

THE EFFECT OF REAL EXCHANGE RATE VOLATILITY ON EXPORT VOLUME IN NIGERIA

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Abstract

This paper examined the effect of real exchange rate volatility on export volumes in Nigeria. The study employed the time series quarterly data for the period of 1970Q1-2014Q4. The analytical method employed was econometric techniques of Johansen Multivariate approach to co-integration as well as the Error Correction Mechanism (ECM). The study also employed the ARCH and GARCH model to determine the presence of volatility in the real exchange rate series. The real export volumes, real exchange rate as well as real exchange rate volatility and all other orthodox determinants of export such as relative price and real foreign income series were non-stationary. They were indeed I (1) series. The estimated result indicated that there was a long run relationship between real exchange rate and its volatility and export volumes in Nigeria. The ARCH and GARCH model showed that the exchange rate was volatile. The paper concluded that real exchange rate uncertainty had significantly and positively impacted on the volume of trade of the Nigerian economy. It was therefore recommended that the monetary authorities in Nigeria should initiate policies and programme that would stabilize naira exchange rate and remove the negative effect of exchange rate fluctuations on Nigeria's export performance.

Keywords: Real Exchange Rate, Export Income, Volatility, J-Curve.

1. Introduction

Export earnings assume vital importance not only for developing, but also for developed countries. Developed countries mainly export capital and final goods, while the main part of the export of developing countries consists of mining-industry goods, especially natural resources (Obadan, 2006). According to export-led growth hypothesis, increased export can perform the role of "engine of economic growth" because it can increase employment, create profit, trigger greater productivity and lead to rise in accumulation of reserves, allowing a country to balance their finances (Emilio (2001), Goldstein & Pevehouse (2008), Gibson & Michael (1992), McCombie & Thirlwall (1994)).

However, exchange rate fluctuation is of interest because of its adverse effects on export trade. More particularly, economists are interested in the operations involved in exchange rate especially in developing countries. Real exchange rate uncertainty is said to probably have a negative effect on international trade as bilateral trades are threatened with the risks involved. The economic relationship supporting the negative link is the unwillingness of firms to take on risky activity, namely trade (Anderton & Skudely, 2001).

Aliyu (2008) stated that the conception behind exchange rates is not exclusively as an important relative price, which creates a correlation between the domestic market and the world market for goods and assets, but as well distinguishes the competitiveness of a country's exchange power vis-à-vis the rest of the world in a pure market. It also sustains the internal and external macroeconomic balances over the medium-to-long term.

Since the adoption of a floating exchange-rate regime in 1973 in Nigeria, the effects of exchange-rate volatility on the volume of international trade have been the subjects of both theoretical and empirical investigations (Obadan, 2006). Exchange rate volatility is defined as the risk associated with unexpected movements in the exchange rate. Economic fundamentals such as the inflation rate, interest rate and the balance of payments, which have become more volatile in the past three decades are sources of exchange rate volatility. The high degree of volatility and uncertainty of exchange rate movements since the beginning of the generalized floating in 1973 has led policy makers and researchers to investigate the nature and extent of the impact of such movements on the volume of trade.

The lack of certainty regarding economic variables that influence production is a problem that characterizes the productive sector in general and is discussed in the literature both on the level of the firm and on the level of aggregate investment. The path-breaking article by Hartman (1972) tested the effect of uncertainty on the firm's production decision. Since then, interest has grown on the effect of uncertainty (of various types: ranging from economy-wide uncertainty to price uncertainty and industry-wide shocks) on various components of demand and in particular on private consumption and investment. Studies have been carried out under various assumptions regarding the degree of risk aversion among individuals and firms, i.e. under the assumption that individuals and firms are risk averse or alternatively that they are risk indifferent.

The past several decades have witnessed considerable research concerning the impact of exchange-rate volatility on the volume of international trade, and much has been written on both the theoretical and empirical sides of this issue. Nonetheless, there is no real consensus about the effects of real exchange rate on trade volume. Therefore, this research work is to present additional evidence about the influence of real exchange rate uncertainty on exports, using data for the developing economy of Nigeria.

Nigeria benefits when there is an increase in the price of oil and experiences a decline in the value of her currency against the US dollar as a large volume of revenues is from oil export and at the same time, the country is spending significant resources to import refined petroleum and other oil related products which are basically traded in US dollars. The naira exchange rate has witnessed some period of relative calm since the Implementation of the Structural Adjustment Programme (SAP) in July, 1986; its continued depreciation, however, scored an indelible mark in the level of real sector activities in the country. The naira which traded at N0.935 = 1.00USD in 1985 depreciated to N2.413 = 1.00USD and further to N7.901 against the US dollar in 1990. The naira as since depreciated from N21.886 = 1.00 USD to N142.00 = 1 USD between the period of 1994 to 2009 as a result of pegging and further deregulation. It majorly declined by 12.95% and a further decline of 7.98% in 2008 and 2009 respectively. In spite of these developments, the national income accounts, for the country revealed an impressive performance. Real GDP grew at an average of 5.01 percent between 2000 and 2008 with the highest of 9.6 percent in 2003 (CBN Statistical Bulletin, 2010).

