Authors:
FRIDAY O. ALEGWU, Department of Agricultural Economics, University of Agriculture, Makurdi, Nigeria
GOODNESS C. AYE, Department of Agricultural Economics, University of Agriculture, Makurdi, Nigeria
BENJAMIN C. ASOGWA, Department of Agricultural Economics, University of Agriculture, Makurdi, Nigeria

ASYMMETRIC EFFECT OF REAL EXCHANGE RATE VOLATILITY ON AGRICULTURAL PRODUCTS EXPORT: A CASE STUDY

ABSTRACT

This paper investigates the asymmetric effects of real exchange rate volatility on agricultural products export using Nigeria as a case study. Annual time series data covering between 1970 and 2013 were used. Real exchange rate volatility is measured using GARCH (1, 1) and subsequently the VAR model was used for analyzing the relationship. This paper through the Augmented Dickey-Fuller (ADF) and Philip Perron (PP) unit root tests confirm that all variables were stationary in their first difference. Asymmetric effects test based on the Wald statistic shows that with exception of cotton exports, the effects of real exchange rate volatility shock during appreciation and depreciation on cocoa, coffee and rubber exports are significantly different. In particular, the study revealed that in Nigeria, real exchange rate volatility have significant effects on agricultural products export negative or positive in periods of appreciation or depreciation but the magnitude of the effect during appreciation or depreciation differ depending on the export product.

Keywords: Real Exchange Rate Volatility, Asymmetry, Agricultural Products Export, Appreciation, Depreciation
JEL Classification: C32, F10, F14, F31

RIASSUNTO

Effetti asimmetrici della volatilità del tasso di cambio reale sulle esportazioni di prodotti agricoli: studio di un caso

Questo lavoro esamina gli effetti asimmetrici della volatilità del tasso di cambio reale sull'export dei prodotti agricoli analizzando il caso della Nigeria. Le serie di dati annuali considerate coprono il periodo 1970-2013. La volatilità del tasso di cambio reale è misurata tramite il modello GARCH (1, 1) e successivamente con il modello VAR per l'analisi della relazione. Attraverso l'utilizzo dei test Agumented Dickey-Fuller (ADF) e Phillip Perron (PP) lo studio

conferma che tutte le variabili erano stazionarie nelle loro differenze prime. Test sugli effetti asimmetrici basati sulla statistica di Wald mostrano che gli effetti degli shock della volatilità del tasso di cambio reale sulle esportazioni sono significativamente differenti per le diverse tipologie di produzioni agricole.

1. Introduction

Exchange rate is a prominent determinant of world trade, receiving much attention in the context of global imbalances. Past decades witnessed disputes on trade and exchange rate issues. The case of the United States of America (USA) and China is a ready example and is believed to be resolvable through adjustments to exchange rate by China (Umaru *et al.*, 2013). Oguro *et al.* (2008) observed that the Marshal-Lerner condition, requiring the sum of the absolute values of price elasticities of imports and exports to exceed one for an appreciation of the result in a deterioration of a country's balance of trade, is the focus of new studies at explaining the effect of exchange rate on trade balances.

Over the past couple of years, economists have recognized the influence and importance of the exchange rate on international agricultural trade. Agricultural producers have been both more sensitive to and interested in the role that exchange rates have in determining commodity prices. The role of the exchange rate in valuing farm production and equipment has become very important because of the rapidly increasing global economy and constant change that has been occurring in both international trade law and technology. Economists have examined the influence of exchange rate movement on agricultural trade but disagreement persists as to the magnitude of the effect (Kafle and Kennedy, 2012).

The effect that the exchange rate may have on export volumes is directly related with over valuation and/or undervaluation of a currency with respect to a foreign currency (Kafle and Kennedy, 2012). For example, overvaluation of a currency, such as the US dollar, depresses agricultural prices and thereby agricultural export volumes. This may lead to an under-valuation of agricultural resources which, in the long run, induces a large technical change (Kafle and Kennedy, 2012). This technical change resulting from an overvaluation of a currency and undervaluation of agricultural resources finally lowers the real prices of agricultural products and places severe pricing pressure on the farm sector, forcing it to make an adjustment in the factors of production, most particularly labour and capital. Again, risk-averse traders leave the business, operating farms become less profitable and farm based employment is drastically reduced (Orden, 2002).

