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EXCHANGE RATE VOLATILITY AND EXPORTS: THE NIGERIAN SCENARIO

Innocent.U.Duru[a]
Millicent Adanne Eze[b]
Abubakar Sadiq Saleh[c]
Benedict I. Uzoechina[d]
Gabriel .O. Ebenyi[e]
Ekechi Chukwuka[f]

[a,e,f]*Department of Economics, Renaissance University, Ugbawka, Enugu State, Nigeria.*
[b]*School of Business, Law and Social Sciences, Abertay University, Dundee, United Kingdom.*
[c]*Department of Banking and Finance, University of Abuja, Abuja, Nigeria.*
[d]*Department of Economics, Nnamdi Azikiwe University, Awka, Anambra State, Nigeria.*

✉ iud3x@yahoo.com *(Corresponding author)*

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ABSTRACT
This paper investigated the impact of exchange rate volatility on exports in Nigeria utilizing data from 2005Q1 to 2020Q4. The ARCH model and its extensions of GARCH, TARCH and EGARCH models and nominal effective exchange rate were employed to measure exchange rate volatility. The Autoregressive Distributed Lag Bounds test methodology was used to examine the short-run and long-run effects of exchange rate volatility on exports. The findings validated the presence of exchange rate volatility. In addition, the results revealed that exchange rate volatility had a negative and insignificant impact on exports. The study, thus, recommends that the government of Nigeria through the Central Bank of Nigeria should foster stable regimes of exchange rate through the implementation of appropriate policies of the exchange rate. Also, an enabling environment for the production of exportable goods should be provided by the government.

Contribution/Originality: This study combined the ARCH model and its extensions of GARCH, TARCH and EGARCH models to measure exchange rate uncertainty in its examination of exports and exchange rate volatility in Nigeria thereby making it more dependable and robust compared to most works.

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1. INTRODUCTION
The primary and vital barometer for assessing the international competitiveness of an economy and by implication its trade position is the exchange rate (Wang, 2015). Thus, the nexus between exchange rate volatility and exports has attracted far-reaching debate among governments, investors, analysts, researchers, economists, policymakers, since the Bretton Woods system of fixed exchange rate collapsed in March, 1973. The relevance of the knowledge of the nexus between exchange rate volatility and exports to the exchange rate and policies of trade of both developing and developed economies of the world had resulted in the proliferation of theoretical and empirical literature in this area yielding conflicting results.

Two famous hypotheses have surfaced from this literature. The first is that exchange rate volatility would have an adverse effect on trade flows. However, the second is that exchange rate volatility would boost trade flows. The hypothesis that volatility of exchange rate would reduce flows of trade finds an advocate in Cushman (1983); Cushman (1986); Cushman (1988); Akhtar and Hilton (1984); Kenen and Rodrik (1986); Thursby and Thursby

(1987); (De Grauwe, 1988); Koray and Lastrapes (1989); Perée and Steinherr (1989); Kumar and Dhawan (1991); Pritchett (1991); Pozo (1992); Savvides (1992); Chowdhury (1993); Arize (1995); Dell' Ariccia (1998); Vergil (2002); Doğanlar (2002); Esquivel and Felipe (2002); Vita and Abbott (2004); Clark, Tamirisa, and Wei (2004); Poon, Choong, and Habibullah (2005); Onafowora and Owoye (2007); SaangJoon (2008); Oskoose and Hegerty (2009); Hayakawa and Kimura (2009); Zelekha and Bar-Efrat (2011); Mohammadi, Taghavi, and Bandidarian (2011); Mougoué and Aggarwal (2011); Verheyen (2012); Nishimura and Hirayama (2013); Grier and Smallwood (2013); Poon and Hooy (2013); Oluyemi and Isaac (2017).

However, the hypothesis that exchange rate volatility would boost flows of trade finds an advocate in Brada and Méndez (1988); Giovannini (1988); Klein (1990); Asseery and Peel (1991); Franke (1991); Viaene and De Vries (1992); Sercu and Vanhulle (1992); Dellas and Zilberfarb (1993); McKenzie and Brooks (1997); Doyle (2001); Bredin, Fountas, and Murphy (2003); Todani and Munyama (2005); Kasman and Kasman (2005); Oyovwi and Ukavwe (2013); Umaru, Sa'idu, and Musa (2013); Butt (2013); Adaramola (2016); Ajinaja, Popoola, and Ogunlade (2017). Nevertheless, the adverse effects of exchange rate volatility on flows of trade are more noticeable for developing economies (Aghion & Howitt, 2007; Grier & Smallwood, 2007). Furthermore, the effect of the volatility of the real exchange rate on trade is greater under a flexible exchange rate than a fixed exchange rate (Koray & Lastrapes, 1989).

Furthermore, some scholars showed that exchange rates fluctuations in the long-run exert more significant effects on volumes of trade than exchange rate changes in the short-run which can be hedged at a low cost (Cho, Sheldon, & McCorriston, 2002; De Grauwe & De Bellefroid, 1986; Obstfeld, 1995; Perée & Steinherr, 1989). However, Viaene and De Vries (1992) demonstrated that short-run volatility in exchange rate still disturbs trade in the presence of instruments of hedging since it build-ups the risk premium in the forward exchange rate. This study will be of immense benefits to exporters and underpin the process of decision making for monetary policy authority, particularly in the formulation of appropriate macroeconomic policies in order not to destabilize the goals of trade liberalization. Again, the relevance of this study is underscored by the volatile nature of crude oil export, the main source of foreign exchange in Nigeria.

Even though the switch to floating exchange rate gives autonomy to the monetary authorities in the management of monetary policy thereby allowing changes in the exchange rate to be dictated by fluctuating market conditions, the situation still generates instability in the exchange rate capable of inflicting significant costs on the economy compared to the expected gains (Grydaki & Fountas, 2009; McKenzie, 1998). On the other hand, under the regime of the fixed exchange rate, exchange rates that are misaligned inflicted costs on the economy. Hence, a flexible exchange rate was supported to ease real exchange rate volatility in the economy. Nigeria is among the economies of the globe that relies seriously on exports, particularly crude oil export for economic growth. This is not surprising since economic growth is the concrete benefit that a universal shift to export-led growth (ELG) presents to developing and developed economies of the universe.

Furthermore, uninterrupted and stable non-oil export can serve as a veritable tool for sustainable economic growth and development in Nigeria as was witnessed in the early 1960s if fully exploited. Numerous economic activities with capacities to boost economic growth, industrialization, create employment, maintain external equilibrium and stabilize the exchange rate can be generated through non-oil export. However, these gains cannot be realized under a domestic economy with an unstable exchange rate. Hence, exchange rate stabilization is critical in ascertaining the performance of non-oil export. Thus, knowledge of the extent to which exports is influenced by exchange rate uncertainty is crucial for establishing the ideal exchange rate policy in Nigeria. This is crucial because several economies of the world experienced volatility in exchange rates following the withdrawal of the Bretton Wood system of fixed exchange rate regime in 1973 (Musibau, Babatunde, Halimah, & Hammed, 2017).

Before the era of the Structural Adjustment Programme (SAP), Nigeria implemented the regime of fixed exchange rate like most economies in sub-Saharan Africa. In 1986, Nigeria adopted the SAP to realize a feasible and pragmatic exchange rate, among others, through a flexible procedure. Hence, the country migrated from a peg exchange rate regime to a floating one with the adoption of SAP. The government of Nigeria initiated the managed float approach under the flexible regime of the exchange rate to enhance the level of output and motivate economic growth. However, the performance of output in the country falls below expectation (Mordi, 2006). Ever since the SAP was implemented in Nigeria, the level of instability in the exchange rate had been high. There have been numerous attempts by successive governments in Nigeria directed at stabilizing the exchange rate. Some of the measures include the Second-tier Foreign Exchange Market (SFEM), Foreign Exchange Market (FEM), Autonomous Foreign Exchange Market (AFEM), Dutch Auction System (DAS), Inter-bank Foreign Exchange Market (IFEM), the Wholesale Dutch Auction System (WDAS) and the Retail Dutch Auction System (RDAS) (Yakub, Sani, Obiezue, & Aliyu, 2019).

