tau_t)$ is considered rather than τ_t to ensure the positivity of the long-term volatility, and $\phi_k(w_1, w_2)$ is the beta weighting scheme:

$$\phi_k(w_1, w_2) = \frac{(k/(K+1))^{w_1-1}.(1-k/(K+1))^{w_2-1}}{\sum_{l=1}^{K}(l/(K+1))^{w_1-1}.(1-l/(K+1))^{w_2-1}}, \quad (4)$$

The weights, ϕ_k, are completely determined by two parameters w_1 and w_2. It is easy to discover that $\phi_k \geq 0$ for $k=1,...,K$, and $\sum_k^K \phi_k = 1$. Accordingly, a positive (negative) coefficient of X, (θ), will imply that prospective exogenous variable increases (reduces) long-term volatility persistence. Since GARCH-MIDAS with realized volatility explains the long term variability of the market the role of each explanatory variable is the changes exhibited by this variable on the long term variability of the market (see Engle, 2013). The explanatory variables considered are: price level differential and interest rate differential between Nigeria and US, terms of trade, stock market performance, Crude oil price and foreign exchange supply by the CBN.

Further analysis involves distinction between the effects of financial and macroeconomic indicators. Accordingly, the exogenous variables are grouped into two; financial factors and macroeconomic factors, using Principal Component Analysis (PCA) technique. Macroeconomic factors consist of the price level differential, interest rate differential, terms of trade, and foreign exchange supply by the CBN, while financial factors consist of stock market performance and crude oil price.

5. RESULTS AND DISCUSSION

This section deals with presentation and discussion of the empirical results on the drivers of exchange rate persistent variability in Nigeria. The GARCH-MIDAS results on the impact of different potential drivers of Naira/USD exchange rate variability are presented and discussed. The procedure involves examination of the long term forex market variability using GARCH-MIDAS model with realized volatility. The impact of each exogenous variable on exchange rate (short and long term) volatility persistence is then determined as the changes in the long term forex market variability due to a particular variable using GARCH-MIDAS-X model; where X indicates a particular exogenous variable.

In this study, we consider factors such as price level differential between Nigeria and the US, interest rate differential between the two countries, terms of trade, stock market performance, oil price and forex supply by the CBN. The study employs fixed window and random window modeling approaches and select optimal model using notable model selection criteria such as the Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC) and logarithmic likelihoog (LogL). The optimal model shall be the one that minimises AIC and BIC, and maximises LogL. Following the objectives of this study, this section is partitioned into two. First part will be on the drivers of exchange rate variability and the second part will be on suggested remedial monetary policy to the central bank based on inference from the main results.

5.1 Drivers of Persistent Exchange Rate Variability in Nigeria

Market Condition and Price Level Differential as Drivers

Table 2 presents the GARCH MIDAS when price level differential between Nigeria and the US is the exogenous variable. The price level differential between Nigeria and the US measures the impact of relatively higher inflation in Nigeria on the country's exchange rate volatility persistence. To ascertain the effect of this variable however, we first consider volatility persistence of the Nigerian foreign exchange market given only the FX

market conditions. This is explained by GARCH-MIDAS-RV model. According to fixed window and rolling window approaches, the summation of α and β parameters is equal to 1 suggesting that there is permanent or sustained volatility persistence in the Nigeria foreign exchange market, and the coefficient of long term volatility persistence as indicated by Θ is 0.0965 according to fixed window approach and 0.0986 according to rolling window approach. Evidence of market volatility persistence suggests that Nigeria foreign exchange market is inefficient, and as such, it is possible to make abnormal profit/loss through speculation in the market. This market condition can also serve as one of the drivers of persistent Naira/USD exchange rate volatility in Nigeria.

Table 2: GARCH MIDAS with Price Level Differential

	Fixed Window			**Rolling Window**		
Parameters	**RV**	**Inflation**	**Diff**	**RV**	**Inflation**	**Diff**
μ	-5.86E-07**	1.50E-04***	0.0002***	-2.57E-06***	0.0001***	0.0002***
α	0.0874***	0.0500***	-0.0374***	0.0873***	0.0500***	-0.0373***
β	0.9126***	0.9000***	-0.0126***	0.9127***	0.9000***	-0.0127***
Θ	0.0965***	0.1000***	0.0035***	0.0986***	0.1000***	0.0014***
ω	3.9723***	5.0000***	1.0277***	4.9547***	5.0000***	0.0453***
m	0.0108***	4.82E-07***	-0.0108***	0.0088***	3.57E-07***	-0.0088***
Model Selection Criteria						
AIC	-40101.8	-34049.9		-40116	-33913.7	
BIC	-40064.4	-34012.5		-40078.5	-33876.2	
LogL	20056.9	17031		20064	16962.8	

Note: AIC indicates Akaike Information Criterion, BIC is Bayesian Information Criterion, and LogL means Logarithmic likelihood. Optimal model is determined as the one that maximizes LogL and minimizes AIC and BIC. Asterisks ***, ** and * indicate 1%, 5% and 10% statistical level of significance, respectively.

The result of GARCH-MIDAS with inflation or price level differential is also presented in Table 2 and compared with the result of GARCH-MIDAS with only market conditions (realized volatility). Based on the difference between the two models, the result shows that price level differential between Nigeria and US or higher inflation in Nigeria than US changes the dynamics of volatility persistence from permanent to temporary and increases the degree of long term volatility persistence of the Nigeria foreign exchange market. This is evident as the summation of α and β parameters is less than 1 and the coefficient of long term volatility persistence as indicated by Θ is higher than 0.0965

(increased by 0.0035). This result is produced by fixed window model adjudged to be the optimal model by all available model selection criteria, and corroborated by rolling window model. According to this result, persistent exchange rate depreciation in Nigeria may not be unrelated to higher inflation in Nigeria relate the US. As this implies that foreign goods are cheaper, pressure on forex market to secure US dollar to buy foreign goods is fuelling persistent exchange rate variability in Nigeria. More so, inflation increases economic uncertainties and reduces investment returns. This result suggests that persistent exchange rate depreciation may be due to investors' tendency to accumulate and use US dollar as store of value in order to hedge against economic uncertainties in the country.

Interest Rate Differential as a Driver

Table 3 presents the result of GARCH MIDAS with interest rate differential as a driver. Interest rate differential is the relative difference between Nigeria and US prime lending rate. Higher interest rate differential implies higher Nigeria interest rate above the US interest rate. As evident in the table, interest rate differential model with rolling window approach outperforms alternative with fixed window judging by all available model selection criteria. Thus, the result reveals that interest rate differential changes the dynamics of volatility persistence from permanent to temporary and reduces the degree of long term volatility persistence of the Nigeria foreign exchange market. This is evident as the summation of α and β parameters is less than 1 and the coefficient of long term volatility persistence as indicated by Θ is lower than 0.0986 (reduced massively by 0.0970). This result is corroborated by fixed window model which shows that the coefficient of long term volatility persistence reduces by 0.0964.