There are few studies specifically on agricultural exports and exchange rate volatility. These include Awokuse and Yuan (2006) on the impact of exchange rate volatility on US poultry exports; Cho *et al.* (2002) on exchange rate uncertainty and agricultural trade; De Vita and Abbot (2004) on the impact of exchange rate volatility on UK exports to EU countries; Foragasi, (2011) on the effect of exchange rate volatility upon foreign trade of Hungarian agricultural products; Huchet-Bourdon and Korinek (2011) onto what extent do exchange rates and their volatility affect trade; Kandilov (2008) on the effects of exchange rate volatility on agricultural trade; Wang and Barrett (2007) on the effect of exchange rate volatility on export volumes. However none of these previous studies has looked at the asymmetric effect of exchange rate volatility on agricultural export in Nigeria. Existing studies on asymmetric effect of exchange rate are mainly on the aggregate export as evidenced in the literature review section. Hence the contribution of the current study is to examine the asymmetric effect of real exchange rate volatility on agricultural products export in Nigeria.

The rest of this paper is organized as follows: Section 2 provides a brief review of related literature. Section 3 describes the data and empirical models used for investigation. Section 4 presents the empirical results and Section 5 concludes the paper.

2. LITERATURE REVIEW

Schuh (1974) originally raised the issue of the exchange rate and its effects on agricultural trade flows. His effort was followed by several other studies where the effect of the nominal exchange rate and the real exchange rate were quantified. Later in the 1990s, a study of the effect of exchange rate volatility on agricultural trade was initially begun (Pick, 1990). Since then, most studies in agricultural trade have concentrated on exchange rate fluctuations and their impact (Kristinek and Anderson, 2002).

An important aspect in the literature is whether the effect of positive and negative macro-economic variables' shocks such as exchange rate, monetary policy, oil price among others are similar (symmetric) or different (asymmetric). Asymmetry has also been considered in terms of differences across regions or countries or other sub-groups. A few studies have examined asymmetric effect of exchange rate volatility, though these are limited to aggregate export. For example Fang *et al.* (2009), examine the asymmetric effects of exchange rate volatility on monthly bilateral exports from eight Asian countries (Japan, Korea, Malaysia, the Philippines, Singapore, Indonesia, Taiwan and Thailand) to the US using the dynamic conditional correlation bivariate GARCH(1,1)-M model. The data are monthly for the period from 1979:1 to 2003:4. For all the countries, foreign income affects exports positively and significantly with contemporaneous, one-month-lagged or two-month-lagged effects. Exchange rate depreciation exhibits the normal positive effect but proves insignificant in two countries. Exchange rate volatility produces significant effects on exports for all countries, negative or positive. Indonesia, Japan, and Taiwan respond negatively to exchange rate risk during depreciations. Korea and the Philippines respond negatively to exchange rate risk during appreciations and positively in appreciations. Malaysia exhibits a positive exchange rate risk effect during depreciations. The findings strongly support the view that exchange rate risk affects exports asymmetrically. The asymmetries response may be due to factors such as the exporter asymmetric risk perception, the US dollar invoicing, original sin, fear of floating, fear of appreciation, love of depreciation and lack of foreign exchange market intervention. Thus, policy makers can consider the stability of exchange rate and its depreciation as a method of controlling export growth.

Bahmani-Oskooee and Harvey (2011) investigated the effect of exchange rate volatility on trade flows between US and Malaysia. Annual data for the period from 1971 to 2006 were used. Neither short run nor long effect could be established. Disaggregating the trade data which results to 101 US exporting industries to Malaysia and 17 US importing industries from Malaysia, they find that exchange rate volatility is found to have a negative impact on international trade mostly in the short run and not in the long run. Further, Bahmani-Oskooee *et al.* (2013) examined the impact of exchange rate volatility on bilateral aggregated export and import between the US and Brazil. Annual data for the period from 1971 to 2010 were used. Of the 57 cointegrated US export industries, 20 industries are found to have a positive relationship, 9 industries are found to have a negative relationship and the rest of 28 industries are found to have an insignificant relationship with exchange rate volatility.

Nishimura and Hirayama (2013) explore the impact of Renminbi against Japanese Yen exchange rate volatility on international trade between Japan and China with a focus on the impact of the Renminbi reform, which is implemented on 21st July 2005. The data are daily for the period from January 2002 to December 2011. Two measures of exchange rate volatility are used, namely the Exponential Generalized ARCH (EGARCH) model (specifically the AR (1)-EGARCH (1, 1) model) and the standard deviation. The results show that Japanese exports to China are not affected by exchange rate volatility but Chinese exports to Japan are affected by exchange rate volatility. In addition, the exchange rate level is found not to have a significant impact on Japanese exports but it has a significant impact on Chinese exports. This asymmetric result may be due to differences in the depth of financial markets and in the maturity of exporters of the two countries.