Regardless of the numerous institutional frameworks, strategies of management and measures of exchange rate stability adopted by successive governments in Nigeria to stabilize the exchange rate, enhance exports, and thus economic growth, the performance of exports leaves much to be desired. Nevertheless, exchange rate uncertainty had continued to persist. It is against this backdrop that this study contributes to the unending debate on the impact of exchange rate volatility on exports in Nigeria. The question to answer in this study is: What is the impact of exchange rate volatility on exports in Nigeria? The main thrust of this study is to investigate the impact of exchange rate volatility on exports in Nigeria.

The rest of the paper is organized as follows: Section 2 presents the literature review and theoretical framework. Section 3 discusses the methodology. Section 4 discusses the results of the study while the conclusion and policy recommendations are presented in section 5.

2. LITERATURE REVIEW AND THEORETICAL FRAMEWORK

2.1. Empirical Literature

2.1.1. Empirical Literature for the Rest of the World

Numerous empirical literature has utilized diverse data and methodologies to investigate the relationship between exchange rate volatility and exports. Regrettably, there is no consensus in terms of results. For example, Altintaş, Cetin, and Öz (2011) utilized the methodologies of Multivariate cointegration and Error Correction Model (ECM) from 1993Q3 to 2009Q4 to examine the short-run and long-run relationships among exchange rate volatility, relative prices, exports and foreign income in Turkey. The results showed that foreign income and real exchange rate volatility had a positive and significant impact on exports in Turkey in the long run. However, relative prices exerted a negative and significant effect on exports in the long run. The short-run result revealed that exchange rate volatility had a positive and significant impact on exports in Turkey. However, relative prices have a negative and significant effect on exports in Turkey in the short run.

Also, Oiro (2012) employed the Autoregressive Distributed Lag (ARDL) methodology and GARCH technique to investigate the impact of exchange rate volatility on exports of Kenyan main commodities such as horticulture, tea and coffee to the European Union (EU) and United Kingdom (UK). The results signalled that exchange rate volatility affected exports of tea to the UK and exports of horticulture to the EU. In another related study and applying the ARDL methodology, Srinivasan and Kalaivani (2013) examined empirically the nexus between exchange rate volatility and real exports in India from 1970-2011. The results showed the existence of a long-run relationship between real exports and exchange rate volatility, Gross Domestic Product (GDP), real exchange rate and foreign economic activity. The results revealed that exchange rate volatility had a negative and significant effect on real exports in the short-run and long-run respectively.

Likewise, Chamunorwa and Choga (2015) applied the GARCH methodology from 2000-2014 to examine the link between exchange rate volatility and export performance in South Africa. The findings showed that exchange rate volatility exerted a negative and significant impact on exports in South Africa. Similarly, Yusoff and Sabit (2015) used panel data of ASEAN original five-member countries exports to China from 1992-2011 and the Generalized Method of Moments (GMM) to investigate the effect of exchange rate volatility, real exchange rates and real GDP of China on ASEAN member nations bilateral exports to China. The results revealed that the real GDP of China used as a proxy for income of China had a positive impact on ASEAN exports to China. Exchange rate volatility exerted a negative impact on ASEAN exports to China. Furthermore, the real exchange rate had a positive impact on ASEAN exports to China.

In the same vein, Almohaisen (2015) utilized the Autoregressive Conditional Heteroscedasticity (ARCH) model suggested by Engle (1982) and the Generalized Autoregressive Conditional Heteroscedasticity (GARCH) model proposed by Bollerslev (1986) from 1997Q1 to 2013Q2 to examine the impact of exchange rate volatility on international trade in Jordan. The results revealed that exchange rate volatility had a negative impact on exports and imports in Jordan. Using data from 1980-2013, and the ARDL methodology, Shaikh and Hongbing (2015) studied the short-run and long-run relationships between fluctuations in the exchange rate and flows of trade in China, Pakistan and India. The short-run results revealed that exchange rate volatility exerted a negative impact on exports in China. However, it had a positive effect on Chinese exports in the long run. On the other hand, exchange rate volatility had a negative impact on the overall trade volume in India and Pakistan in both the short-run and long-run respectively.

Safuan (2017) in another study utilized the Seemingly Unrelated Regression (SUR) methodology and data from 1996-2014 to investigate the effect of exchange rate volatility on exports of Indonesia to Japan, China and the United States (US) employing aggregate and disaggregated data. The findings showed that exchange rate volatility exerted a negative impact on exports. Based on estimations using disaggregated data, the effect of exchange rate volatility on exports remained negative. However, it differs among industries in the countries investigated.

Gachunga (2018) utilized the multiple regression methodology in another similar study to examine the effect of fluctuations in the exchange rate on exports and imports in Kenya from 1980 to 2015. The findings showed that exchange rate volatility affects exports and imports significantly in Kenya. Using the ARDL methodology and data from 2000Q1-2014Q4, Thuy and Thuy (2019) as well examined the link between exchange rate volatility and exports in Vietnam. The results revealed that exchange rate volatility affects the volume of exports negatively in the long run. However, domestic currency depreciation exerts a negative and positive impact on exports in the short-run and long-run respectively in line with the J curve effect. Shockingly, real foreign income had a negative impact on the volume of exports in Vietnam. Also, employing panel data technique and data from 2000-2016, Subanti, Hakim, Riani, Hakim, and Nasir (2019) examined the impact of exchange rate volatility on exports in five ASEAN countries. The results showed that exchange rate volatility affects exports negatively.

In addition, Chaudhry and Yuce (2019) used the ARDL cointegration approach in a similar study to examine the relationship among exchange rate volatility, total exports of Canada, exports to the United States of America (USA), total imports and imports from the USA utilizing data from 1997M04-2017M08. The results showed the absence of a long-run equilibrium relationship between exchange rate volatility and total exports of Canada, exports from the USA, total imports and imports from the USA. The findings showed that exchange rate volatility had a negative and significant impact on total exports, exports to the USA and total imports. However, it had a negative and insignificant relationship with imports of Canada from the USA. The Toda and Yamamoto test results revealed a bi-directional causal relationship between exchange rate volatility and total exports of Canada, exchange rate volatility and exports to the USA, exchange rate volatility and total imports of Canada and exchange rate volatility and Canadian imports from the USA in the short-term.

Furthermore, employing the Vector Error Correction Model (VECM) and data from 2000M01 to 2016M12, Havi (2019) examined the impact of real exchange rate volatility on exports and imports in Ghana. The results showed that real exchange rate and real exchange rate volatility had a positive and significant effect on exports. Also, industrial output exerted a positive and significant impact on exports. However, the result of the tested hypotheses showed that real effective exchange rate had a significant effect on the growth of exports in Ghana. On the other hand, the real exchange rate had a positive and insignificant impact on imports. Also, real exchange rate volatility exerted a positive and significant effect on imports. However, industrial output had a negative and significant impact on imports. The results of the tested hypotheses showed that real effective exchange rate had no significant impact on the growth of imports in Ghana.

Using the ARCH model and its extensions of GARCH and EGARCH and utilizing data from 2013M01-2019M06, Rahman, Majumder, and Hossain (2020) in a similar study investigated the effect of exchange rate volatility on trade in Bangladesh. The findings based on the GARCH model showed that exchange rate volatility exerted a negative impact on trade. However, the estimates from the EGARCH model showed the absence of leverage effect in the country studied. Njoroge (2020) utilized a panel gravity model in another study and data from 1997-2019 to investigate the impact of exchange rate volatility on exports in COMESA member countries. The findings based on the application of two different measures of exchange rate volatility showed that exchange rate volatility depresses intra and extra COMESA trade.