Table 3: GARCH MIDAS with Interest Rate Differential

Parameters	Fixed Window			Rolling Window		
	RV	Interest rate	Diff	RV	Interest rate	Diff
μ	-5.86E-07**	0.0001***	0.0001***	-2.57E-06***	-0.0002***	-0.0002***
α	0.0874***	0.0623***	-0.0251***	0.0873***	0.0504***	-0.0369***
β	0.9126***	0.9007***	-0.0119***	0.9127***	0.9006***	-0.0121***
Θ	0.0965***	4.67E-06***	-0.0964***	0.0986***	0.0015***	-0.0970***
ω	3.9723***	5.0364***	1.0641***	4.9547***	4.9989***	0.0442***
m	0.0108***	7.09E-08***	-0.0108***	0.0088***	1.46E-05***	-0.0088***
Model Selection Criteria						
AIC	-40101.8	-38100.8		-40116	-31295.2	
BIC	-40064.4	-38063.4		-40078.5	-31257.7	
LogL	20056.9	19056.4		20064	15653.6	

Note: AIC indicates Akaike Information Criterion, BIC is Bayesian Information Criterion, and LogL means Logarithmic likelihood. Optimal model is determined as the one that maximizes LogL and minimizes AIC and BIC. Asterisks ***, ** and * indicate 1%, 5% and 10% statistical level of significance, respectively.

This result implies a negative relationship between interest rate differential and long term volatility persistence. In other words, a lower interest rate will stimulate higher long term exchange rate volatility persistence in Nigeria. This suggests that most investors in Nigeria are risk-averse portfolio investors and would prefer to diversify into holding US dollar as asset rather than investing in real sector whenever there is a reduction in interest rate.

Terms of trade as a Driver

The result of GARCH MIDAS with terms of trade as a driver is presented in Table 4. Terms trade is defined as export to import ratio which implies that higher terms of trade implies favourable trade balance. As evident in the table, fixed window approach produced the optimal model with terms of trade judging by all available model selection criteria. Thus, the result reveals that terms of trade, like interest rate differential, changes the dynamics of volatility persistence from permanent to temporary and reduces the degree of long term volatility persistence of the Nigeria foreign exchange market. This is evident as the summation of α and β parameters is less than 1 and the coefficient of long term volatility persistence, as indicated by Θ, is lower than 0.0965 (reduced by 0.0393).

This result is corroborated by rolling window model which shows that the coefficient of long term volatility persistence reduced by 0.0412.

Table 4: GARCH MIDAS with Terms of Trade

Parameters	Fixed Window			Rolling Window		
	RV	**ToT**	**Diff**	**RV**	**ToT**	**Diff**
μ	-5.86E-07**	0.0001**	0.0001**	-2.57E-06***	0.0001	0.0001
α	0.0874***	0.0502***	-0.0372***	0.0873***	0.0502***	-0.0371***
β	0.9126***	0.9004***	-0.0122***	0.9127***	0.9004***	-0.0124***
Θ	0.0965***	0.0571***	-0.0393***	0.0986***	0.0573***	-0.0412***
ω	3.9723***	5.0000***	1.0277***	4.9547***	5.0000***	0.0453***
m	0.0108***	-0.0292***	-0.0400***	0.0088***	-0.0289***	-0.0377***
Model Selection Criteria						
AIC	-40101.8	-8155.49		-40116.0	-7901.10	
BIC	-40064.4	-8118.03		-40078.5	-7863.64	
LogL	20056.9	4083.75		20064.0	3956.55	

Note: AIC indicates Akaike Information Criterion, BIC is Bayesian Information Criterion, and LogL means Logarithmic likelihood. Optimal model is determined as the one that maximizes LogL and minimizes AIC and BIC. Asterisks ***, ** and * indicate 1%, 5% and 10% statistical level of significance, respectively.

This result implies a negative relationship between terms of trade and long term volatility persistence of the Nigeria foreign exchange market. In other words, lower term of trade or deficit trade balance will stimulate higher long term exchange rate volatility persistence in Nigeria. This suggests that dwindling foreign trade prospect of Nigeria is one of the drivers of persistent currency depreciation. While low interest rate and dwindling terms of trade stimulate higher long term exchange rate volatility persistence similarly, the results reveal that the impact of interest rate is stronger.

Stock Market Performance as a Driver

Table 5 presents the result of GARCH MIDAS with stock market performance as a driver. Stock market performance is considered as average stock market returns in Nigeria. Higher stock market returns implies improved stock market performance. As revealed in the table, exchange rate - stock market performance model with rolling window approach outperforms fixed window approach judging by all available model selection criteria. Thus, the result reveals that stock market performance also changes the dynamics of

volatility persistence from permanent to temporary and reduces the degree of long term volatility persistence of the Nigerian foreign exchange market. This is evident as the summation of α and β is less than 1 and the coefficient of long term volatility persistence, as indicated by Θ, is less than 0.0986 (reduced massively by 0.0970). This result is corroborated by fixed window model which shows that the coefficient of long term volatility persistence reduces by 0.0949.

Table 5: GARCH MIDAS with Stock Market Performance

	Fixed Window			Rolling Window		
Parameters	**RV**	**Stock**	**Diff**	**RV**	**Stock**	**Diff**
μ	-5.86E-07**	-1.66E-05	-1.60E-05	-2.57E-06***	-6.77E-06	-4.21E-06
α	0.0874***	0.0504***	-0.0370***	0.0873***	0.0501***	-0.0371***
β	0.9126***	0.9004***	-0.0122***	0.9127***	0.9002***	-0.0126***
Θ	0.0965***	0.0016***	-0.0949***	0.0986***	0.0015***	-0.0970***
ω	3.9723***	4.9997***	1.0274***	4.9547***	4.9998***	0.0451***
m	0.0108***	2.64E-06***	-0.0108***	0.0088***	2.63E-06***	-0.0088***
Model Selection Criteria						
AIC	-40101.8	-34269.3		-40116.0	-34291.9	
BIC	-40064.4	-34231.9		-40078.5	-34254.4	
LogL	20056.9	17140.7		20064.0	17151.9	

Note: AIC indicates Akaike Information Criterion, BIC is Bayesian Information Criterion, and LogL means Logarithmic likelihood. Optimal model is determined as the one that maximizes LogL and minimizes AIC and BIC. Asterisks ***, ** and * indicate 1%, 5% and 10% statistical level of significance, respectively.

This result implies a negative relationship between stock market performance and long term volatility persistence of the Nigerian foreign exchange market. In other words, adverse stock market performance will stimulate higher long term exchange rate volatility persistence in Nigeria. Notably, low interest and adverse stock market performance have massive effect in stimulating persistent currency depreciation compared to terms of trade. This suggests that exchange rate variability in Nigeria is driven by financial activities than real activities.

Crude Oil Price as a Driver

The result of GARCH MIDAS with crude oil price as a driver of exchange rate variability is presented in Table 6. Nigeria is an exporter as well as an importer of oil, hence the impact of oil price on Nigeria exchange rates cannot be presumed. As evident in the table, fixed window approach produced the optimal model with crude oil price judging by all available model selection criteria. Thus, the result reveals that crude oil price does not affect the dynamics of volatility but reduces the degree of long term volatility persistence of the Nigeria foreign exchange market. This is evident as the summation of α and β parameters equals 1 and the coefficient of long term volatility persistence, as indicated by Θ, is lower than 0.0965 (reduced by 0.0898). This result is corroborated by rolling window model which shows that the coefficient of long term volatility persistence reduced by 0.0584.