McKenzie (1999) and Clark, Tamirisa and Wei, (2004) are amongst notable scholars to have analyzed the relationship between exchange rate volatility and international trade. They concluded that there was a boom in international trade as a result of balance to the exchange market. McKenzie (1999) further stated that there were theoretical models which supported both negative and positive relationship between exchange rate volatility and international

trade. This shows that there is no consensus among scholars on the relationship between exchange rate volatility and international trade, whether in the developed economies or the developing ones. Moreover, most of the theories as well as the empirical studies on the subject of real exchange rate uncertainty and its effect on exports are concentrated in the developed countries. It is against this background that this paper seeks to measure the effect of real exchange rate volatility on export volume in Nigeria.

2. Literature Review

2.1 Theoretical Literature

Clark's (1973) model is one of the earliest theories that examined the connection between exchange rate volatility and trade flows. The model makes several assumptions. First, the firm has no market power, produces only one commodity which is sold entirely to one foreign market and does not import any intermediate inputs. Second, payment is made to this firm in foreign currency and the proceeds of its exports are converted at the current exchange rate. In addition, the exchange rate is unpredictable and there are no hedging possibilities. Lastly, the firm makes its production decision in advance because of the exchange rate and therefore cannot alter its output in response to favourable or unfavourable shifts in the profitability of its exports arising from fluctuations in the exchange rate. From this scenario, Clark posited that the variability in the firm's profits arises solely from the exchange rate, and where the managers of the firm are adversely affected by risk, greater volatility in the exchange rate – with no change in its average level leads to a reduction in output, and hence in exports, in order to reduce the exposure to risk. This position was corroborated by Hooper and Kohlhagen (1978) who also reached the same conclusion of a clear negative relationship between exchange rate volatility and the level of trade. On the other hand, Barkoulas, Baum & Caglayan (2002) developed a model in which exchange rate volatility had positive effect on exports. However, the effect became negative when the assumption of the existence of the forward exchange market is relaxed.

According to the J-Curve theory, depreciation of the national currency leads to serious deterioration of the trade balance which is later followed by an improvement. A price effect occurs immediately after the depreciation due to higher prices of imported goods and this specifically affects inputs that are sourced from foreign countries. However, when traders have had some time to change their input strategy, they integrate their loss in competitiveness vis-à-vis goods produced abroad. This leads to what is termed the quantity effect. The latter effect adjusts the volume of imports downward while local production increases significantly. The final effect in the longer term is a net improvement in the trade balance. This phenomenon is named the J-curve effect because when a country's net trade balance is plotted on the vertical axis and time is plotted on the horizontal axis, the response of the trade balance to a devaluation or depreciation looks like the curve of the letter J. This is shown in Fig. 2.1:

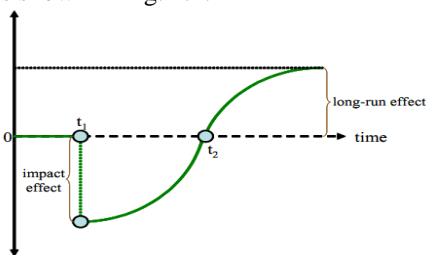


Fig. 2.1: The J-Curve

Marshall–Lerner theory used the J-Curve to explain why a reduction in value of a nation's currency need not immediately improve its balance of payments. According to the theory, for a currency depreciation to have a positive impact on the trade balance, the sum of price elasticity of exports and imports in absolute value must be greater than one. Since a devaluation or depreciation of the exchange rate implies a reduction in the price of exports, the quantity exported will increase. At the same time, the price of imports will rise and their quantity demanded will diminish. The net effect of these two phenomena – greater quantities of exports at lower prices and diminished quantities of more expensive imports – depends on import and export price elasticities. If exported goods are price elastic, their quantity demanded will increase proportionately more than the decrease in price, and total export revenue will increase. Similarly, if goods imported are elastic, total import expenditure will decrease. This is shown in Fig. 2.2:

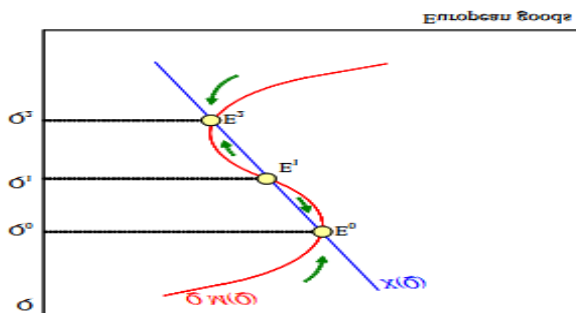


Fig. 2.2: Marshall–Lerner Curve

2.2 Empirical Evidence

Many studies have investigated the effect of exchange rate on export. Broadly, speaking, studies on the effect of exchange rate volatility can be distinguished in terms of measures of risks and technique of analysis adopted.

Callabero and Corbo (1989) investigated the effect of real exchange rate uncertainty on exports for six developing countries (Chile, Colombia, Peru, Philippines, Thailand and Turkey) and found that real exchange rate uncertainty did reduce exports in the short-run and the results were substantially magnified in the long-run. Co-integration technique was adopted by Samanta (1998) in examining the implications of exchange rate volatility for India's export. The results showed that over the period, 1953-1989, exchange rate risk had a significant adverse impact on exports.