2.1.2. Empirical Literature from Nigeria

Some studies have investigated the relationship between exchange volatility and exports in Nigeria with diverse outcomes. For example, Oyovwi and Ukavwe (2013) applied the ECM to examine the nexus between exchange volatility and international trade in Nigeria from 1970-2010. The results revealed that exchange rate volatility had a positive and insignificant impact on imports. However, it had a positive and significant impact on exports. In another similar study and applying the OLS, Granger Causality test, ARCH model and its GARCH extension, Umaru et al. (2013) examined the impact of exchange rate volatility on exports in Nigeria. The results revealed that exchange rate volatility had a positive impact on exports. The causality result revealed that there is a uni-directional causal relationship from exchange rate to exports in Nigeria.

In another related study, Duke, Audu, and Aremu (2016) employed quarterly data from 1981-2015 and the VECM to investigate the impact of exchange rate uncertainty on non-oil exports in Nigeria. The results showed that exchange rate volatility had a positive and significant impact on non-oil exports. Equally, Adaramola (2016) used the Johansen Multivariate Method of cointegration and the ECM to investigate the impact of real exchange rate volatility on the volumes of exports in Nigeria from 1970Q1 to 2014Q4. The results signalled a positive and significant impact of real exchange rate volatility on trade volume in Nigeria. Oluyemi and Isaac (2017) utilized monthly data from 1996 to 2015 and the Vector Auto Regression (VAR) methodology to investigate the impact of exchange rates on exports and imports in Nigeria. The results revealed that exchange rates exerted a positive and insignificant impact on imports. On the other hand, its impact on exports was negative and insignificant at the first lag. However, it was positive and insignificant at the second lag. Furthermore, it was discovered that exports had a negative impact on exchange rates. Again, it was found that imports had a positive impact on exchange rates.

Ajinaja et al. (2017) in another similar study utilized data from 1982 to 2015 and the Ordinary Least Square (OLS) methodology to examine the impact of exchange rate fluctuations on export performance in Nigeria. The findings showed that foreign direct investment, changes in the exchange rate and gross domestic product had a positive impact on export performance in Nigeria. Also, Musibau et al. (2017) employed the ARCH model and its numerous extensions of GARCH, TGARCH, and EGARCH models to investigate the volatility of exchange rate and used the ECM to examine the impact of exchange rate volatility on non-oil exports in Nigeria from 1986Q1 to 2014Q4. The findings confirmed the presence of exchange rate volatility and found that it exerted a negative and significant impact on non-oil exports in Nigeria.

Furthermore, Yakub et al. (2019) employed data from 1997M01 to 2016M12 to examine the effect of exchange rate volatility on the flows of trade in Nigeria. The study utilized the ARDL methodology and Granger Causality test. The findings revealed that exchange rate volatility had a negative impact on flows of trade in the short run. However, it does not have any significant effect on flows of trade in Nigeria in the long run. The causality result showed that there is a uni-directional causality from the volume of exports to exchange rate volatility. Furthermore, the findings showed that there is no causal relationship between exchange rate volatility and imports and between imports and exchange rate volatility.

Evidence from reviewed previous studies on exchange rate volatility to date revealed that most of the studies dwelled on the nexus between exchange rate volatility and non-oil exports. Studies in this regard include (Akinlo & Adejumo, 2014; Alagbe, Yusuf, & Oluwaseyi, 2017; Aliyu, 2009a; Imoughele & Ismaila, 2015; Mohagheghzadeh, Nasiri, Mohagheghzadeh, & Mahdizadeh, 2014; Musibau et al., 2017; Oriavwote & Eshenake, 2015; Uduakobong & Williams, 2017; Uduakobong & Williams, 2018; Yusuf & Edom, 2007). In addition, some studies investigated the relationship between exchange rate volatility and trade (see, for instance, (Akpokodje, 2009; Obiora & Igue, 2006; Yakub et al., 2019)).

Furthermore, some of these studies examined the link between exchange rate volatility and economic growth (see, for instance, (Adeniyi & Olasunkanmi, 2019; Akpan, 2008; Akpan & Atan, 2011; Aliyu, 2009b; Okorontah & Odoemena, 2016; Stephen, 2017; Ufoeze, Okuma, Nwakoby, & Alajekwu, 2018; Ugochukwu, 2015)). Again, some works investigated the effect of exchange rate volatility on certain macroeconomic variables (see, for instance, (Alaba, 2003; Azeez, Kolapo, & Ajayi, 2012; Essien, Dominic, & Sunday, 2011; Oladipupo & Onotaniyohuwo, 2011; Omotola,

2016; Oyovwi, 2012; Taiwo & Adesola, 2013)) with little studies on the link between exchange rate volatility and exports (see, for instance, (Adaramola, 2016; Ajinaja et al., 2017; Umaru et al., 2013)). This is regardless of the apparent high level of exchange rate fluctuations in the country. Thus, the impact of exchange rate volatility on exports has not been studied adequately.

However, there is no consensus in terms of results among the studies that examined the impact of exchange rate volatility on exports in Nigeria. Thus, this study seeks to bridge this gap by contributing to this unending debate between exchange rate volatility and exports. This study is different from past studies because to the best of our knowledge, it is the first study to test exchange rate volatility through the ARCH model and its extensions of General Autoregressive Conditional Heteroscedasticity (GARCH), the Threshold ARCH (TARCH) and Exponential GARCH (EGARCH) in the examination of the link between exchange rate volatility and exports. Musibau et al. (2017) examined the nexus between exchange rate volatility and non-oil exports in Nigeria from 1986Q1-2014Q4 with the ARCH model and its extensions of GARCH, TGARCH and EGARCH models. However, their focus was on non-oil exports.

2.2. Theoretical Review

From the perspective of theory, no conclusion exists on the nexus between exchange rate volatility and exports. This is because of the conflicting predictions of theories on the link between exchange rate volatility and exports. Two principal theories underpin the discussion of the relationship between exchange rate uncertainty and exports. These are the traditional theories and the risk portfolio theories. A negative link between exchange rate volatility and exports is assumed by the traditional theories. However, a positive link is postulated between exchange rate volatility and exports by the risk portfolio theories. Nevertheless, a third paradigm, the political economy theory purports that there is no link between exchange rate volatility and exports.

The traditional school of thought on exchange rate volatility executed the initial theoretical studies on exchange rate volatility. The results of these studies formed the traditional paradigms. These paradigms concentrated on the behaviour of firms. These theories assumed that exchange rate volatility would heighten profits uncertainty on deals denominated in foreign currencies (Muyatwa, 2018). Hence, exports that would have existed in the absence of uncertainty would be reduced. Thus, risk-averse and risk-neutral investors would be compelled by risk or profit uncertainties to transfer their resources from higher-risk foreign markets to lower risk domestic markets thereby reducing international trade (Oyovwi, 2012). Evidence from Ethier (1973) demonstration revealed that there will be a reduction in international trade if the avenues through which the businesses of entrepreneurs would be affected by the exchange rate were unclear to them.

The inability of the traditional theories to demonstrate the means through which firms cope with risks had been labelled as one of its major shortcomings (Muyatwa, 2018). Another criticism is that the traditional paradigms opined that exchange rate volatility is exclusively responsible for the risk exposure of exporters (Thuy & Thuy, 2019). It excluded others factors that the risk exposure of exporters could depend on such as opportunities for hedging, prospects of diversification in broad areas of trade, the presence of imported inputs, possibilities for profitability, among others. Some of the unrealistic assumptions of the traditional theories led to the emergence of a new theory known as the risk portfolio theory to address the weaknesses of the traditional theories. The risk portfolio theories consist of various theories with a unified view that some assumptions of the traditional theories were unrealistic.