Table 6: GARCH MIDAS with Oil Price

	Fixed Window			Rolling Window		
Parameters	**RV**	**Oil Price**	**Diff**	**RV**	**Oil Price**	**Diff**
μ	-5.86E-07**	-2.36E-06***	-1.78E-06***	-2.57E-06***	-5.91E-06***	-3.35E-06***
α	0.0874***	0.0987***	0.0113***	0.0873***	0.0978***	0.0106***
β	0.9126***	0.9014***	-0.0113***	0.9127***	0.9022***	-0.0106***
Θ	0.0965***	0.0146**	-0.0818**	0.0986***	0.0402**	-0.0584**
ω	3.9723***	5.1288**	1.1565***	4.9547***	5.1049***	0.1502***
m	0.0108***	7.38E-05***	-0.0107***	0.0088***	1.74E-04***	-0.0086***
Model Selection Criteria						
AIC	-40101.8	-40929.8		-40116.0	-40751.7	
BIC	-40064.4	-40892.3		-40078.5	-40714.3	
LogL	20056.9	20470.9		20064.0	20381.9	

Note: AIC indicates Akaike Information Criterion, BIC is Bayesian Information Criterion, and LogL means Logarithmic likelihood. Optimal model is determined as the one that maximizes LogL and minimizes AIC and BIC. Asterisks ***, ** and * indicate 1%, 5% and 10% statistical level of significance, respectively.

This result implies a negative relationship between crude oil price and long term volatility persistence of the Nigeria foreign exchange market. In other words, lower crude oil price will stimulate higher long term exchange rate volatility persistence in Nigeria. This suggests that falling crude oil price when experienced in the international oil market can serve as is one of the drivers of persistent Naira-USD exchange rate depreciation.

Central Bank Forex Supply as a Driver

Table 7 presents the result of GARCH MIDAS with CBN forex supply as a driver of exchange rate variability in Nigeria. As revealed in the table, exchange rate - CBN forex supply model with fixed window approach outperforms the one with rolling window approach, judging by all available model selection criteria. Thus, the result reveals that CBN forex supply also changes the dynamics of volatility persistence from permanent to temporary and accounts for changes in degree of long term volatility persistence of exchange rate in Nigeria almost totally. This is evident as the summation of α and β is less than 1 and the coefficient of long term volatility persistence, as indicated by Θ, reduced to almost zero (reduced by about 0.0965). This result is corroborated by rolling window model which shows that the coefficient of long term volatility persistence reduced by 0.0986.

Table 7: GARCH MIDAS with Central Bank Forex Supply

	Fixed Window			**Rolling Window**		
Parameters	**RV**	**FX SS**	**Diff**	**RV**	**FX SS**	**Diff**
μ	-5.86E-07**	1.49E-04***	1.50E-04***	-2.57E-06***	1.51E-04***	1.53E-04***
α	0.0874***	0.0504***	-0.0370***	0.0873***	0.0504***	-0.0369***
β	0.9126***	0.9008***	-0.0118***	0.9127***	0.9008***	-0.0120***
Θ	0.0965***	7.23E-08***	-0.0965***	0.0986***	9.49E-07***	-0.0986***
ω	3.9723***	5.0001***	1.0278***	4.9547***	5.0001***	0.0454***
m	0.0108***	-4.22E-08***	-0.0108***	0.0088***	-6.48E-07***	-0.0088***
Model Selection Criteria						
AIC	-40101.8	-35362.8		-40116.0	-31017.8	
BIC	-40064.4	-35325.4		-40078.5	-30980.3	
LogL	20056.9	17687.4		20064.0	15514.9	

Note: AIC indicates Akaike Information Criterion, BIC is Bayesian Information Criterion, and LogL means Logarithmic likelihood. Optimal model is determined as the one that maximizes LogL and minimizes AIC and BIC. Asterisks ***, ** and * indicate 1%, 5% and 10% statistical level of significance, respectively.

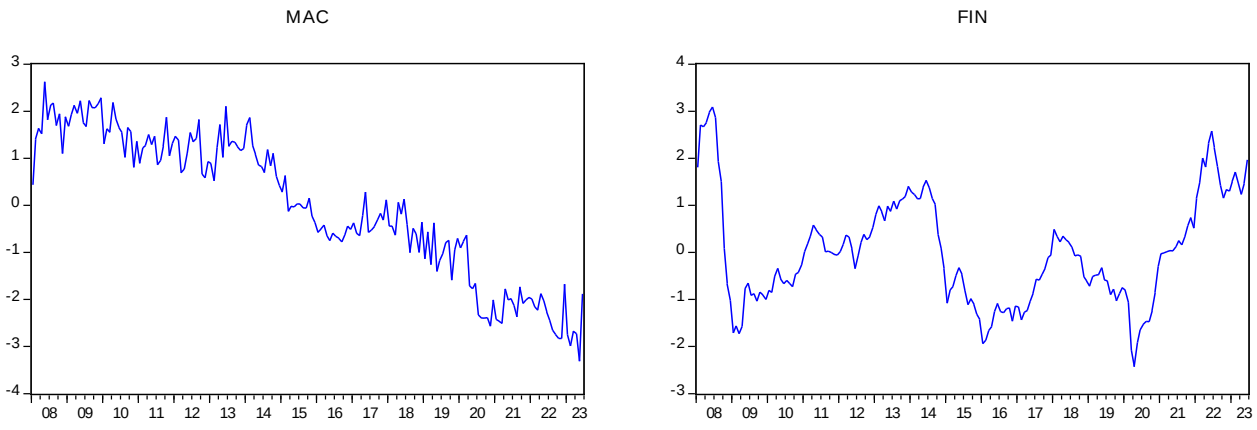
This result implies a negative relationship between CBN FX supply and long term volatility persistence of the Naira/USD exchange rate. In other words, a fall in the CBN FX supply to Nigeria forex market will stimulate higher long term exchange rate volatility persistence in Nigeria. Evidently, even while interest rate and stock market performance

appear to be major drivers of exchange rate variability in Nigeria, there impacts are less compared to that of FX supply by CBN, which accounts for almost all long term exchange rate volatility.

5.2 Addition Results (Macroeconomics vs Financial Factors)

Another contribution of this study is the application of Principal Component Analysis (PCA) technique to separate the drivers of exchange rate variability in Nigeria to macroeconomic and financial factors. This is to help policy makers in setting priorities when choosing between implementation of stabilization policies for macroeconomic or financial sector. Accordingly, macroeconomic factors consist of the price level differential, interest rate differential, terms of trade, and foreign exchange supply by the CBN, while financial factors consist of stock market performance and crude oil price. Figure 3 presents the PCA-generated macroeconomic and financial drivers of exchange rate variability in Nigeria. The trend reveals that macroeconomic performance has been falling but financial performance has been unstable.