Hooper et al. (1978) and Chinn (2004, 2005) found that trade flows are significantly affected by real exchange rates. This is corroborated by Thorbecke (2006), though he notes that exchange rate elasticities for trade between the US and Asia are not large enough to lend confidence that the depreciation of the US dollar will improve the US trade balance with Asia. Comparing this with the multilateral trade balance approach, Oguro, Fukao and Khatri (2008) observed that aggregate bias problems are reduced in bilateral trade analysis. In their study of trade between the US and Japan, Breuer and Clements (2003) concluded that trade between the two countries are affected by exchange rate elasticities. Commenting, Oguro et al. (2008) opined that sensitivity of export trade to exchange rate changes is dependent on certain conditions. Using a six-industry-panel data to investigate industry specific sensitivity of exports to exchange rates for 38 trading pairs including China, USA and Japan, they

concluded that higher inter-industry trade reduces the export sensitivity to exchange rates due to lower elasticity of substitution among differentiated products; but where inter-industry trade does not exist, exchange rate changes affect export trade. Cui and Syed (2007) suggest that these conditions do not eliminate the dependence of export trade on exchange rate volatility; rather, China's trade growth with the US is hinged on a favourable exchange rate of China's Yuan to the US dollar.

Panel data approach was employed by Ghura and Greenes (1993) in exploring the effect of exchange rate volatility on the trade flows of sub-Saharan Africa countries. Gauging exchange rate volatility by the coefficient of variation and utilizing data covering the period 1972-1987, they found that exchange rate volatility had a significantly negative and robust impact on trade flows. The study however, focused exclusively on the fixed exchange rate era and therefore did not investigate the likely impact of increased volatility during the flexible exchange rate period on trade flows. Nigeria's NEEDS document agreed that Nigeria's tariff and trade policies had been characterized by uncertainty and counter policies; to which the government established a market determined nominal exchange rate using the inter-bank foreign exchange market (IFEM), the autonomous foreign exchange market (AFEM), and the Dutch auction system (DAS) at different times to avoid overvaluation of the naira exchange rate and boost non-oil export. At the foreign exchange market, the naira depreciated consistently against major foreign currencies which in theory should have improved export performance as witnessed in China. Findings by De Grauw (1988) and Caballero & Corbo (1989) of the effect of currency depreciation of individual member countries of the European Union on the export trade of those countries support this idea that currency depreciation affects export trade positively.

Chukwu (2007) observed the instability exchange rate as a determinant of trade in Nigeria: having a positive influence on the dependent variable, export trade; and at other times a negative influence. This suggests an erratic change in its value having a long-run effect on export and economic growth. Egert and Morales (2005) attempted to analyse the direct impact of exchange rate volatility on the export performance of ten Central and Eastern European transition economies as well as its indirect impact via changes in exchange rate regimes. Not only aggregate but also bilateral and sectoral export flows were studied. First, they analyzed shifts in exchange rate volatility linked to changes in the exchange rate regimes and then, they used these changes to construct dummy variables that were included in their export function. The results suggest that the size and the direction of the impact of for exchange volatility and of regime changes on exports varied considerably across sectors and countries and that they may be related to specific periods.

2.3 Exchange Rate Volatility, Export Performance and Economic Growth in Nigeria

Fluctuations, positive or negative, are not desirable to producers of export products as they have been found to increase risk and uncertainty in international transactions which according to Adubi & Okunmadewa (1999) discourage trade. Findings by the International Monetary Fund (1984) reveal that these fluctuations induce undesirable macroeconomic phenomena inflation; though Caballero and Carba (1989) observed a positive effect of exchange rate fluctuations on export trade in European Union countries. Viewing the effect of these fluctuations first from its impact on foreign direct investment, Walsh and Yu (2010) noted that low exchange rate favours the importation of production machinery, and production and export in periods of high foreign exchange rate. Further, Froot and Stein (1991) found strong evidence that weak currency of a host country increases inward foreign

direct investment within an imperfect capital market model as depreciation (down change in exchange rate) makes a host country less expensive than export destination countries. Making a firm-specific-asset analysis argument, Blonigen and Piger (2011) argued that exchange rate depreciation in host countries tend to increase foreign direct investment inflows; adding that a strong real exchange rate strengthens the incentives of foreign companies to produce at home for export instead of investing in a host country for export.

Lama and Medina (2010) opine that economies experience different episodes of exchange rate appreciation in response to different types of stocks, contending that an appreciation in exchange rate induces a contraction of the exporting manufacturing sector. According to them, maintenance of export performance requires the depreciation of the real exchange rate of a country's currency. This, they suggest, is achievable through monetary injections, since a policy of exchange rate depreciation can successfully prevent a contraction of export output, having an allocative effect on the economy.

Adubi and Okunmadewa (1999) posited that Nigeria, a developing nation, is expected to gain from export conversion price increase as a result of currency devaluation. Findings by Obadan (1994) and Osuntogun, Edordu & Oramah (1993) on the effect of stable exchange on export performance show that the exchange rate affects a country's export performance; and instability in an exchange rate with its attendant risk affects export earnings, performance and growth: positive to exporters when devalued.

Poor results from the floating exchange regimes of the 1970's necessitated a change in foreign exchange rate management. The Structural Adjustment Program (SAP) was introduced in 1986 with the cardinal objective of restructuring the production base of the economy with a positive bias for agricultural export production. This reform facilitated the continued devaluation of the Nigerian naira with the expected increase in domestic prices of agricultural export boosting domestic production. Empirical findings by Oyejide (1986), Osuntogun et al. (1993), Ihimodu (1993) revealed changes in both structure and volume of Nigeria's trade as a result of the devaluation of naira.