The premise under which the traditional paradigms assumed that exchange rate volatility would shrink the volume of trade was risk aversion. However, this assumption was unwound by the risk portfolio theorists who hypothesized that the outcomes are subject to the properties of the utility function (Muyatwa, 2018). This was based on the premise that an increase in risk has income and substitution effects and they operate in different directions (Cote, 1994). Chit, Rizov, and Willenbockel (2008) stated that "the substitution effect per se decreases export activities as an increase in exchange rate risk induces agents to shift from risky export activities to less risky ones" (p.6). Again, they emphasized that "the income effect, on the other hand, induces a shift of resources into the export sector when expected utility of export revenues declines as a result of the increase in exchange rate risk" (p.6). Thus, if the substitution effect is overshadowed by the income effect, the impact of exchange rate volatility on export activity will be positive. On the other hand, if the income effect is overshadowed by the substitution effect, the impact of exchange rate volatility on export activity will be negative. De Grauwe (1988) argued that the risk aversion assumption is not enough to conclude that there is a negative link between exchange rate volatility and international trade. However, he emphasized that the important factor is the extent of risk aversion. In conclusion, the outcomes of studies conducted on the nexus between exchange rate volatility and exports are diverse. The findings of these studies have been conditioned by factors such as the currency denomination of contracts (Satawatananon, 2014) the degree of risk aversion De Grauwe (1988) the existence of other forms of business risk (Sauer & Bohara, 2001) opportunities for hedging (Sercu & Vanhulle, 1992) risk mindsets, functional forms, the existence of adjustment costs, the structure of the market (Chit et al., 2008) the specification of forward exchange markets (Caporale & Doroodian, 1994) and form of trader. Nevertheless, most recent empirical evidence suggests that a negative relationship often prevails. On a final note, the link between exchange rate volatility and exports is unclear. It is more of an empirical matter.

3. METHODOLOGY AND MODEL SPECIFICATION

This study investigated the nexus between exchange rate volatility and exports. Exchange rate volatility was tested through the Autoregressive Conditional Heteroscedasticity (ARCH) model suggested by Engle (1982) and its extensions of the GARCH model suggested by Bollerslev (1986) TARCH models initiated separately by Zakoian

(1994) and Glosten, Jagannathan, and Runkle (1993) and the EGARCH model suggested by Nelson (1991). The Autoregressive Distributed Lag (ARDL) bound test methodology was employed to uncover the short-term and long-term effects. The study utilized data from 2005Q1 to 2020Q4. The period of study was informed by the availability of quarterly data on determinants of exports. The data were derived from International Monetary Fund's (IMF's) International Financial Statistics (IFS). The time series characteristics of the variables were checked for unit root using the Augmented Dickey-Fuller (ADF) test. Following Adaramola (2016) with modifications, the export demand model that would be estimated to ascertain the nexus between exchange rate volatility and exports in Nigeria is specified in Equation 1 as:

$$LVEXP_t = \beta_0 + \beta_1 LGDP_t + \beta_2 LERVOL_t + \beta_3 LINDPROI_t + \epsilon_t \qquad (1)$$

Where:

$LVEXP_t = Log\ of\ the\ volume\ of\ exports\ at\ time\ t$

$LGDP_t = Log\ of\ Real\ Gross\ Domestic\ Product\ at\ time\ t$

$LERVOL_t = Log\ of\ Exchange\ rate\ volatility\ measured\ as\ Nominal\ effective\ exchange\ rate\ at\ time\ t$

$LINDPROI_t = Log\ of\ Industrial\ Production\ Index\ at\ time\ t$

$\epsilon_t = Error\ term$

The model is specified in logarithm form. The logarithm sign is denoted by L. We incorporated the real GDP of the local economy into the model. However, the relative price of exports was dropped from the model to reduce the collinearity issue. The Nominal Effective Exchange Rate (NEER) was employed to measure exchange rate volatility instead of the Real Effective Exchange Rate (REER). This was based on the premise that volatility was only found for the nominal exchange rate series. The impact of the industrial production index on exports is expected to be positive. This is based on the premise that exports rise with an increase in the industrial production index. Theoretically, the impact of exchange rate volatility on exports is ambiguous. It is expected to be positive or negative. Thus, depending on the sign, as exchange rate volatility increases or decreases, Nigeria's exports to its trading partners' increases or decreases. Exports demand to some extent depends on the real GDP growth of the home economy. Hence, the real GDP of the local economy is expected to motivate the need for foreign goods and Nigerian exports. Thus, the real GDP of the local economy is anticipated to have a positive sign.

Following Doroodian (1999); Sauer and Bohara (2001); Serven (2003); Clark et al. (2004); De Vita and Abbott (2004); Chit et al. (2008); Fang, Lai, and Miller (2009); Umaru et al. (2013); Khan, Azim, and Syed (2014); Wang (2015); Situ (2015); Adaramola (2016); Asteriou, Masatci, and Pılbeam (2016) the ARCH model suggested by Engle (1982) and the GARCH model suggested by Bollerslev (1986) was utilized to measure exchange rate volatility in this study. The use was based on the premise that the studies on volatility had been overshadowed by the GARCH model from the beginning of the 1980s. It gives room for continuance in conditional variance by forcing an autoregressive structure on squared errors of the process (Bala & Asemota, 2013). This shows the advantage of the ARCH/GARCH models in predicting exchange rate uncertainty compared to other models. Exchange rate volatility was generated from the Nominal Effective Exchange Rate (NEER). Following Osei-Assibey (2010) the ARCH, the GARCH, EGARCH and TARCH models are specified as:

3.1. The ARCH Model

When the conditional variances are stated as a function of squares of previous shocks, we have the main ARCH model suggested by Engle (1982). Hence, the conditional variances of ARCH models change with time. An ARCH (q) can mathematically be stated in Equation 2 as:

$$h_t = \propto_0 + \propto_1 \epsilon_{t-1}^2 + \propto_2 \epsilon_{t-2}^2 \ldots + \propto_q \epsilon_{t-q}^2 \qquad (2)$$

Where:

$q\ is\ the\ number\ of\ lags$

$\propto_0 > 0, \propto_1 \geq 0\ for\ i \geq 1$

This implies that the conditional variance depends on previously squared residuals of returns or percentage changes. The condition $\propto_0 > 0$ and $\propto_i \geq 0$ must be fulfilled for any ARCH (q) process since the conditional variance needs to be non-negative. When $\propto i = 0$, h_t equals a constant and under this condition, conditional variance is homoscedastic. The ARCH (1) suggested by Engle (1982) is the main variant of the ARCH models and is modelled in Equation 3 as:

$$h_t = \propto_0 + \propto_1 \epsilon_{t-1}^2 \qquad (3)$$

The unconditional variance of an ARCH (q) model is mathematically stated in Equation 4 as:

$$Var(\epsilon_t) = \frac{\propto_0}{1 - (\propto_1 + \propto_2 + \cdots + \propto_q)} \qquad (4)$$

3.2. The GARCH Model

Bollerslev (1986) created this approach of modelling to accommodate an ARCH (q) method gradual decaying process. When contrasted with the ARCH models, the probability of the GARCH models breaching the non-negative constraints is less. The GARCH (p, q) model permits the conditional variance at time t to rely on a constant, past shocks, and past variances. The p and q in a GARCH (p, q) model denotes the GARCH element and the ARCH element respectively. The specification of the GARCH (p, q) process is as follows in Equation 5:

$$h_t = \beta_0 + \sum_{i=1}^{p} \beta_i \epsilon_{t-i}^2 + \sum_{j=1}^{q} \gamma_j h_{t-j} \qquad (5)$$

$Where: \beta_0 \geq 0;\ \beta_i \geq 0\ and\ \gamma_j \geq 0\ for\ i \geq 1\ and\ j \geq 1$

The main variant of the GARCH (p, q) process in terms of the degree of application is GARCH $_{(1,1)}$ and is stated in Equation 6 as:

$$h_t = \beta_0 + \beta_1 \epsilon_{t-1}^2 + \gamma_1 h_{t-1} \qquad (6)$$

Under the conditional variance in Equation 6,

$\beta = Mean\ term$

$\epsilon_{t-1}^2 = ARCH\ term$

$h_{t-1} = GARCH\ term$

The news about volatility in the past period is shown by the ARCH term. On the other hand, the GARCH term shows the forecast error variance of the last period. If the sum of the parameters is closer to 1, the gradual the mean-reverting. However, if the sum is closer to 0, the quicker the mean-reverting. In the GARCH (p, q) process, the conditional variance of returns is established by three core effects and they are as follows:

$a.\ A\ constant\ expressed\ as\ \beta_0$

$b.\ Past\ shock\ or\ innovations, \sum_{i=1}^{p} \beta_1 \epsilon_{t-i}^2\ termed\ the\ ARCH\ element$