Figure 3: Trends in the PCA-generated macroeconomic and financial drivers of exchange rate in Nigeria



Empirical result of GARCH-MIDAS model with macroeconomic factors is presented in Table 8. Evidence from comparing the model selection criteria reveals that fixed window model fits the relationship better than rolling window model. The results from both

methods are however similar in terms of signs and significance of the coefficient, which shows robustness of the results. Particularly, the result reveals that macroeconomic performance inversely affects the dynamics of volatility persistence. This is evident as the summation of α and β reduces from 1 (permanent) to less than 1 (temporary). This inverse relationship suggests that falling macroeconomic performance in Nigeria drives exchange rate variability towards permanents volatility persistence. The coefficient of long term volatility persistence, as indicated by Θ, reduced to negative (reduced by 0.0986). This result is corroborated by rolling window model which shows that the coefficient of long term volatility persistence reduced by 0.0987. This implies that falling macroeconomic performance also increases long term volatility persistence of exchange rate in Nigeria.

Table 8: GARCH MIDAS with Macroeconomic Factors

	Fixed Window			Rolling Window		
Parameters	**RV**	**MAC**	**Diff**	**RV**	**MAC**	**Diff**
μ	-5.86E-07**	-0.0002***	-0.0002***	-2.57E-06***	-0.0002***	-0.0002***
α	0.0874***	0.0448***	-0.0425***	0.0873***	0.0505***	-0.0368***
β	0.9126***	0.9003***	-0.0125***	0.9127***	0.9008***	-0.0119***
Θ	0.0965***	-4.8e-06***	-0.0986***	0.0986***	-0.0001***	-0.0987***
ω	3.9723***	4.9939***	0.0392***	4.9547***	4.9999***	0.0452***
m	0.0108***	1.1e-07***	-0.0088***	0.0088***	0.0000***	-0.0088***
Model Selection Criteria						
AIC	-40101.8	-36647.4		-40116.0	-35023.5	
BIC	-40064.4	-36610.0		-40078.5	-34986.0	
LogL	20056.9	18329.7		20064.0	17517.7	

Note: AIC indicates Akaike Information Criterion, BIC is Bayesian Information Criterion, and LogL means Logarithmic likelihood. Optimal model is determined as the one that maximizes LogL and minimizes AIC and BIC. Asterisks ***, ** and * indicate 1%, 5% and 10% statistical level of significance, respectively.

Similarly, empirical result of GARCH-MIDAS model with financial factors is presented in Table 9. Comparing the model selection criteria, it shows that rolling window model outperforms the fixed window model in fitting the relationship. The results from both methods are however similar in terms of signs and significance of the coefficient, which shows robustness of the results. Specifically, the result reveals that financial performance inversely affects the dynamics of volatility persistence, but positively influences the long

term volatility persistence. This is evident as the summation of α and β reduces from 1 (permanent) to less than 1 (temporary). This inverse relationship suggests that adverse financial market performance in Nigeria drives exchange rate variability towards permanents volatility persistence. The coefficient of long term volatility persistence, as indicated by Θ, increased to 0.1 (increased by 0.0014). This implies that adverse financial market performance also reduces long term volatility persistence of exchange rate in Nigeria. This can be justified as foreign investment inflow will reduce in reaction to adverse financial market performance.

Table 9: GARCH MIDAS with Financial Factors

	Fixed Window			Rolling Window		
Parameters	**RV**	**FIN**	**Diff**	**RV**	**FIN**	**Diff**
μ	-5.86E-07**	0.0002*	0.0002*	-2.57E-06***	0.0002	0.0002
α	0.0874***	0.0500***	-0.0373***	0.0873***	0.0500***	-0.0373***
β	0.9126***	0.9000***	-0.0127***	0.9127***	0.9000***	-0.0127***
Θ	0.0965***	0.1000***	0.0014***	0.0986***	0.1000***	0.0014***
ω	3.9723***	5.0000***	0.0453***	4.9547***	5.0000***	0.0453***
m	0.0108***	0.0019***	-0.0069***	0.0088***	0.0019***	-0.0069***
Model Selection Criteria						
AIC	-40101.8	-18445.8		-40116.0	-18465.2	
BIC	-40064.4	-18408.4		-40078.5	-18427.7	
LogL	20056.9	9228.91		20064.0	9238.59	

Note: AIC indicates Akaike Information Criterion, BIC is Bayesian Information Criterion, and LogL means Logarithmic likelihood. Optimal model is determined as the one that maximizes LogL and minimizes AIC and BIC. Asterisks ***, ** and * indicate 1%, 5% and 10% statistical level of significance, respectively.

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5.3 Summary and Remedial Monetary Policy Actions

In this section, we suggest some remedial monetary policy actions to monetary authority towards resolving the problem of persistent exchange rate depreciation in Nigeria based on inferences from the empirical results discussed in section 5.1. Basically, summary of the empirical results can be highlighted as follows:

i. The Nigeria foreign exchange market is inefficient, making it profitable for speculators to explore, thereby increasing exchange rate variability.

ii. High inflation reduces the real value of money and prompts economic agents to increase their demand for US dollars in order to hedge inflation.

iii. Low interest rate implies low return on investment in real sector and increase in the potential for diversification into portfolio assets including US dollars; thus fuelling exchange rate variability.

iv. Dwindling foreign trade prospect of Nigeria is one of the drivers of persistent currency depreciation.

v. Lower crude oil price stimulates higher long term exchange rate volatility persistence in Nigeria.

vi. A fall in the CBN FX supply to forex market stimulates higher long term exchange rate volatility persistence in Nigeria.

vii. Adverse stock market performance will stimulate higher long term exchange rate volatility persistence in Nigeria.

viii. While low interest rate and dwindling terms of trade stimulate higher long term exchange rate volatility persistence similarly, the results reveal that the impact of interest rate is stronger.

ix. While interest rate and stock market performance are among the major drivers of exchange rate variability in Nigeria, there impacts are less compared to that of FX supply by CBN, which accounts for almost all long term exchange rate volatility.

x. Additional result of this study shows that falling macroeconomic performance increases long term volatility persistence of exchange rate, while adverse financial market performance also reduces long term volatility persistence of exchange rate in Nigeria.

Based on inference from the above conclusions, we recommend the following monetary policy actions to the CBN towards reducing exchange rate variability in Nigeria.

i. **Ensure improvement in forex market efficiency** by initiating policies and programmes that will ensure increased transparency in the management of foreign exchange market. The problem of round-tripping is as a result of lack of transparency in the market. Exchange rate variability will be minimized if enough transparency can exist such that buyers of forex for genuine international trade activities have enough information about when, where and how to get the US dollars.

ii. **Promote and facilitate productivity and export of tradeable goods and services**. The most significant driver of exchange rate variability in Nigeria is low CBN supply of foreign exchange. Apparently, low crude oil price will reduce inflow of forex to Nigeria and the CBN has no control over it. Meanwhile, the CBN promote and facilitate private sector productivity and export of tradeable goods and services through its various programmes for agricultural sector and MSMEs. With increased efficiency and higher productivity and export of tradeable goods, the terms of trade will improve and exchange rate variability in Nigeria will reduce.

iii. **Facilitate reduction in macroeconomic uncertainties**. Market speculation is a major driver of exchange rate variability in Nigeria and is caused partially by the decision of economic agents to hedge against inflation and other macroeconomic uncertainties leading to adverse stock market performance. If monetary policy can be effective in taming inflation and reducing general macroeconomic uncertainties, demand for safe haven financial assets will reduce and eventually, the variability of Naira/USD exchange rate.

iv. **Promote policy consistency in exchange rate and macroeconomic management**. The problem of policy inconsistency reduces investors' confidence and promotes speculation. Given that investors' confidence in Nigeria financial markets has reduced over time, there is a need for the monetary authority to reassure potential investors of her intention to maintain popular monetary policy stance that will attract domestic and foreign investors

to our investment assets. This will further reduce speculations and unfettered demand for US dollars.

v. **Choosing between stabilization of financial market or macroeconomic performance.** Additional result of this study suggests that improvement in macroeconomic performance and adverse financial market performance can reduce long term volatility persistence of exchange rate in Nigeria. Monetary authorities need not introduce hostile financial market policy to reduce exchange rate variability; rather they should embark on policies to enhance macroeconomic performance.