To Srour (2006), diversification of countries export base is one reason given by developing nations for changing foreign exchange rates and regimes which in turn according to the World Trade Organization (2010) increases local production, employment, income and economic growth. In their study of Canada, Lama and Medina (2010) observed that foreign exchange rate appreciation coincided with a contraction of 3% in the country's gross domestic product in the manufacturing sector; as well as a 2% average decline in manufacturing GDP over a 20-year period. Though carrying attendant risks, foreign exchange rate movement are monetary policy instruments to achieve export growth, economic growth and development of any nation.

3. Methodology

This paper aims at presenting additional evidence about the influence of real exchange-rate uncertainty on exports, using data for the developing economy of Nigeria. The study will employ the Johansen (1988) Multivariate Co-integration procedure as well as the Error-Correction Mechanism (ECM) to ascertain the long-run association and to evaluate the dynamic relationship between real exchange-rate uncertainty and exports respectively. Prior to testing for co-integration, the time series properties of the individual variables shall be investigated using the Augmented Dickey Fuller (ADF) test of unit root.

However, it is necessary to derive an operational measure of exchange-rate volatility. Though there is no universal consensus in the literature with respect to the most appropriate proxy to represent uncertainty, this study will employ the time-varying measure of exchange-rate uncertainty. The measure captures the movements of exchange rate uncertainty over time. The main characteristic of this measure is its ability to capture the higher persistence of real exchange rate movements in the exchange rate (Klaassen, 2004). This proxy is constructed by the Moving Average Standard Deviation (MASD) expressed as;

$$J_{t+m} = \left[\frac{1}{m} \sum_{i=1}^m (R_{t+i-1} - R_{t+i-2})^2 \right]^{1/2}, \quad \text{----- (3.1)}$$

Where R is the natural logarithm of real exchange rate and m is the order of moving average.

The current volatility is calculated on the movements of exchange rate during the previous eight quarters reflecting the backward-looking nature of risk, that is, firms' use past volatility to predict present risk. However, in testing for the presence of volatility in the series, this study shall the autoregressive conditional heteroscedasticity (ARCH) and the generalised autoregressive conditional heteroscedasticity (GARCH) model.

In order to model the impact of exchange rates and their volatility on export, a multiple linear regression model has been constructed following the work of Hooper and Kohlhagen (1978). This study made an extra effort to derive the nominal values of all the variables by adjusting for inflation (real values) since inflation is a major challenge in Nigeria. The model is thus specified as follows:

$$REXP_t = f(RFI_t, REP_t, RER_t, RERV_t) \quad \text{----- (3.2)}$$

The model is explicitly stated below in a natural log form:

$$\ln REXP_t = \beta_0 + \beta_1 \ln RFI_t + \beta_2 \ln REP_t + \beta_3 \ln RER_t + \beta_4 \ln RERV_t + \mu_t \quad \text{----- (3.3)}$$

where:

- $REXP$ = Real Exports
- RFI = Real Foreign Income
- REP = Relative Price
- RER = Real Exchange Rate
- $RE RV$ = Real Exchange Rate Volatility
- $\beta_0, \beta_1, \beta_2, \beta_3, \beta_4$ = parameters estimate in the model,
- μ = Stochastic error term

Data for this study are mainly from secondary sources, particularly from Central Bank of Nigeria (CBN). The economic a-priori expectation is as follows: if foreign income rises, the demand for exports will rise, so β_1 is expected to be positive (i.e. $\beta_1 > 0$). On the other hand, if relative prices rises, the demand for exports will fall, so β_2 is expected to be negative (i.e. $\beta_2 < 0$). Conversely, real exchange rate movements are negatively correlated to real exports. A decrease in the real exchange rate means a real depreciation of the domestic currency, which makes exportable items cheaper and therefore boosts demand of foreign trading partners. If the real exchange rate appreciates, the reverse is likely to occur, hence, β_3 is expected to be negative (i.e. $\beta_3 < 0$). Regarding the effects of real exchange rate volatility, recent theoretical

developments suggest that real exchange-rate volatility could have negative or positive effects on trade volume (i.e. $\beta_4 \neq 0$). Durbin - Watson statistics (ρ) will be used to show the presence or otherwise of auto-correlation in the model.

4. Results and Discussion

4.1 Descriptive Statistics

The data used in this study consist of quarterly data spanning between 1970 through 2010.

Table 4.1: Descriptive Statistics Result

	<i>REXP</i>	<i>RFI</i>	<i>REP</i>	<i>RER</i>	<i>RERV</i>
Mean	4798.185	67037.28	10.30683	0.288271	0.020454
Median	3359.526	57779.80	2.078402	0.229613	0.009989
Maximum	21267.30	286944.5	55.61027	1.168514	0.238858
Minimum	469.9046	506.2800	0.065563	0.041367	6.56E-05
Observations	164	164	164	164	164

Source: Author's Computation

The descriptive statistics of the data series employed in this study is displayed in Table 4.1 above. From the table, Real Export (REXP) averages 4798.185 and varies from a minimum of 469.9046 to a maximum of 21267.30. Real Foreign Income (RFI) and Relative Price (REP) have a mean of 67037.28 and 10.30683 and ranges from a minimum of 506.2800 and 0.065563 to a maximum of 286944.5 and 55.61027 respectively. Consequently, Real Exchange Rate (RER) and Real Exchange Rate Volatility (RERV) have a mean of 0.288271 and 0.020454 and vary from a minimum of 0.041367 and 6.56E-05 to a maximum of 1.168514 and 0.238858 respectively.