Grier and Smallwood (2013) investigate the impact of exchange rate volatility on international trade in 27 countries (eight developed countries, namely Canada, Denmark, Japan, Norway, Sweden, Switzerland, the UK and the US and 19 developing countries, namely Turkey, India, Pakistan, Morocco, Nigeria, South Africa, Indonesia, Korea, Malaysia, the Philippines, Singapore, Thailand, Argentina, Brazil, Chile, Ecuador, Mexico, Peru and Venezuela). The data are monthly for the period from 1973:1 to 2007:4. The results display that real exchange rate volatility negatively affects international trade for several less developed countries and real exchange rate volatility tends to be associated with a real currency appreciation.

Aye *et al*. (2015) examined the impact of real effective exchange rate uncertainty on aggregate exports of South Africa for the period 1986Q4-2013Q2. Results based on bivariate GARCH-in-Mean VAR show that exchange rate uncertainty has a significant and negative effect on exports. Also real exports respond asymmetrically to negative and positive shocks to real effective exchange rate shocks of the same size.

This review clearly shows a dearth of studies on asymmetric effect of exchange rate on agricultural exports in general.

3. DATA AND EMPIRICAL MODELS

Since agricultural export commodity level data comes only annually, we employ annual time series data covering 1970-2013, that is forty-three (43) years. This is consistent with Bahmani-

Oskooee *et al*. (2013) and Oseni (2016). The data on agricultural products export were sourced from Food and Agriculture Organization (FAO)-STAT website, data on real exchange rate, inflation rate and interest rate were sourced from Central Bank of Nigeria (CBN) Statistical Bulletin/Annual Report and World Bank database, data on trade openness index were also sourced from World Bank database. All variables were transformed to their natural logarithm. The measure of real exchange rate volatility was calculated from a Generalized Autoregressive Conditional Heteroskedasticity (GARCH (1, 1)) model using the real exchange rate data.

Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests were also used to ascertain the time series properties (stationarity) of all the variables, so as to avoid spurious regression which results from the regression of two or more non-stationary time series data. Asymmetric effect of real exchange rate volatility was realized using VAR model. Wald test was employed to test the equality of the coefficients of appreciation and depreciation in the export equations.

3. 1 Vector Autoregressive Model

To capture the asymmetric effects, the positive and negative exchange rate volatility shock is included in the VAR model. The asymmetric effect of exchange rate volatility is considered on four agricultural commodity exports namely cotton export (EXCOT), cocoa export (EXCOC), coffee export (EXCOF) and rubber export (EXRUB). The VAR is specified below using cotton export (EXCOT) as an example:

$$EXCOT = \alpha + \beta_i EXCOT_{t-i} + \gamma_i RERV^{+}_{t-i} + \theta_i RERV^{-}_{t-i} + \delta_i INF_{t-i} + \sigma_i INR_{t-i} + \mu_i TOP_{t-i} + U_{1t} \quad (1)$$

$$RERV^{+}_{t} = \alpha + \beta_i EXCOT_{t-i} + \gamma_i RERV^{+}_{t-i} + \theta_i RERV^{-}_{t-i} + \delta_i INF_{t-i} + \sigma_i INR_{t-i} + \mu_i TOP_{t-i} + U_{2t} \quad (2)$$

$$RERV^{-}_{t} = \alpha + \beta_i EXCOT_{t-i} + \gamma_i RERV^{+}_{t-i} + \theta_i RERV^{-}_{t-i} + \delta_i INF_{t-i} + \sigma_i INR_{t-i} + \mu_i TOP_{t-i} + U_{3t} \quad (3)$$

where $RERV^{+}_{t}$ is positive exchange rate volatility (depreciation) shock, $RERV^{-}_{t}$ is the negative exchange rate volatility (appreciation) shock, $EXCOT$ is Cotton export, INF is Inflation, INR is

Interest rate, TOP is Trade openness, α = Intercept, $U_1 - U_3$ = error terms, $\beta_i, \gamma_i, \theta_i, \delta_i, \delta_i, \sigma_i, \mu_i$ = coefficients to be estimated. The positive and negative exchange rate shocks were obtained from the GARCH (1, 1) model following Lee *et al.* (1995) and Mendoza and Vera (2010). Here the exchange rate shock is deflated by its contemporaneous conditional standard deviation and subsequently decomposed into positive and negative component. In other words, the exchange rate shock variable reflects both the unanticipated component and the time-varying conditional variance of exchange rate.