6. CONCLUSION

In this study, we examine the drivers of persistent exchange rate depreciation in Nigeria and suggest remedial monetary policy actions based on inference from the results. Using time series data from January 2008 to June 2023, the following potential drivers were considered; price level differential, interest rate differential, terms of trade, stock market performance, oil price and central bank forex supply to the FX market. While Naira/USD exchange rate is a daily observation data, potential drivers are majorly available on monthly basis. On this note, we employ GARCH variant of Mixed Data Sampling (GARCH-MIDAS) technique. For robustness purpose, we employ conduct modeling with fixed window and rolling window data sampling techniques. Notable model selection criteria such as Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC) and Logarithmic Likelihood (LogL) are utilized to determine the optimal model.

Overall, our results reveal that foreign exchange market inefficiency, high inflation, low interest rate, dwindling oil price, adverse stock market performance, and low CBN FX supply to forex market are major drivers of exchange rate variability in Nigeria. Furthermore, the study shows that while interest rate and stock market performance are among the major drivers of exchange rate variability in Nigeria, there impacts are less

compared to that of FX supply by CBN, which accounts for almost all the long term exchange rate volatility. The results are robust to alternative data sampling techniques. Based on intuition from these findings remedial monetary policy actions proposed by this study include; improvement in forex market efficiency, promotion of productivity and export of tradeable goods and services, reduction in macroeconomic uncertainties, and policy consistency in exchange rate and macroeconomic management. This study has monetary orientation and as such fiscal policy indicators with potential to affect exchange rate variability such as foreign debts are neglected. Future studies can advance on this study by considering both monetary and fiscal drivers of exchange rate variability.

REFERENCES

Abdi. Z., W., Muturi, and Olweny, T. (2020). Factors Affecting Exchange Rate Volatility In Kenya. *International Journal of Economics, Commerce and Management*, 7(6), 355 – 379.

AbdulSalam, S.A., and Onipede, S.F. (2023). Economic Policy Uncertainty and the ECOWAS Exchange Rate Mechanism. *Scientific African*, 21, e01844,https://doi.org/10.1016/j.sciaf.2023.e01844

Abid, A., and Rault, C. (2020). On the Exchange Rate and Economic Policy Uncertainty Nexus: A Panel VAR Approach for Emerging Markets. *CESIFO Working Papers*, 8189

Abreu, M.K.M (2021). Are Exchange Rates More Volatile with Greater Uncertainty? Evidence from the PHP/USD Exchange Rate Using GARCH-MIDAS Models. *SSRN Electronic Journal*, https://ssrn.com/abstract=3915554

Adeoye, B.W., and Atanda, A.A. (2012). Exchange Rate Volatility in Nigeria: Consistency, Persistency & Severity Analyses. *CBN Journal of Applied Statistics*, 2(2), 29 – 29.

Aftab, M., and Mehmood A. (2023). Does Central Bank Transparency Deter the Exchange Rate Volatility? New Evidence from Asian Emerging Markets. *Journal of Central Banking Theory and Practice*, 2, 133 – 163, DOI: 10.2478/jcbtp-2023-0017

Aghevli, B.B., Moshin, S.K., and Peter, J.M. (1991). Exchange rate Policy in Developing countries:

Agosin, M., and Diaz-Maureira, J.D. (2023). Explaining the Volatility of the Real Exchange Rate in Emerging Markets. *International Review of Economics and Finance*, 87, 110 – 123, https://doi.org/10.1016/j.iref.2023.04.024

Ahmed, H.F.T., and Mazlan, N.S. (2021). The Impact of Interest Rate on Exchange Rate Within ASEAN Countries: Evidence from Linear and Nonlinear ARDL Frameworks. *Global Journal of Emerging Market Economies* 13(1) 7 – 34, 2021,DOI: 10.1177/0974910120974798

Aimer, N.M (2021). Economic Policy Uncertainty and Exchange Rates Before and During the COVID-19 Pandemic, *Journal of Ekonomi*, 06, 119 – 127.

Anwar, C.J., N., Okot, I., Suhendra, S., Yolanda, R.A.F., Ginanjar, and Sutjipto, H. (2022). Response of Exchange Rate to Monetary Policy Shocks: An Evidence from Indonesia. *International Journal of Economics and Finance Studies*, 14(1), 443 – 446. doi:10.34111/ijefs.20220020

Armah, M.K., I.K., Ofori, and Andoh, F.K. (2023). A Re-Examination of the Exchange Rate – Interest Rate Differential Relationship in Ghana. *Heliyon*, 9(e14605), https://doi.org/10.1016/j.heliyon.2023.e14605

Ashogbon, F.O., A.B., Onakoya, and Omokehinde, J.O. (2023). Public Debt, Institutional Quality and Exchange Rate Volatility: Evidence from Nigeria. *International Research Journal of Economics and Management Studies*

Aworinde, O.B., A.M., Adetokunbo, and Oyedele, O. (2021). Spillovers and Connectedness Of Economic Policy Uncertainty and Exchange Rate Volatility: Evidence From Advanced Economies And Nigeria, *International Journal of Social Science and Economic Research*, 6(4), 1143 – 1164, https://doi.org/10.46609/IJSSER.2021.v06i04.003

Aysun, U (2023). Identifying the External and Internal Drivers of Exchange Rate Volatility in Small Open Economies. *SSRN Electronic Journal*, https://ssrn.com/abstract=4353942

Babalola, A. (2021). Impact of Interest Rates on Exchange Rate in Nigeria: An Analytical Investigation. *Timisoara Journal of Economics and Business*, 14(2), 107 – 124.

Bacchetta, P., and van Wincoop, E. (2004). A Scapegoat Model of Exchange Rate Determination. *American Economic Review*, *Papers and Proceedings*, 94, 114 -18

Baek, J (2022). Does COVID-19 Play Any Role in the Asymmetric Relationship Between Oil Prices and Exchange Rates? Evidence from South Korea. *Economic Analysis and Policy*, 74, 553 – 559, https://doi.org/10.1016/j.eap.2022.03.015

Bartsch, Z (2018). Economic Policy Uncertainty and Dollar-Pound Exchange Rate Return Volatility, *SSRN Electronic Journal*, https://ssrn.com/abstract=3067782

Bilson, J.F.O. (1978). Rational Expectations and the Exchange Rate, The Economics of Exchange Rates in (Eds.) J. A. Frenkel and H. G. Johnson (eds), Addison-Wesley, Reading, MA, 75-96.