4.2 Unit Root Test

In order to determine the stationary state i.e. time series properties of the variables, unit root test was carried out. The unit root test shows the order of integration of each of the variables and whether or not there is presence of stochastic trend. Testing for the existence of unit roots is of major interest in the study of time series models and co-integration. The presence of a unit root implies that the time series under investigation is non-stationary; while the absence of a unit root show that the stochastic process is stationary (Iyoha & Ekanem, 2002). The time series behaviour of each of the series using both the Augmented Dickey-Fuller (ADF) tests of unit root is presented in Tables 4.2 (a and b). Moreover, trend status of each of the variables was determined using a line graph.

Table 4.2a: ADF unit root test results at level

Variables	ADF test statistics	Critical value	Order of integration	Remarks
<i>REXP</i>	-3.495701	-2.8793	I(0)**	Stationary
<i>RFI</i>	-3.286384	-2.8793	I(0)**	Stationary
<i>REP</i>	-2.539847	-2.5761	I(0)**	Not Stationary
<i>RER</i>	-5.703570	-2.8793	I(0)**	Stationary
<i>RERV</i>	-8.413449	-2.8793	I(0)**	Stationary

Source: Author's Computation

Tables 4.2a and 4.2b above show the time series performance of the variables using the ADF Unit Root Test Statistics. Tables 4.2a shows the level of stationarity at level while Table 4.2b shows the level of stationarity at first difference. However, from Table 4.2a, it is

revealed that all the variables in the model are stationary at 5% levels of significance and are integrated of the order I(1).

TABLE 4.2b: ADF unit root test results at first difference

Variables	ADF test statistics	Critical value	Order of integration	Remarks
REXP	-16.23815	-2.8794	I(1)**	Stationary
RFI	-17.56194	-2.8794	I(1)**	Stationary
REP	-17.19629	-2.5762	I(1)*	Stationary
RER	-17.26448	-2.8794	I(1)**	Stationary
RERV	-17.32816	-2.8794	I(1)**	Stationary

Source: Author's Computation

Note: * - Significant at 10 percent

** - Significant at 5 percent

*** - Significant at 1 percent;

The null hypothesis is that there is a unit root.

4.3 Johansen Co-integration Test

Confirmation of the presence of non-stationary series suggests a bogus relationship in the short-run because of the stochastic possessed by these non-stationary series.

Table 4.3a: Johansen co-integration test results

Series: REXP RFI REP RER RERV

Eigen value	Likelihood Ratio	5% Critical Value	1% Critical Value	Hypothesized No. of CE(s)
0.595680	200.3943	68.52	76.07	None **
0.169871	53.69531	47.21	54.46	At most 1 *
0.092386	23.53518	29.68	35.65	At most 2
0.037936	7.831456	15.41	20.04	At most 3
0.009621	1.566205	3.76	6.65	At most 4

Source: Author's Computation

*(**) denotes rejection of the hypothesis at 5% (1%) significance level

L.R. test indicates 2 co-integrating equation(s) at 5% significance level. However, they cannot generate an equilibrium relationship in the short-run; they can only do so in the long-run if they co-integrate. Therefore, Johansen Co-integration test is carried out to test for the presence of co-integrating equation of the multivariate series in the long-run. In the Johansen Co-integration test, the Likelihood ratio is compared with 5% and 1% critical values in order to determine the number of co-integrating vectors in the model.

Table 4.3b presents the long-run co-integration equilibrium relationship that exists among the variables under consideration in the model employed in this study. As the table shows, the dependent variable, (i.e. Real Export - REXP), depicts a positive long-run relationship with Real Foreign Income (RFI), Real Exchange Rate (RER) and Real Exchange Rate Uncertainty (RERV) while Relative Price (REP) has a negative relationship with the dependent variable in the long-run. From the long-run equation as presented in 4.3 with substituted coefficients, it was observed that a 10% increase in RFI, RER and RERV will cause the dependent variable – REXP to increase by 9.9 %, 9.6% and 7.2% respectively. This result conforms to the economic *a priori* expectation of positive relationship between real export and real foreign income. Consequently, a 10% increase change in REP will bring about a decrease of about 6.4% in REXP. This result also conforms to the economic *a priori* expectation of negative relationship between relative price and real export.

Table 4.3b: Normalized co-integrating coefficients:1 cointegrating equation(s)

<i>REXP</i>	<i>RFI</i>	<i>REP</i>	<i>RER</i>	<i>RERV</i>	<i>C</i>
1.000000	0.997161 (0.25688)	-0.640408 (0.11587)	0.963625 (0.48108)	0.723954 (0.17264)	-11.79861
Log likelihood	-15.33056				

Source: Author's Computation

$$\ln REXP = -11.79861 + 0.997161 \ln RFI - 0.640408 \ln REP + 1.963625 \ln RER + 0.723954 \ln RERV \quad (4.3)$$

4.4 Error Correction Mechanism (ECM)

Having identified the co-integrating vector using the Multivariate Johansen Co-integration Test, we proceeded to investigate the dynamics of the model. The Error Correction Mechanism (ECM) intends to validate the presence of long-run relationship and incorporate the short-run dynamics into the long-run equilibrium relationship. The result is presented in table 4.4.1.