$c.\ Past\ forecasted\ conditional\ variance, \sum_{j=1}^{q} \gamma_j h_{t-j}, defined\ as\ the\ GARCH\ element$

$The\ addition\ of\ \beta_1 + \gamma_1\ shows\ the\ effect\ of\ past\ conditional\ variance\ on\ the\ present\ measure\ of\ conditional\ variance$

$When\ \beta_1 + \gamma_1 = 1, conditional\ variance\ is\ labelled\ an\ integrated\ GARCH\ or\ IGARCH$

$When\ \beta_1 + \gamma_1 > 1, the\ conditional\ variance\ is\ not\ stationary$

The predicted conditional variance will not converge on the unconditional value for higher horizons. In a GARCH (p, q) process, the unconditional variance of ε_t is stated in Equation 7 as:

$$Var(\epsilon_t) = \frac{\propto_0}{1 - \left(\sum_{i=1}^{p} \beta_i + \sum_{j=1}^{q} \gamma_j\right)} \qquad (7)$$

3.3. The EGARCH Model

Nelson (1991) proposed the EGARCH model that controls asymmetry in financial data. Even if the estimated coefficients are negative, the logarithmic characteristics of the EGARCH model guarantee that the conditional variance is positive. The expression of the conditional variance for an EGARCH model is stated in Equation 8 as follows:

$$log h_t = \propto + \sum_{j=1}^{p} \beta_j log h_{t-j} + \left[\sum_{i=1}^{q} \omega_i \frac{\epsilon_{t-i}}{h_{t-i}}\right] + \left(\sum_{i=1}^{q} \lambda_i \frac{\epsilon_{t-i}}{h_{t-i}}\right) \qquad (8)$$

$If \sum_{j=1}^{p} \beta_j < 1, stationarity\ is\ guaranteed$

$If\ \omega\ is\ \neq 0, there\ is\ an\ asymmetry\ effect\ but\ if\ \omega = 0, there\ is\ no\ effect\ of\ asymmetry$

$If\ \omega < 0\ in\ financial\ markets, there\ is\ the\ presence\ of\ leverage\ effect$

$If\ \omega > 0, depreciation\ is\ expected\ to\ increase\ volatility$

Hence, depreciation of real local currency increases exchange rate volatility more than the appreciation of the real local currency.

$$If\ \omega < 0, depreciation\ is\ expected\ to\ decrease\ volatility$$

Hence, appreciation of real local currency increases exchange rate volatility more than the depreciation of the real local currency. The unconditional variance of the EGARCH model is mathematically specified in Equation 9 as:

$$Var(\epsilon_t) = exp\left[\frac{\propto}{1-\sum_{j=1}^{p}\beta_j}\right] \qquad (9)$$

3.4. The TARCH Model

In the contention of Zakoian (1994) and Glosten et al. (1993) the Threshold ARCH model uses a piecewise equation to the conditional standard deviation to permit asymmetry in the conditional variance. The TARCH model is mathematically defined in Equation 10 as:

$$h_t = \beta_0 + \sum_{j=1}^{p}\beta_j\, h_{t-i} + \sum_{i=1}^{p}\gamma_i\, \epsilon_{t-1}^2 + \sum_{i=1}^{p}\gamma_i \epsilon_{t-i}^2 l_{t-i}^- \qquad (10)$$

$\gamma_i \neq 0$ *shows asymmetry.* l_{t-i}^- *is a dummy variable specified as:*

$$I_{t-i}^- = \begin{Bmatrix} 1\ if\ \epsilon_{t-1} < 0 \\ 0\ otherwise \end{Bmatrix}$$

$$Stationarity\ is\ guaranteed\ if\ \sum_{i=1}^{q}\propto_i + \sum_{j=1}^{p}\beta_j + \frac{1}{2}\sum_{j=1}^{p}\gamma_i < 1$$

When utilized for leverage effect analysis, the expectation is that $\gamma_i > 0$ so that 'bad news' which is denoted by $\varepsilon_{t-1} < 0$ will exert a larger effect on volatility. Concerning percentage changes in the real exchange rate, real currency appreciation from this specification impact exchange rate volatility through the addition of the coefficients $\propto_i + \gamma_i$ (Osei-Assibey, 2010).

If $\gamma_i < 0$, *depreciation of the local currency would increase exchange volatility more than appreciation*

The unconditional variance of a TARCH model is stated in Equation 11 as:

$$Var(\epsilon_t) = \frac{\propto_0}{1 - \langle\sum_{i=1}^{q}\propto_i + \sum_{j=1}^{p}\beta_j + \frac{1}{2}\sum_{j=1}^{p}\gamma_i\rangle} \qquad (11)$$

Stating Equation 1 in ARDL framework yields Equation 12:

$$LVEXP_t = \propto_0 + \sum_{i=1}^{\rho}\propto_1 \Delta LVEXP_{t-i} + \sum_{i=1}^{\rho}\propto_2 \Delta LGDP_{t-i} + \sum_{i=1}^{\rho}\propto_3 \Delta LERVOL_{t-i} + \sum_{i=1}^{\rho}\propto_4 \Delta LINDPROI_{t-i}$$
$$+ \beta_1 LVEXP_{t-i} + \beta_2 LGDP_{t-i} + \beta_3 LERVOL_{t-i} + \beta_4 LINDPROI_{t-i}$$
$$+ \mu_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 12$$

Where p and Δ symbolize the lag length and difference operator. α_0 and μ_t denote the drift and disturbance term. The parameters of the short-run dynamics are α_1, α_2, α_3, and α_4. However, β_1, β_2, β_3 and β_4 are the parameters of the long-run relationship.

4. DATA PRESENTATION, ANALYSIS AND DISCUSSION OF RESULTS

4.1. Results of Augmented Dickey-Fuller (ADF) Test

Table 1. ADF Unit Root Test Results.

Variable	Augmented Dickey-Fuller (ADF)		
	Level	First Difference	I(d)
LVEXP	-2.9271**	-	I (0)
LGDP	0.4527	-7.0001***	I (1)
LERVOL	0.3848	-7.0135***	I (1)
LINDPROI	-1.5919	-4.2070***	I (1)

Note: *** and ** indicate statistical significance at the 1% and 5% levels of significance.

The results of the ADF unit root test in Table 1 revealed that the variables were either I(0) or I(1).

Table 2. ARCH LM Test Result.

H_o: No ARCH Effect		
F-Statistic	383.6147	Prob. F (0.0000)
Observed R-squared	54.3566	Prob. Chi-square (0.0000)

4.2. Results of ARCH LM Test

The outcome of the test for the ARCH effect executed to establish the presence of exchange rate volatility is depicted in Table 2. Since the probability values of the observed R-squared and the corresponding Chi-square is less than the 5% level of significance, we reject the null hypothesis that there is no ARCH effect. Hence, we conclude that there is an ARCH effect in this model. This suggests that Naira-Dollar exchange rate is volatile. Since there is clustering volatility in the exchange rate and an ARCH effect, we have the right to run the ARCH family models.

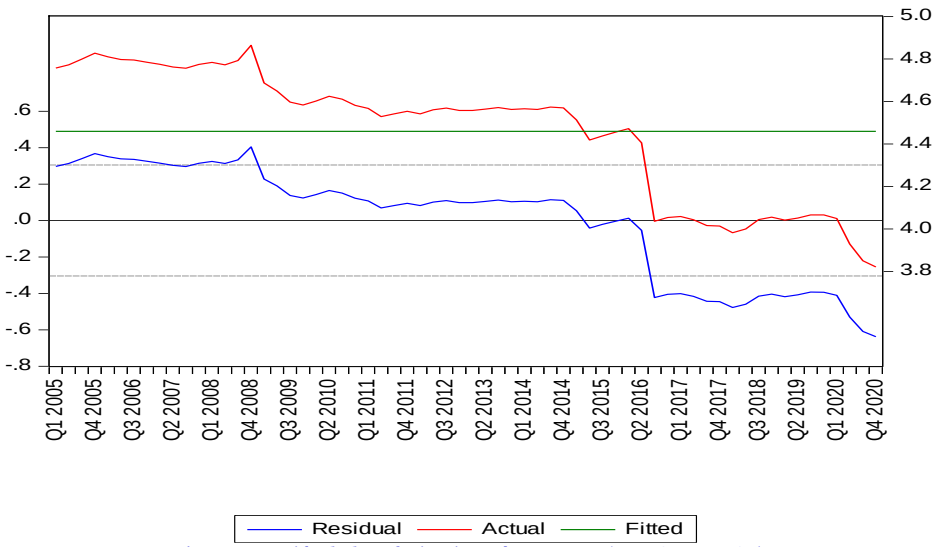

Figure 1. Residual plot of Nigeria exchange rate (2005Q1-2020Q4).