Blacilar, M., R., Gupta, C., Kyei, and Wohar, M.E. (2015). Does Economic Policy Uncertainty Predict Exchange Rate Returns and Volatility? Evidence from a Nonparametric Causality-in-Quantiles Test,

Bonato, M., O., Cepni, R., Gupta, and Pierdzioch, C. (2022). Climate Risks and Realized Volatility of Major Commodity Currency Exchange Rates, *University of Pretoria Department of Economics Working Paper Series*, Working Paper: 2022-10

Branson, W. H. (1977). Asset markets and relative prices in exchange rate determination. Sozialwissenschaftliche Annalen 1, 69—89.

Branson, W.H., and D. Henderson, (1985). Specification and Influence of Asset Markets, ch. 15 in R. Jones and P. Kenen (eds), Handbook of International Economics, 2, Amsterdam: North- Holland (1985): ch. 15.

Cai, Y. (2022). A Study of the Impact of Economic Policy Uncertainty in the US and China on the Volatility of the RMB Exchange Rate, *Advances in Economics and Management Research*, DOI: 10.56028/aemr.3.1.77,

Cassel, G. (1916). The Present Situation of the Foreign Exchanges, *The Economic Journal*, 26(101), 62 – 65, https://doi.org/10.2307/2222038

Chaturvedi, P., and Kumar, K. (2022). Econometric Modelling of Exchange Rate Volatility Using Mixed-Frequency Data, *MPRA Paper No. 115222*, https://mpra.ub.uni-muenchen.de/115222/

Chowdhury, K.B., and Garg, B. (2022). Has COVID-19 Intensified the Oil Price–Exchange Rate Nexus? *Economic Analysis and Policy*, 76, 280 – 298, https://doi.org/10.1016/j.eap.2022.08.013

Dell'Ariccia, G (1999). Exchange Rate Fluctuations and Trade Flows: Evidence from the European Union, *IMF Staff Papers*, 46, 315 – 334.

mirbas, E., and Can, N. (2022). Impact of Reserve Option Mechanism on Exchange Rate Volatility During the FED's Tapering Period, *Journal of Central Banking Theory and Practice*, 3 155 - 170, DOI: 10.2478/jcbtp-2022-0028

Devereux, M.B, and Lane, P.R. (2001). Understanding Bilateral Exchange Rate Volatility, Empirical Exchange Rate Models*, Madison, Wisconsin* Sept 28-29.

Dooley MP, and Isard, P. (1983). The Portfolio-Balance Model of Exchange Rates and Some Structural Estimates of the Risk Premium, *International Monetary Fund Staff Papers*, 683 – 702.

Dornbusch, R. (1976). Expectations and Exchange Rate Dynamics, *Journal of Political Economy*, 84, 1161 - 1176.

Dornbusch, R. (1985). Purchasing Power Parity, *National Bureau of Economic Research, Working Paper No*. 1591, Cambridge, MA. https://doi.org/10.3386/w1591

Driskill R (1980). Exchange Rate Dynamics, Portfolio Balance, And Relative Prices, *Am. Econ. Rev*, 70(4), 776 – 783.

Eichler, S., and Littke, H.C.N. (2017). Central Bank Transparency and the Volatility of Exchange Rates, *IWH Discussion Papers*, No. 22/2017, Leibniz-Institut für Wirtschaftsforschung Halle (IWH), Halle (Saale), https://nbn-resolving.de/urn:nbn:de:gbv:3:2-80759

Engle, R. (1982). Autoregressive conditional heteroscedasticity with estimates of the variance of United Kingdom inflation. *Econometrica* 50, 987–1007.

Engle, R. F., Ghysels, E., & Sohn, B. (2013). Stock market volatility and macroeconomic fundamentals. *Review of Economics and Statistics*, 95(3), 776–797.

Enumah, N.K., and H.S., Adewinbi (2023). An Analysis of the Exchange Rate Volatility in Poland using the GARCH, GJR-GARCH and EGARCH Models, *Earthline Journal of Mathematical Sciences,* 11(2), 2023, 287 – 302, https://doi.org/10.34198/ejms.11223.287302

Erdogan, S., A., Gedikli, and E., Ismail (2020). Volatility Spillover Effects Between Islamic Stock Markets and Exchange Rates: Evidence from three Emerging Countries, *Borsa Istanbul Review,* 20-4, 322 – 333, https://doi.org/10.1016/j.bir.2020.04.003

Fisher, I (1930), The Theory of Interest, New York, Macmillan, 1930. Frankel, Jeffrey, On the Mark: A Theory of Floating Exchange Rates Based on Real Interest Differentials, *American Economic Review,* 69, 610 – 622.

Frenkel, J. (1976). A Monetary Approach to the Exchange Rate: Doctrinal Aspects and Empirical Evidence, *Scandinavian Journal of Economics*, 76, 200 – 224.

Froot, K.A., and Rogoff, K. (1995). Perspectives on PPP and long-run real exchange rates. In: *Handbook of International Economic*s,. 3(c), 1647 – 1688, https://doi.org/10.1016/S1573-4404(05)80012-7

Geng, X., and Guo, K. (2022). The Spillover Effect of VIX And Oil Price on the Exchange Rate Volatility Among Belt and Road Countries, *Procedia Computer Science*, 199, 765 – 772.

Gidigbi, M.O., G.F., Babarinde, and M.W., Lawan (2018). Inflation and Exchange Rate Volatility Pass-Through In Nigeria, *Journal of Management, Economics, and Industrial Organization*, 2(3), 18 – 40.

Hameed, A., and Rose, A.K. (2017). Exchange Rate Behavior with Negative Interest Rates: Some Early Negative Observations, *ADBI Working Paper Series* , No 699

Hassan et al., 2017; Hassan. A., M., Abubakar, and Y.U., Dantama (2017). Determinants of Exchange Rate Volatility: New Estimates from Nigeria, *Eastern Journal of Economics and Finance*, 3(1), 1 – 12, DOI: 10.20448/809.3.1.1.12

He, Y., and Hamori, S. (2019). Conditional Dependence Between Oil Prices and Exchange Rates in BRICS Countries: An Application of the copula-GARCH model, *Journal of Risk and Financial Management*, 12(2), 1 – 25, https://doi.org/10.3390/jrfm12020099

Hlongwane, N.W (2022). The Relationship between Oil Prices and Exchange Rates in South Africa, *MPRA Paper No*. 113209, https://mpra.ub.uni-muenchen.de/113209/

Humphrey, T.M. (1979). The Purchasing Power Parity Doctrine, *FRB Richmond Economic Review*, 65(3), 3 – 13.

Hung, N.T., L.T.M., Nguyen, and X.V., Vo (2022). Exchange Rate Volatility Connectedness During Covid-19 Outbreak: DECO-GARCH and Transfer Entropy approaches, *Journal of International Financial Markets, Institutions & Money*, 81 (101628), https://doi.org/10.1016/j.intfin.2022.101628

Isah, K.O., and P., Ekeocha (2023) . Modelling Exchange Rate Volatility in Turbulent Periods: The Role of Oil Prices in Nigeria, *Scientific African*, 19(e01520), https://doi.org/10.1016/j.sciaf.2022.e01520

Iyke, B.N., A.H.B., Phan, and Narayan, P.K. (2022). Exchange Rate Return Predictability in Times of Geopolitical Risk, *International Review of Financial Analysis*, 81(102099).