4.4.1 Overparameterized Error Correction Model

Table 4.4a: Overparameterized Error Correction Model Result

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.000931	0.020185	0.046105	0.9633
D(REXP(-1),2)	-0.497485	0.066482	-7.482977	0.0000
D(RFI,2)	0.274082	0.073073	3.750797	0.0003
D(RFI(-1),2)	0.139501	0.076193	1.830885	0.0691
D(REP,2)	-0.319959	0.264006	-1.211941	0.2274
D(REP(-1),2)	-0.128965	0.247658	-0.520735	0.6033
D(RER,2)	0.944987	0.226815	4.166334	0.0001
D(RER(-1),2)	0.446845	0.229306	1.948679	0.0532
D(RERV,2)	-0.005126	0.023947	-0.214066	0.8308
D(RERV(-1),2)	-0.003879	0.015051	-0.257726	0.7970
ECM(-1)	-0.181810	0.041250	-4.601429	0.0000
R^2	0.947203	<i>F-statistic</i>	269.1064	
Adjusted R^2	0.943683	<i>Prob(F-statistic)</i>	0.000000	
Durbin-Watson stat	2.258877			

Source: Author's Computation

The Overparameterized Error Correction Mechanism (ECM) was carried out to depict the main dynamic pattern of the model and ensure that the dynamics of the model have not been constrained by a too short lag length. The Overparameterized ECM presented in Table 4.4a above shows that there truly exists a long-run equilibrium relationship among the variables. This is evident by the correctly signed and significant ECM coefficient (-0.181810). Hence, for terse clarification of the ECM, non-significant variables were removed from each pairs in the overparameterized model, for a Parsimonious Error Correction Model to be generated by choosing 0.05 level of significance.

4.4.2 Parsimonious Error Correction Model

The Parsimonious ECM result presented in Table 4.4b above shows that the coefficient of one period lag of ECM is statistically significant and correctly signed. This validates the existence of long-run equilibrium relationship among the variables despite the presence of short-run inconsistencies due to non-stationary of one of the series.

Table 4.4b: Parsimonious Error Correction Model Result

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.000976	0.020052	0.048662	0.9613
D(REXP(-1),2)	-0.498655	0.065185	-7.649862	0.0000
D(RFI,2)	0.263775	0.071870	3.670166	0.0003
D(RFI(-1),2)	0.135157	0.074021	1.825931	0.0698
D(RER,2)	0.661871	0.064924	10.19453	0.0000
D(RER(-1),2)	0.331054	0.078571	4.213418	0.0000
ECM(-1)	-0.193805	0.040789	-4.751405	0.0000
<i>R</i> ²	0.946499	<i>F</i> -statistic	454.0763	
<i>Adjusted R</i> ²	0.944415	<i>Prob(F</i> -statistic)	0.000000	
<i>Durbin-Watson stat</i>	2.256991			

Source: Author’s Computation

$$D(REXP,2) = 0.0009757852388 - 0.498655356*D(REXP(-1),2) + 0.2637749787*D(RFI,2) + 0.1351572058*D(RFI(-1),2) + 0.6618713705*D(RER,2) + 0.3310541545*D(RER(-1),2) - 0.1938045609*ECM(-1) \text{ ----- (4.4)}$$

The result shows that about 19% of the short-run inconsistencies are being corrected and incorporated into the long-run equilibrium relationship. In the parsimonious ECM result, the short-run inter-relationship between differenced real foreign income and real export is positive and statistically significant. The significance of the coefficient can be attributed to fact that an increased foreign income (foreign exchange earnings) will boost the productive capacity of the economy thereby leading to increased export of domestic goods. This result however conforms to the economic *a priori* expectation of positive relationship. However, a 10% increase real foreign income will bring about 2.6% increase in real export in the short-run. Consequently, from the parsimonious ECM result presented in the Table 4.4b, it is observed that real exchange rate depicts a positive and statistically significant relationship with the explained variables – real export. This result however does not conform to the economic *a priori* expectation of negative relationship with the explained variable. This is due to the ever increasing exchange Nigeria exchange rate at the international market. However, since crude oil provides the major export earnings of the economy, and this commodity is indispensable to by the Nigeria’s importing trade partners, the increasing exchange rate will further increase export as a result of the adduced reason, hence, a unit change in the real exchange rate will bring about an increase of about 0.6% in the value of real export in the economy. Moreover, the result shows the coefficient of multiple determination (*R*²) to be 0.946499. This implies that 95% of the systematic variations in the dependent variable (real export) can be explained by the explanatory variables. Moreover, the statistical significance of the *F*-Statistics depicts the overall goodness of fit of the model. This implies that the systematic variations in the dependent variable are truly explained by the behaviour of the explanatory variables. However, the Durbin Watson test of first order serial autocorrelation is inconclusive.

4.5 ARCH and GARCH Model

This section aims to test for the presence of volatility by employing the ARCH and GARCH model.

4.5.1 Mean Equation

$$RER = \phi_1 + \phi_2 RFI + e \quad \text{----- (4.5)}$$

where

RER= Real rate of exchange,

RFI= Real foreign income accruing from transactions in the international market,

e = Residual.