The plot of the residual for 64 quarters is shown in Figure 1. There is evidence of volatility clustering in this graph. Periods of high changes or volatilities are followed by periods of low changes or volatilities. On the other hand, periods of low changes or volatilities are followed by periods of high changes or volatilities. Also, we have wild periods and calm periods. This justifies us running ARCH family models.

Table 3. ARCH-TYPE models results.

Variables	ARCH (1,1)	GARCH (1,1)	EGARCH	TARCH
Mean Equation				
Constant	0.0743 (0.1055)	-0.0225 (0.3987)	-0.0452 (0.0373**)	-0.0459 (0.0000***)
$LNEER_{t-1}$	0.9840 (0.0000***)	1.0059 (0.0000***)	1.0111 (0.0000***)	1.0094 (0.0000***)
Variance Equation				
Constant	0.0003 (0.0002***)	0.0003 (0.0393**)	-8.0350 (0.0000***)	0.0000 (0.6813)
ARCH (1)	2.8006 (0.0000***)	3.1706 (0.0000***)	1.7588 (0.0001***)	0.0193 (0.9494)
GARCH (1)	-	-0.0025 (0.9497)	0.0174 (0.9289)	1.0836 (0.0000***)
ASYMMETRY (1)	-	-	-0.1726 (0.5473)	-
THRESHOLD (1)	-	-	-	-0.1010 (0.7357)
Diagnostic Test				
AIC	-3.6278	-3.5684	-3.7783	-3.3600
SIC	-3.4917	-3.3983	-3.5742	-3.1559
HQC	-3.5743	-3.5015	-3.6981	-3.2797

Note: Probability Values are in bracket - ( ).
***, ** and * denote statistical significance at 1%, 5% and 10% levels, respectively.

4.3. Results of ARCH-TYPE Models

The results of the estimated four models from the ARCH family are depicted in Table 3. Under ARCH (1,1), the mean equation was 0.0743 and it was insignificant. Under the variance equation, the constant was 0.0003. For interpretation, the ARCH term tells us the extent to which the degree of a shock to the variance influences future volatility in the exchange rate. The leverage effect term gives us an intuition into how the sign of the shock affects the future volatility of the exchange rate. Furthermore, the GARCH term gives us an intuition into the persistence of previous volatility and how previous volatility aids to forecast future volatility. The coefficient of ARCH in the model was 2.8006 and it was significant. This implies that past exchange rate volatilities can significantly explain the present exchange rate value. The positive sign of the ARCH term implies that there is a positive relationship between the past variance and the current variance in absolute value. This suggests that the higher the degree of the shock to the variance, the higher the volatility. This result contravenes the submissions of Musibau et al. (2017).

The underlying assumption is that $\beta_0>0$ and β_1 should lie between zero and one. Let us see whether the variance equation satisfies this condition. The constant in the variance equation was greater than zero. However, the coefficient of ARCH does not lie between zero and one. This implies that volatility was explosive and tends to infinity

as shocks persist forever. Furthermore, the GARCH coefficient of -0.0025 was insignificant with probability values of 0.9497. This implies that the past volatility of the exchange rate is not significant in explaining the current value of Nigeria's exchange rate. Hence, past volatility does not help to forecast future volatility. The insignificance of the GARCH parameter signifies the absence of the GARCH effect. This suggests that past periods news regarding volatility cannot adequately explain present volatilities. In addition, the insignificance of the GARCH coefficient implies that a large excess return value either positive or negative would not result in future predictions of the variance being high for a lengthy time. The GARCH results are contrary to the submissions of Musibau et al. (2017) and Olufayo and Fagite (2014). A negative asymmetry parameter -0.1726 that was insignificant was revealed by the result of the EGARCH model. Hence, the leverage effect term was insignificant. The negative sign of the shock affects exchange rate volatility. The leverage effect term was negative. It means that bad news will increase the volatility of Nigeria's exchange rate more than good news of the same size – evidence of leverage effect. Alternatively, it implies that negative shocks would increase the volatility of Nigeria's exchange rate more than positive shocks of the same degree. Furthermore, it means that a fall in the exchange rate of the Naira results in more volatility than an increase in the Naira exchange rate of the same degree (leverage effect). Also, there is an asymmetry effect since ω is $\neq 0$. Hence, there is an indication or sign of leverage effect. Thus, bad news has more tendency to increase exchange rate volatility than good news in the foreign exchange market of Nigeria. However, in the determination of asymmetric effect in exchange rate volatility, the findings of the TARCH model revealed that thresholds are not important.

The best-fitted model is the EGARCH model. This is because it has the lowest value of Schwarz Information Criterion SIC (-3.5742). The superiority of the EGARCH model is akin to the result of Musibau et al. (2017). We conducted post estimation tests for all the ARCH family models utilized in this study to ensure that the instability in the series was captured sufficiently in our models. The findings were reported in Table 4. The findings showed that the unpredictability of the series was sufficiently captured in our models. This was based on the premise that all the probability values were more than any of the conventional levels of significance. In addition, we conducted the correlogram of squared residuals to supplement the ARCH test in spotting heteroscedasticity. The results of the correlogram of squared residuals for the numerous extensions of the ARCH-type model used in this study is depicted in Tables 9, 10, 11 and 12 respectively in the appendix.

Table 4. Post estimation test results using ARCH LM test.

H_o: No ARCH Effect				
	ARCH (1,1)	**GARCH (1,1)**	**EGARCH**	**TARCH**
F-Statistic	0.7981	0.6392	0.3104	1.4651
Prob. Value	0.3752	0.4272	0.5795	0.2309
Obs. R-Squared	0.8139	0.6535	0.3191	1.4779
Prob. Value	0.3670	0.4189	0.5721	0.2241

The results of the Heteroscedasticity post estimation test for the four models in the ARCH family is depicted in Table 4. The probability values for the ARCH, GARCH, EGARCH and TARCH models were insignificant. These probability values were greater than all the conventional levels of significance. Hence, there were no heteroscedasticity problems in their residuals.

These models passed the homoscedasticity tests. Hence, we failed to reject the null hypothesis that there is no ARCH effect in their residuals. There is no presence of the ARCH effect in their residuals. Furthermore, the results of the correlogram of squared residuals for the numerous extensions of the ARCH-type model utilized in this study in the appendix revealed that there is no autocorrelation in their residuals. This is because the results revealed that all the probability values for the 28 diverse lags were greater than any of the conventional levels of significance.

Table 5. Bound test results.

F-statistics	**Significance Level**	**Lower Critical Value Bound I(0)**	**Upper Critical Value Bound I(1)**
3.4956	1%	5.17	6.36
	5%	4.01	5.07
	10%	3.47	4.45

Note: Critical value bounds for the F-statistic from Pesaran, Shin, and Smith (2001).

4.4. Results of Bound Test

The results of the bounds F-test is presented in Table 5. The F-values falls between the lower critical value bound I(0) and the upper critical value bound I(1). Thus, the test was considered inconclusive. However, considering the empirical illustration as shown in Table 5, we considered both long-run and short-run models.

Table 6. Diagnostic results.