Jara, A., and Pina, M. (2023). Exchange Rate Volatility and the Effectiveness of FX Interventions: The Case of Chile. *Latin American Journal of Central Banking*, 4(100086), https://doi.org/10.1016/j.latcb.2023.100086

Joof, F., and Jallow, O. (2020). The Impact of Interest Rate and Inflation on the Exchange Rate of the Gambia, *International Journal of Economics, Commerce and Management*, 7(1), 340 – 349.

Juhro, S.H., and Phan, D.H.B. (2018). Can Economic Policy Uncertainty Predict Exchange Rate And Its Volatility? Evidence From ASEAN Countries, *Bulletin of Monetary Economics and Banking*, 21(2), 251 – 268, https://doi.org/10.21098/bemp.v21i2.974

Kaur, M., and Kulaar, N. (2022). The Determinants of Indian Rupee Exchange Rate Volatility: An Empirical Evidence. *Social Science Journal*, 12(5), 1587 – 1602.

Kenen, P. (1969). The Theory of Optimal Currency Areas: An Eclectic View, in R. A. Mundell and A. K. Svoboda (eds.), Monetary Problems of the International Economy, Chicago University Press: Chicago Il.

Khaliq, A. (2022). Global and Country-Specific Geopolitical Risks and Exchange Rate Volatility: New Empirical Evidence from Indonesia. Jurnal Ekonomi Kuantitatif Terapan, 15(2), 225 – 239.

Kilicarslan, Z. (2018). Determinants of Exchange Rate Volatility: Empirical Evidence for Turkey, *Journal of Economics, Finance and Accounting*, DOI: 10.17261/Pressacademia.2018.825, JEFA- V.5-ISS.2- 204 – 213.

Kim, J., and Jung, H. (2018). Dependence Structure between Oil Prices, Exchange Rates, and Interest Rates, *The Energy Journal*, 39(2), 259 – 280, https://doi.org/10.5547/01956574.39.2.jkim

Kisaka, S.E., and Ouma, N. (2017). Effect of Interest Rates on Foreign Exchange Rates in Kenya: A Test of the Forward Premium Puzzle, *Research Journal of Finance and Accounting*, 8(22), 41 – 52

Kisswani, K.M., and Elian, M.I. (2021). Analyzing The (A)Symmetric Impacts of Oil Price, Economic Policy Uncertainty, and Global Geopolitical Risk on Exchange Rate. *The Journal of Economic Asymmetries*, 24(e00204), https://doi.org/10.1016/j.jeca.2021.e00204

Kouri, P., (1976). The Exchange Rate and the Balance of Payments in the Long Run and in the Short Run, *Scandinavian Journal of Economics,* 78, 280 – 304.

Krugman, P.R. and Obstfeld, M. (2009). International economics: Theory and policy, 8/E. *Pearson Education India*.

Kuncoro, H (2020). Interest Rate Policy and Exchange Rates Volatility Lessons from Indonesia. *Journal of Central Banking Theory and Practice*, 2, 19 – 42.

Li, X., X., LI, and Si, D. (2020). Investigating Asymmetric Determinants of the CNY–CNH Exchange Rate Spreads: The Role of Economic Policy Uncertainty. *Economics Letters*, 186(108827), https://doi.org/10.1016/j.econlet.2019.108827

Lim, S.Y., and Sek, S.K. (2014). Exploring the Inter-Relationship between the Volatilities of Exchange Rate and Stock Return, *Procedia Economics and Finance*, 14, 367 – 376.

Liming, C., D., Ziqing, and Zhihao, H. (2020). Impact of Economic Policy Uncertainty on Exchange Rate Volatility of China. *Finance Research Letters*, 32(101266), https://doi.org/10.1016/j.frl.2019.08.014

Long, S., R., Zhang, and J., Hao (2022). Asymmetric Impact of Sino-US Interest Rate Differentials and Economic Policy Uncertainty Ratio on RMB Exchange Rate, *Journal of International Financial Markets, Institutions & Money*, 78(101570), https://doi.org/10.1016/j.intfin.2022.101570ax

Luo, T., L., Zhang, H., Sun, and Bai, J. (2023). Enhancing Exchange Rate Volatility Prediction Accuracy: Assessing the Influence of Different Indices on the USD/CNY Exchange Rate, *Finance Research Letters,* 58(104483), https://doi.org/10.1016/j.frl.2023.104483

Maio, P., and Zeng, M. (2023). On the Driving Forces of Real Exchange Rates: Is the Japanese Yen Different? *Journal of Empirical Finance*, 74(101423), https://doi.org/10.1016/j.jempfin.2023.101423

McKinnon, R. I. (1963). Optimum Currency Areas, *American Economic Review*, 53, 717 – 725.

Min, H. G., & McDonald, J. (1993). The portfolio-balance model of exchange rates: short-run behavior and forecasting (The Korean Won/US Dollar Case). *International Economic Journal*, *7*(4), 75-87.

Moazzam, M (2023). External Debt and Real Exchange Rate Volatility in South Asia. *South Asian Journal of Macroeconomics and Public Finance*, 12(1), 83 – 110, DOI: 10.1177/22779787221107711

Mohammed, S., A., Mohammed and Nketiah-Amponsah, E. (2021). Relationship between Exchange Rate Volatility and Interest Rates Evidence from Ghana. *Cogent Economics & Finance*, 9:1, 1893258, DOI: 10.1080/23322039.2021.1893258

Moldovan, P., S., Lagoa, and D., Mendes (2021). The impact of Economic Policy Uncertainty on the real exchange rate: Evidence from the UK, *Documento De Trabalho Working Paper,* WP NO 2021/06, DOI: 10.15847/dinamiacet-iul.wp.2021.06

Mundell, R. A. (1961). A Theory of Optimum Currency Areas. *American Economic Review*, 51, 657 – 675.

Musa, A.A., and Sanusi, A.R. (2020). Effect of Interest Rate on Exchange Rate Management in Nigeria, *Nigerian Journal of Economic and Social Studies*, 62(3), 295 – 313.

Mussa, M. (1976). The Exchange Rate, the Balance of Payments, and Monetary and Fiscal Policy Under A Regime Of Controlled Floating. *Scandinavian Journal of Economics*, 78, 229 – 248.

Noria, G.L., and Bush, G. (2019). Uncertainty and Exchange Rate Volatility: the Case of Mexico. *Banco de México Working Papers*, No 2019-12

Nurkse, R., (1944). International Currency Experience: Lessons of the Inter- *War Period (League of Nations, 1944*).

Nwinee, B.F., and Olulu-Briggs, O.V. (2022). Determinants of Exchange Rate Volatility in Nigeria: An empirical review,

Oaikhenan, H. E., & Aigheyisi, O. S. (2015). Factors explaining exchange rate volatility in Nigeria: theory and empirical evidence. *Economic and Financial Review*, *53*(2), 47-77.

Ojeda-Joya, J., and Romero, J.V. (2023). Global Uncertainty Shocks and Exchange-Rate Expectations in Latin America, *Economic Modelling*, 120(106185), https://doi.org/10.1016/j.econmod.2022.106185

Oloko, T. F., Adediran, I. A., & Fadiya, O. T. (2022). Climate change and Asian stock markets: A GARCH-MIDAS approach. *Asian Economics Letters*, *3*(Early View).