Having estimated the OLS regression of the above mean equation model, the residual plot result for ascertaining the presence/absence of ARCH and GARCH effect is presented in the figure below;

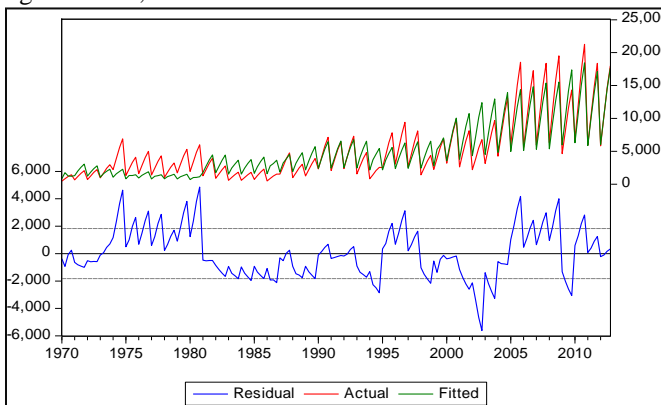


Figure 4.1: Residuals of Nigeria Exchange Rate

Source: Author's Computation

It is evident from Figure 4.1 that there is prolonged period of low volatility from 1970 to 1974 and a prolonged period of high volatility from 1975 to 1980. In other words, periods of low volatility are followed by periods of high volatility and period of high volatility are followed by periods of low volatility. This suggests that the residual or error term is heteroscedastic and it can be represented by ARCH and GARCH model.

4.5.2 Variance Equation

Residuals derived from the mean equation above is used in making the variance equation, this is presented below;

$$H_t = \phi_3 + \phi_4 H_{t-1} + \phi_5 e_{t-1}^2 + \phi_6 OP \quad \text{----- (4.6)}$$

where:

H_t = variance of the residual (error term) derived from the mean equation. It is also known as the current year's volatility of Nigeria exchange rate in real term.

ϕ_5 = constant

H_{t-1} = previous year's residual variance of Nigeria's real exchange rate. It is also known as the GARCH term

e_{t-1}^2 = previous period's squared residual derived from the mean equation. It is also previous year's real exchange rate information about volatility. This is the ARCH term.

OP= Oil price in the international market. It is an exogenous or predetermined variable.

Equation (4.6) is a GARCH (1.1) model as it has one ARCH (e_{t-1}^2) and one GARCH (H_{t-1}) term. In other words, it refers to a first order ARCH term and a first order GARCH term. Hence, the mean equation of equation (4.5) as well as the variance equation of equation (4.6) shall be estimated thus simultaneously. It should however be noted that this study aims to model the volatility of Nigeria real exchange rate and the factor(s) affecting the volatility of Nigeria real exchange rate.

4.5.3 Result and Discussion of GARCH (1.1) Model: Variance Equation

Annual data for estimating GARCH (1.1) model have been chosen in which all the variables therein are assumed to be stationary. However, the student's t-distributions have been employed in this analysis.

Table 4.5: Result of GARCH (1.1) Model

Dependent Variable: RER				
Method: ML - ARCH (Marquardt) - Student's t distribution				
GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*GARCH(-1) + C(6)*OP				
Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.165123	0.015311	10.78487	0.0000
RFI	3.57E-07	1.25E-07	2.855856	0.0043
Variance Equation				
C	0.003273	0.001459	2.243728	0.0248
RESID(-1)^2	0.336939	0.154953	2.174451	0.0297
GARCH(-1)	0.568444	0.164497	3.455649	0.0005
OP	-0.000111	3.22E-05	-3.458511	0.0005

Source: Author's Computation

Under this distribution as presented in Table 4.5, ARCH is significant. This implies that the previous year's real exchange rate information (that is, e_{t-1}^2 in equation 4.6) can influence this year's real exchange rate volatility (that is, H_t in equation 4.6). In the same vein, under this distribution, GARCH is also significant. This means that the previous year's real exchange rate volatility (that is, H_{t-1} in equation 4.6) can influence this year's real exchange rate volatility. This result implies that Nigeria's real exchange rate is influenced by its own ARCH and GARCH factors or own shocks. On the other hand, Oil Price (OP) is significant, meaning that the volatility in the price of oil can transmit to the exchange rate situation in Nigeria. Therefore, we can conclude that the volatility in Nigeria exchange rate is largely dependent on its own shocks such as ARCH and GARCH and oil price.

However, in order to ascertain if the estimated GARCH (1.1) model above is theoretically meaningful; some of the following assumptions must be fulfilled:

- i. There is no serial correlation in the residual or error term;
- ii. Residuals are normally distributed; and
- iii. There is no ARCH effect.

4.5.4 Test of Serial Correlation of the GARCH (1.1) Model: Correlogram Squared Residual

The “Correlogram Squared Residual” is employed to check for the presence/absence of first order serial correlation in the estimated GARCH (1.1) model. This is analysed as follows:

Autocorrelation Hypothesis

H₀: There is no serial correlation.

H₁: There is serial correlation.

Table 4.6: Correlogram Squared Residual Result

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
. *	. *	1	0.110	0.110	2.1157	0.146
*** .	*** .	2	-0.411	-0.429	31.916	0.000
* .	. .	3	-0.111	0.002	34.079	0.000
. *****	. *****	4	0.636	0.591	106.03	0.000
. .	*** .	5	0.040	-0.346	106.32	0.000
*** .	. .	6	-0.377	0.058	131.96	0.000
* .	. .	7	-0.167	-0.016	137.03	0.000
. ***	. .	8	0.463	0.019	176.14	0.000

Source: Author’s Computation

The decision rule states that, if the p-values are more than 5%, we accept the null hypothesis (H₀) and vice versa. However, it is evident from the above result that virtually all the probability values chosen for the 8 different lags are less than 5%, hence, we reject the null hypothesis (H₀) and we accept the alternative hypothesis (H₁) we therefore conclude that the estimated GARCH (1.1) model has serial correlation.