Statistical evidence of asymmetric effect exists if either $\sum_{i=1}^{p} \gamma_i = 0$ or $\sum_{i=1}^{p} \theta_i = 0$ or both statistically differ from zero and the difference between the two ($\sum_{i=1}^{p} \gamma_i + \sum_{i=1}^{p} \theta_i = 0$) is statistically significant (Fang *et al.*, 2009).

4. EMPIRICAL RESULTS AND DISCUSSION

The asymmetric effect of exchange rate volatility is considered on four agricultural commodity exports namely cotton export (EXCOT), cocoa export (EXCOC), coffee export (EXCOF) and rubber export (EXRUB).The control variables included in the analysis are inflation (INF), is interest rate (INR) and trade openness (TOP).

4.1 Preliminary Analysis

The descriptive statistics of the variables used are reported in table 1. The results show that among the export commodities, Cocoa export has the highest mean value of 12.064 followed by Rubber export (10.600) which implies that Cocoa is the first in Nigeria's export profile. Results further show that EXRUB with a skewness value of 0.302 and RERV (0.767) display positive skewness (the distribution has a long right tail) while EXCOC (-0.357), EXCOF (-0.493), EXCOT (-1.054), INF (-0.051), INR (-0.353) and TOP (-0.567) display negative skewness (the distribution has a long left tail). In addition, a platykurtic distribution is observed for all the variables as their kurtosis values are all less than 3. The probability of the Jarque-Bera test of normality indicate that at 5% probability level, all the variables except EXCOT and TOP are normally distributed.

TABLE 1 - *Descriptive Statistics of Variables Used*

	EXCOC	EXCOF	EXCOT	EXRUB	INF	INR	RERV	TOP
Mean	12.064	6.165	4.329	10.600	1.430	2.613	0.055	0.636
Std. Dev.	0.263	1.440	8.038	0.463	2.443	0.482	0.047	0.487
Skewness	-0.357	-0.493	-1.054	0.302	-0.051	-0.353	0.769	-0.567
Kurtosis	2.385	2.674	2.232	2.410	1.474	1.708	2.529	1.321
Jarque-Bera	1.625	1.976	9.226	1.309	4.286	3.972	4.639	7.523
Probabiliy	0.444	0.372	0.010***	0.520	0.117	0.137	0.098*	0.023**

Note: *, **, *** indicate significance at 10%, 5% and 1% level respectively
Source: Author's computation from E-view (2016).

Table 2 presents the results of the unit root test based on the Augmented Dickey-Fuller (ADF) and Phillip-Perron (PP). The tests were applied to each variable over the period of 1970-2013 with a time trend at the variables level and at their first difference. The test statistics are compared against the Mackinnon (1991) critical values for the rejection or otherwise of the null hypothesis of unit root. Table 2 confirm that all variables: Cocoa export (EXCOC), Coffee export (EXCOF), Cotton export (EXCOT), Rubber export (EXRUB), Inflation rate (INF), Interest rate (INR), Real exchange rate volatility (RERV) and Trade openness (TOP) were non-stationary in their level form as evidenced by large p-values. This implies that one cannot reject the null hypothesis of unit root, that is, non-stationarity. After differencing, the variables become stationary as the null hypothesis of unit root is rejected for all variables. This indicates that the variables are integrated of order 1, I(1) and any attempt to specify the dynamic function of the variable in the level of the series will be inappropriate and may lead to problems of spurious regression in line with Mesike *et al.* (2010). The econometric results of the model using the level of these series will not be ideal for policy making (Yusuf and Falusi, 1999).

4.2 Asymmetric Effect of Real Exchange Rate Volatility on Cocoa Export

This subsection considers the asymmetric effect of real exchange rate volatility. The asymmetry measures possible differences in the real exchange rate risk (volatility) effect when there is exchange rate appreciation or depreciation shock. Two forms of asymmetric effect were tested.

TABLE 2 – *Unit Root Test Results*

Variable	ADF		PP	
	Level	First difference	Level	First difference
EXCOC	-1.161	-6.147***	-0.112	-14.699***
	(0.681)	(0.000)	(0.639)	(0.000)
EXCOF	-2.318	-8.003***	-1.273	-6.741***
	(0.171)	(0.000)	(0.184)	(0.000)
EXCOT	-2.324	-6.522***	-2.380	-9.343***
	(0.169)	(0.000)	(0.153)	(0.000)
EXRUB	-2.048	-6.607***	-2.182	-6.610***
	(0.266)	(0.000)	(0.216)	(0.000)
INF	-0.725	-3.243**	-0.576	-3.075**
	(0.829)	(0.024)	(0.865)	(0.036)
INR	-1.405	-6.207***	-1.434	-6.222***
	(0.571)	(0.000)	(0.557)	(0.000)
RERV	-2.202	-6.533***	-2.240	-6.623***
	(0.209)	(0.000)	(0.196)	(0.000)
TOP	-1.310	-6.481***	-1.310	-6.481***
	(0.616)	(0.000)	(0.616)	(0.000)

Note: ** and *** denote rejection of the null hypothesis at 5% and 1% significance level respectively based on the Mackinnon critical values. P-values of corresponding test statistic are given in parenthesis.
Source: Author's computation from E-view (2016).