Test	**Type of Statistic**	**Test Statistic**	**P-value**
Breusch-Godfrey Serial Correlation LM	χ^2	6.8841	0.0488
Ramsey RESET test	F	5.0810	0.0300
Jarque-Bera normality test	χ^2	1.4177	0.4922
Heteroskedasticity Test: ARCH	χ^2	13.9133	0.8349

4.5. Results of Diagnostic Tests

The diagnostic test results are reported in Table 6. The findings revealed that the model had the problem of serial correlation. Also, the Ramsey Reset test showed that the model was not correctly specified. However, the results of the Jarque-Bera test revealed that the residual was normally distributed. Furthermore, the result revealed that the model did not have the problem of heteroscedasticity.

Table 7. Long-run Estimates for export model.

Lgdp	Lervol	Lindproi	C
-2.6121	-0.0292	0.5499	33.8015
[-2.8989***]	[-0.1434]	[0.9712]	[2.9427***]
-0.0061	(0.8867)	(0.3374)	(0.0055)

Note: Probability Values are in bracket - ( ).
t-statistics are in [].
***, ** and * denote significance at 1%, 5% and 10% respectively.

4.6. Results of Estimated Long-run Coefficients

Table 7 depicts the results of the estimated long-run coefficients. The real GDP had a negative and significant relationship with exports. The significance of this variable means that a decreased national income would not boost the economy's productive capability thereby resulting in reduced domestic goods export. This finding, however, contravenes the positive relationship expected between real GDP and exports. Thus, real GDP adversely affects Nigeria's exports. This result contravenes the findings of Ajinaja et al. (2017). Exchange rate volatility had a negative relationship with exports.

Table 8. Results of estimated short-run error correction model.

Dependent Variable: LVEXP				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
Δ(LVEXP(-1))	0.1090	0.1825	0.5978	0.5535
Δ(LGDP)	-2.0421	1.7947	-1.1378	0.2621
Δ(GDP(-1))	-4.4661	2.8274	-1.5796	0.1223
Δ(LERVOL)	0.4106	0.2565	1.6011	0.1174
Δ(LERVOL(-1))	-0.2851	0.3447	-0.8270	0.4132
Δ(LERVOL(-2))	0.2713	0.3257	0.8330	0.4099
Δ(LERVOL(-3))	0.1079	0.2471	0.4364	0.6649
Δ(LINDPROI)	0.4839	0.3624	1.3355	0.1895
Δ(LINDPROI(-1))	0.4844	0.3431	1.4118	0.1659
ECM_{t-1}	-0.7779	0.2150	-3.6183***	0.0008

ECM = LVEXP – 2.6121*LGDP – 0.0292*LERVOL + 0.5499*LINDPROI + 33.8015*C + 0.0161*D.
Note: *** denote significance at 1% level.

This means that a one per cent increase in exchange rate volatility decreases Nigeria's exports by 0.03%. This result is in line with the submissions of the second measure of volatility used by Musibau et al. (2017). However, the coefficient of the industrial production index had a positive relationship with exports. This suggests that a one per cent increase in industrial production index or a measure of the real output of the manufacturing, mining, electric and gas utility industries would increase exports by 0.55%.

4.7. Results of the Short-run Dynamic Model

The results of the short-run dynamics are reported in Table 8. Change in exchange rate volatility had a positive and insignificant relationship with exports. However, the coefficient of exchange rate volatility at the first difference had a negative and insignificant relationship with exports. The change in real GDP had a negative relationship with exports. This implies that a one per cent increase in real GDP would reduce exports by 2.04%. Furthermore, the results revealed that change in the industrial production index is positively associated with exports. Hence, a one per cent rise in the index of industrial production would lead to an increase in exports of Nigeria by 0.48%. The Error Correction Term (ECT) depicts the speed of convergence to equilibrium from disequilibrium. The ECT is -0.7779. This means that real exports correct about 78% of their previous deviation from equilibrium every year. The ECT had the expected negative sign and is high. It revealed a good speed of adjustment from disequilibrium to equilibrium.

5. CONCLUSION AND RECOMMENDATIONS

This paper investigated the impact of exchange rate volatility on exports in Nigeria from 2005Q1 to 2020Q4. We utilized the ARCH model and its extensions of GARCH, TARCH and EGARCH models and NEER to measure exchange rate uncertainty. The ARDL methodology was employed to examine the short-run and long-run relationships between exports and exchange rate volatility. The findings validated the presence of exchange rate volatility. Furthermore, the results revealed that exchange rate volatility had a negative and insignificant effect on exports. Based on the outcome of this study, the following recommendations are proffered: The government of Nigeria through the Central Bank of Nigeria (CBN) should foster stable regimes of exchange rate through the

implementation of appropriate policies of the exchange rate. Also, an enabling environment for the production of exportable goods should be provided by the government. Furthermore, the CBN should endorse a reliable monetary policy with low policy turnarounds and low contradictions to stabilize the Naira.

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APPENDICES

Appendix 1: Correlogram of squared residuals for ARCH family models.

Table 9. Correlogram of squared residuals for ARCH model.

Sample: 2005Q1 2020Q4
Included observations: 64

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob*
. |*. |	. |*. |	1	0.114	0.114	0.8629	0.353
.*| . |	.*| . |	2	-0.116	-0.131	1.7645	0.414
.*| . |	. | . |	3	-0.075	-0.046	2.1463	0.543
. | . |	. | . |	4	-0.047	-0.049	2.3025	0.680
. |*. |	. |*. |	5	0.159	0.161	4.0860	0.537
. |** |	. |** |	6	0.296	0.258	10.402	0.109
. | . |	.*| . |	7	-0.033	-0.069	10.483	0.163
. | . |	. | . |	8	-0.050	0.035	10.668	0.221
. | . |	. | . |	9	0.026	0.061	10.721	0.295
. | . |	.*| . |	10	-0.062	-0.084	11.015	0.356
.*| . |	.*| . |	11	-0.080	-0.161	11.514	0.401
. | . |	.*| . |	12	-0.011	-0.073	11.523	0.485
.*| . |	.*| . |	13	-0.138	-0.148	13.082	0.442
. | . |	. | . |	14	-0.014	-0.030	13.097	0.519
. |** |	. |** |	15	0.222	0.218	17.290	0.302
. |*. |	. |*. |	16	0.088	0.153	17.960	0.326
.*| . |	. | . |	17	-0.100	-0.001	18.846	0.337
.*| . |	. | . |	18	-0.097	0.005	19.710	0.349
.*| . |	. | . |	19	-0.081	0.017	20.325	0.375
. | . |	.*| . |	20	0.008	-0.099	20.331	0.437
. |** |	. | . |	21	0.224	0.033	25.225	0.238
.*| . |	.*| . |	22	-0.068	-0.189	25.686	0.265
. | . |	. | . |	23	-0.058	-0.005	26.027	0.300
. | . |	. | . |	24	0.002	-0.008	26.028	0.352
. | . |	. |*. |	25	0.065	0.166	26.487	0.382
. | . |	. | . |	26	-0.016	0.020	26.515	0.435
. | . |	. | . |	27	-0.048	-0.045	26.775	0.476
. | . |	. |*. |	28	-0.062	0.078	27.222	0.506

Note: *Probabilities may not be valid for this equation specification.

Table 10: Correlogram of squared residuals for GARCH model.