Oloko, T.F. (2018). Portfolio diversification between developed and developing stock markets: The case study of US and UK investors in Nigeria. *Research in International Business and Finance*, 45, 219-232.

Pastorek, D. (2023). European Uncertainty and Euro Exchange Rate Volatility: Exploring the Role of Transnational Economic Policy, *SSRN Electronic Journal*, https://ssrn.com/abstract=4504040

Plihal, T., and Lyocsa, S. (2021). Modeling realized volatility of the EUR/USD exchange rate: Does implied volatility really matter? *International Review of Economics and Finance*, 71, 811 – 829, https://doi.org/10.1016/j.iref.2020.10.001

Poulakis, T., and Tsaliki, P. (2022). Exchange Rate Determinants of the US Dollar and Chinese RMB: A Classical Political Economics Approach, *IE*, 82(323), https://doi.org/10.22201/fe.01851667p.2023.323.83171 3 – 26

Ramachandran, M., (2023). Official Intervention, Reserve Accumulation and Exchange Rate Volatility, *Journal of Quantitative Economics*, 21, 269 – 287, https://doi.org/10.1007/s40953-023-00344-z

Ruan, Q., J., Zhang and Lv, D. (2023). Forecasting Exchange Rate Volatility: Is Economic Policy Uncertainty Better? *Applied Economics*, https://doi.org/10.1080/00036846.2023.2176457

Saidu, M.T., N.A.M., Naseem, S.H., Law, and Yasmin, B. (2021). Exploring the Asymmetric Effect of Oil Price on Exchange Rate: Evidence from the Top Six African Net Oil Importers, *Energy Reports*, 7, 8238 – 8257.

Sakaki, H. (2017). The Dynamic Relationship Between Oil Prices And Exchange Rates. *Finance and Market*, 2(2), 1 – 12, doi: 10.18686/fm.v2i2.909

Salisu, A. A. and **Oloko, T.F.** (2015). Modeling oil price-US stock nexus: A VARMA-BEKK-AGARCH approach. *Energy Economics*, **50**, 1-12.

Salisu, A. A., Gupta, R., Bouri, E., & Ji, Q. (2022). Mixed-frequency forecasting of crude oil volatility based on the information content of global economic conditions. *Journal of Forecasting*, *41*(1), 134-157.

Salisu, A. A., Swaray, R. and Oloko, T. F. (2019). Improving the predictability of the oil–US stock nexus: The role of macroeconomic variables. *Economic Modelling*, 76, 153-171.

Salisu, A. A. (2011). Modelling forecasting exchange rate volatility in Nigeria: does one model fit all? *Economic and Financial Review*, 49(1), 1-29.

Shang, J., and Hamori, S. (2023). Differential Tail Dependence between Crude Oil and Forex Markets in Oil-Importing and Oil-Exporting Countries during Recent Crisis Periods. Sustainability 2023, 15, 14445. https://doi.org/10.3390/su151914445

Smales, L.A (2021). The Influence of Policy Uncertainty on Exchange Rate Forecasting, *Journal of Forecasting,* 41, 997 – 1016, DOI: 10.1002/for.2847

Thornton, J., and Vasilakis, C. (2019). Negative Policy Interest Rates and Exchange Rate Behavior: Further Results, *Finance Research Letters*, 29, 61 – 67, https://doi.org/10.1016/j.frl.2019.03.023

Tumala, M. M., Salisu, A. A., & Gambo, A. I. (2023). Disentangled oil shocks and stock market volatility in Nigeria and South Africa: A GARCH-MIDAS approach. *Economic Analysis and Policy*, *78*, 707-717.

Tumturk, O. (2022). Global Uncertainty and Exchange Rate Volatility. *Ekoist: Journal of Econometrics and Statistics*, 37, 69 – 84, DOI: 10.26650/ekoist.2022.37.1112795

Wang, X., Z., Qi, and J., Huang (2023). How do Monetary Shock, Financial Crisis, and Quotation Reform Affect the Long Memory of Exchange Rate Volatility? Evidence from Major Currencies, *Economic Modelling*, 120(106155), https://doi.org/10.1016/j.econmod.2022.106155

Weber, C.S. (2017). The Effect of Central Bank Transparency on Exchange Rate Volatility, *BGPE Discussion Paper,* No. 174, Friedrich-Alexander-Universität Erlangen-Nürnberg, Bavarian Graduate Program in Economics (BGPE), Nürnberg

Yang, Y., and Peng, Z. (2023). Openness and Real Exchange Rate Volatility: Evidence from China, *Open Economies Review*, https://doi.org/10.1007/s11079-023-09718-5

Yang, Y., Z., Peng, and Ryou, J. (2023). What Determines The Long term Volatility of the Offshore RMB Exchange Rate? *Applied Economics*, 55(21), 2367 – 2388, DOI: 10.1080/00036846.2022.2102575

Yepez, C., and Dzikpe, F. (2022). Accounting for Real Exchange Rates in Emerging Economies: the Role of Commodity Prices. *International Review of Economics and Finance*, 79, 476–492, https://doi.org/10.1016/j.iref.2022.02.019

Yildirim, D.C., F., Erdogan, and Tan, E.N. (2022). Time-Varying Volatility Spillovers between Real Exchange Rate and Real Commodity Prices for Emerging Market Economies. *Resources Policy*, 76(102586), https://doi.org/10.1016/j.resourpol.2022.102586

You, Y., & Liu, X. (2020). Forecasting short-run exchange rate volatility with monetary fundamentals: A GARCH-MIDAS approach. *Journal of Banking & Finance*, *116*, 105849.

Zhang, X., and Baek, J. (2021). The Role of Oil Price Shocks on Exchange Rates for 13 Asian Countries: Asymmetric Evidence from Nonlinear ARDL and Generalized IRFs Approaches, *SSRN Electronic Journal*, https://ssrn.com/abstract=3978719

Zhao, R., and Cui, Y. (2021). Dynamic Cross-Correlations Analysis on Economic Policy Uncertainty and US Dollar Exchange Rate: AMF-DCCA Perspective, *Hindawi Discrete Dynamics in Nature and Society*, 2021(6668912), https://doi.org/10.1155/2021/6668912

Zhou, W. (2023). Did Donald Trump's tweets on Sino–U.S. Trade affect the offshore RMB exchange rate? *Finance Research Letters.* 58(104283), https://doi.org/10.1016/j.frl.2023.104283

Zhou, Z., and F., Zhang (2023). A Study of the Impact of Economic Policy Uncertainty on Exchange Rate Volatility, *SSRN Electronic Journal*, https://ssrn.com/abstract=4510874

Salisu, A. A., Gupta, R., Bouri, E., & Ji, Q. (2022). Mixed-frequency forecasting of crude oil volatility based on the information content of global economic conditions. *Journal of Forecasting*, *41*(1), 134-157.

Tumala, M. M., Salisu, A. A., & Gambo, A. I. (2023). Disentangled oil shocks and stock market volatility in Nigeria and South Africa: A GARCH-MIDAS approach. *Economic Analysis and Policy*, *78*, 707-717.