4.5.5 Test of Normal Distribution: Jarque-Bera Statistics

The “Histogram Normality Test” will be employed to examining if the residuals of the estimated GARCH (1.1) model are normally distributed using the Jarque-Bera statistics.

Normal Distribution Hypothesis

H₀: Residuals are normally distributed.

H₁: Residuals are not normally distributed.

It is evident that the desirable from the above hypothesis is the null hypothesis; however, the result of the Jarque-Bera statistics is presented below.

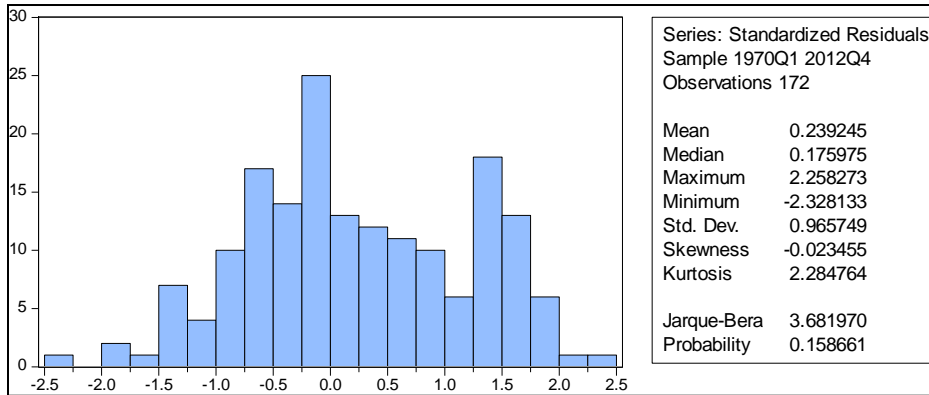


Figure 4.2: Jarque–Bera Statistics Result
Source: Author’s Computation

It is clear from Figure 4.2 that the Jarque–Bera statistics estimate has its probability value to be more than 5%. This implies that we accept the null hypothesis (H_0) and reject the alternative hypothesis (H_1); we therefore conclude that the residuals in the GARCH (1.1) model are normally distributed.

4.5.6 Test of ARCH Effect

The “ARCH LM Test” is used to check if the model has an ARCH effect. This is also known as the test of heteroscedasticity. The result is discussed as follows. However, the desirable in the below hypothesis is the null hypothesis.

ARCH Effect Hypothesis

H_0 : There is no ARCH Effect

H_1 : There is ARCH Effect

Table 4.7: Result of Heteroscedasticity Test: ARCH

F-statistic	2.076559	Prob. F(1,169)	0.1514
Obs*R-squared	2.075630	Prob. Chi-Square(1)	0.1497

Source: Author’s Computation

The decision rule states that, if the p-value of the Observed R*squared is more than 5%, we accept the null hypothesis (H_0), and vice versa. Hence, since the probability value of the observed R*squared is greater than 5% as shown in Table 4.7, we therefore accept the null hypothesis (H_0) and reject the alternative hypothesis and conclude that the model has no ARCH effect.

Overall, it is evident from all the evaluations analyzed above that the residuals of the estimated GARCH (1.1) model has serial correlation, normally distributed and no ARCH effect. However, the estimators of this model are still consistent even though there exists a serial correlation, hence, the model is useful for forecasting the behaviour of the Nigeria’s exchange rate and its determinants in real terms.

5 Conclusion and Recommendations

The effect of real exchange rate volatility on real exports as estimated in this paper suggests that risk-averse exporters will reduce their activities, switch sources of supply and demand or change prices in order to minimize their exposure to the effect of exchange risk. This, in turn, can alter the distribution of output across many sectors in the Nigerian economy. A major policy lesson of this finding is that trade policy actions aimed at stabilizing the export market are likely to generate uncertain results at best, if policymakers ignore the stability, as well as the level, of the real exchange rate. Another implication is that trade adjustment programmes in Nigeria that have mostly stressed the need for export expansion may lose their appeal to local policymakers in periods of high exchange rate volatility. Also, the intended positive effect of a trade liberalization policy may not only be doomed by a variable exchange rate but could also precipitate a balance-of-payments crisis. This study concludes that real exchange rate uncertainty has significant impact on the volume of trade of the Nigerian economy. It is therefore recommended that the monetary authorities in Nigeria should initiate policies and programme that will stabilize naira exchange rate and remove the negative effect of exchange rate fluctuations on Nigeria's export performance. In addition, Nigerian exporters should take advantage of the future market and hedge the export income (real foreign income), reducing the effect of exchange rate fluctuations on export trade. Since interest rate fluctuation is a function of import which itself is a reflection of the poor industrial base of the nation, affecting export capacity, the Nigerian government should initiate policies to boost local production to satisfy local consumption, reduce demand and pressure on the naira exchange rate, stabilize the rate while increasing production capacity, boosting stock of export goods, growth and income.

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