Sample: 2005Q1 2020Q4
Included observations: 64

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob*
. |*. |	. |*. |	1	0.102	0.102	0.6925	0.405
.*| . |	.*| . |	2	-0.108	-0.120	1.4768	0.478
. | . |	. | . |	3	-0.064	-0.041	1.7581	0.624
.*| . |	.*| . |	4	-0.074	-0.078	2.1433	0.709
. |*. |	. |*. |	5	0.078	0.086	2.5769	0.765
. |*. |	. |*. |	6	0.211	0.180	5.7711	0.449
. | . |	. | . |	7	-0.011	-0.043	5.7795	0.566
. | . |	. | . |	8	-0.049	-0.001	5.9583	0.652
. | . |	. |*. |	9	0.065	0.098	6.2814	0.711
.*| . |	.*| . |	10	-0.099	-0.110	7.0386	0.722
.*| . |	.*| . |	11	-0.098	-0.103	7.7948	0.732
. | . |	. | . |	12	0.014	-0.017	7.8098	0.800
.*| . |	.*| . |	13	-0.089	-0.101	8.4620	0.812
.*| . |	.*| . |	14	-0.066	-0.079	8.8224	0.842
. |** |	. |** |	15	0.270	0.267	15.061	0.447
. |*. |	. |*. |	16	0.120	0.125	16.319	0.431
.*| . |	. | . |	17	-0.089	-0.057	17.030	0.452
.*| . |	. | . |	18	-0.075	-0.029	17.543	0.486
.*| . |	. | . |	19	-0.082	0.016	18.163	0.512
. | . |	. | . |	20	-0.002	-0.035	18.164	0.577
. |** |	. |*. |	21	0.245	0.093	24.026	0.292
. | . |	.*| . |	22	-0.065	-0.153	24.454	0.324
. | . |	. | . |	23	-0.062	0.024	24.843	0.358
. | . |	. | . |	24	0.010	-0.022	24.852	0.414
. | . |	. |*. |	25	0.068	0.146	25.348	0.443
. | . |	. | . |	26	-0.038	-0.027	25.512	0.490
. | . |	.*| . |	27	-0.034	-0.077	25.646	0.538
.*| . |	. | . |	28	-0.070	-0.007	26.215	0.561

Note: *Probabilities may not be valid for this equation specification.

Table 11. Correlogram of squared residuals for TARCH model.

Sample: 2005Q1 2020Q4 Included observations: 64						
Autocorrelation	**Partial Correlation**		**AC**	**PAC**	**Q-Stat**	**Prob***
. |*. |	. |*. |	1	0.154	0.154	1.5720	0.210
. | . |	. | . |	2	-0.011	-0.036	1.5801	0.454
.*| . |	.*| . |	3	-0.080	-0.075	2.0208	0.568
. | . |	. | . |	4	-0.061	-0.038	2.2759	0.685
. | . |	. | . |	5	-0.040	-0.028	2.3886	0.793
. | . |	. | . |	6	-0.053	-0.052	2.5940	0.858
. | . |	. | . |	7	0.006	0.014	2.5963	0.920
. | . |	. | . |	8	0.053	0.043	2.8038	0.946
.*| . |	.*| . |	9	-0.068	-0.097	3.1572	0.958
.*| . |	.*| . |	10	-0.112	-0.094	4.1253	0.942
.*| . |	.*| . |	11	-0.097	-0.067	4.8611	0.938
.*| . |	.*| . |	12	-0.089	-0.083	5.4901	0.940
.*| . |	.*| . |	13	-0.067	-0.071	5.8534	0.951
. | . |	. | . |	14	-0.041	-0.052	5.9968	0.967
. |*. |	. |*. |	15	0.172	0.155	8.5232	0.901
. | . |	. | . |	16	0.072	-0.013	8.9707	0.915
.*| . |	.*| . |	17	-0.067	-0.099	9.3746	0.928
. | . |	. | . |	18	-0.049	-0.017	9.5945	0.944
. | . |	. | . |	19	-0.050	-0.047	9.8235	0.957
. | . |	. | . |	20	-0.027	-0.045	9.8907	0.970
. | . |	. | . |	21	-0.006	-0.016	9.8939	0.980
. | . |	.*| . |	22	-0.044	-0.083	10.084	0.986
. | . |	.*| . |	23	-0.027	-0.090	10.159	0.990
. | . |	. | . |	24	-0.036	-0.051	10.292	0.993
. | . |	. | . |	25	0.003	0.017	10.292	0.996
. | . |	. | . |	26	-0.032	-0.060	10.408	0.997
. | . |	.*| . |	27	-0.050	-0.068	10.688	0.998
. | . |	. | . |	28	0.044	0.042	10.912	0.998

Note: *Probabilities may not be valid for this equation specification.

Table 12. Correlogram of squared residuals for EGARCH model.

Sample: 2005Q1 2020Q4 Included observations: 64						
Autocorrelation	**Partial Correlation**		**AC**	**PAC**	**Q-Stat**	**Prob***
.*| . |	.*| . |	1	-0.072	-0.072	0.3387	0.561
. | . |	. | . |	2	-0.007	-0.012	0.3418	0.843
.*| . |	.*| . |	3	-0.079	-0.081	0.7679	0.857
.*| . |	.*| . |	4	-0.119	-0.133	1.7575	0.780
. |*. |	. | . |	5	0.075	0.055	2.1599	0.827
. | . |	. | . |	6	-0.062	-0.065	2.4403	0.875
. |*. |	. |*. |	7	0.102	0.077	3.2069	0.865
.*| . |	.*| . |	8	-0.081	-0.078	3.6984	0.883
. |*. |	. |*. |	9	0.129	0.134	4.9556	0.838
. | . |	. | . |	10	-0.028	-0.023	5.0166	0.890
.*| . |	.*| . |	11	-0.104	-0.086	5.8605	0.883
. | . |	.*| . |	12	-0.053	-0.085	6.0836	0.912
.*| . |	.*| . |	13	-0.109	-0.079	7.0649	0.899
. | . |	.*| . |	14	-0.030	-0.108	7.1403	0.929
. | . |	. | . |	15	0.020	0.001	7.1737	0.953
. |*. |	. |*. |	16	0.149	0.107	9.1187	0.908
.*| . |	.*| . |	17	-0.085	-0.083	9.7567	0.914
. | . |	.*| . |	18	-0.065	-0.089	10.142	0.927
.*| . |	.*| . |	19	-0.088	-0.089	10.859	0.928
. | . |	. | . |	20	0.033	0.060	10.960	0.947
. |*. |	. |*. |	21	0.107	0.075	12.069	0.938
. | . |	. | . |	22	-0.035	-0.033	12.193	0.953
. | . |	.*| . |	23	-0.028	-0.072	12.272	0.966
. | . |	. | . |	24	-0.045	-0.033	12.486	0.974
. |*. |	. |*. |	25	0.142	0.092	14.654	0.949
. | . |	. | . |	26	-0.055	-0.054	14.984	0.958
. | . |	. | . |	27	0.027	0.034	15.066	0.969
. | . |	. | . |	28	-0.054	-0.048	15.402	0.974

Note: *Probabilities may not be valid for this equation specification.

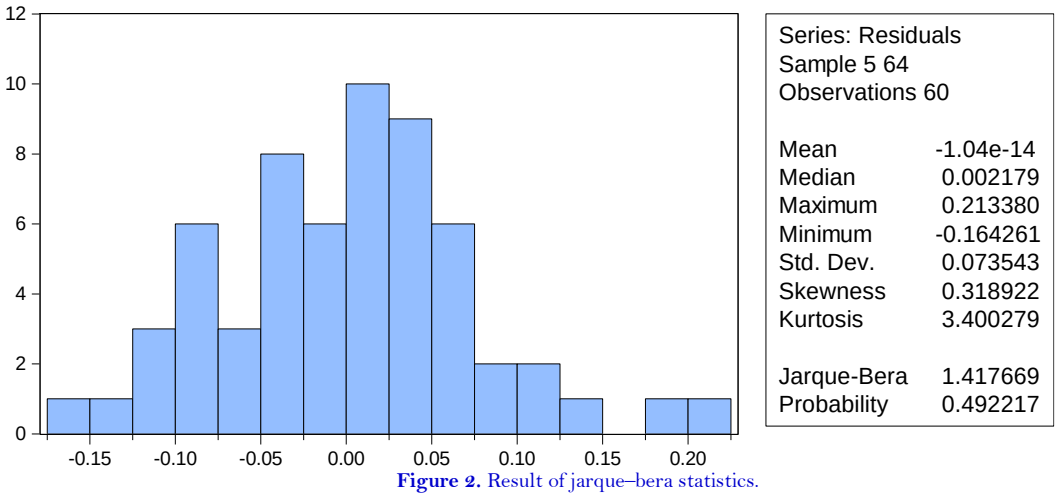

Figure 2. Result of jarque–bera statistics.