In the first form, statistical evidence of asymmetric effect exists if either the coefficient sum of RERVPOS (depreciation) or RERVNEG (appreciation) or both statistically differ from zero. In the second form, statistical evidence of asymmetric effect exists if the difference between the coefficient sums is statistically significant (Fang *et al.,* 2009). The result in table 3 shows that cocoa export respond significantly to positive and negative shocks to real exchange rate volatility, i.e real exchange rate volatility possesses significant effects on cocoa export positive or negative in periods of depreciation or appreciation. The result further revealed that cocoa export increases due to real exchange rate volatility depreciation and decline following an appreciation.

Formal test of asymmetric effect is presented in table 7 based on Wald test. The test supports the first form of asymmetric effect as the coefficient sum of both real exchange rate volatility in depreciation (SUM (RERVPOS)) and appreciation (SUM RERVNEG) is statistically different from zero. Also the second form of asymmetric effect is supported given that the difference between the two coefficient sums, (SUM (RERVPOS+RERVNEG)) significantly differs from zero. The null hypothesis for the two forms of asymmetric effect is rejected at 1% for cocoa export. The effect in depreciation appears to dominate that of appreciation since the difference in the coefficient sum of both is positive. This finding strongly supports the view of Fang *et al*. (2009) who found that real exchange rate risk affects export asymmetrically for all eight countries in the sample under the first form of asymmetric effect and for five countries under the second form. This is also consistent with Aye *et al*. (2015) who found that real exports respond asymmetrically to negative and positive shocks to real effective exchange rate shocks of the same size.

4.3 Asymmetric Effect of Real Exchange Rate Volatility on Coffee Export

The asymmetric effect result in table 4 shows that coffee export responds negatively and significantly to real exchange rate volatility shock with contemporaneous, one year lagged effects. Real exchange rate exhibits the expected positive effect during depreciation in the first unlike in the second year, but proves insignificant. Also, in the case of appreciation, as expected, real exchange rate volatility exhibited negative effect on coffee export in both first year and second year with only the first year real exchange rate volatility shock proving significant. This means that appreciation or negative shock of real exchange rate volatility has serious effect on coffee export in Nigeria. The Wald test presented in table 7 shows that only the first form of asymmetric effect is supported and this is in favour of appreciation since the coefficient sum of the RERVNEG is significantly different from zero at 10% level.

TABLE 3 - *Asymmetric Effect of Real Exchange Rate Volatility on Cocoa Export*

	TOP	INR	INF	RERVPOS	RERVNEG	EXCOC
TOP(-1)	-0.159	0.301**	0.017	-0.980	-0.734	-0.326
	(0.177)	(0.149)	(0.116)	(0.777)	(0.497)	(0.258)
	[-0.896]	[2.025]	[0.144]	[-1.261]	[-1.476]	[-1.260]
INR(-1)	-0.132	-0.054	0.068	-0.290	0.196	0.490*
	(0.175)	(0.148)	(0.115)	(0.770)	(0.493)	(0.256)
	[-0.753]	[-0.364]	[0.590]	[-0.377]	[0.398]	[1.916]
INF(-1)	0.000	0.152	0.479***	-0.209	0.021	-0.187
	(0.199)	(0.168)	(0.131)	(0.876)	(0.561)	(0.291)
	[0.002]	[0.904]	[3.670]	[-0.238]	[0.037]	[-0.642]
RERVPOS(-1)	0.089**	0.027	0.015	0.438**	0.017	0.140
	(0.040)	(0.034)	(0.026)	(0.176)	(0.113)	(0.059)**
	[2.217]	[0.785]	[0.564]	[2.479]	[0.147]	[2.387]
RERVNEG(-1)	0.015	0.102*	-0.138***	0.236	0.302*	-0.262
	(0.063)	(0.053)	(0.041)	(0.278)	(0.178)	(0.093)***
	[0.241]	[1.916]	[-3.321]	[0.847]	[1.695]	[-2.830]
EXCOC(-1)	-0.123	-0.119	-0.002	-0.855**	-0.293	-0.504***
	(0.089)	(0.075)	(0.058)	(0.389)	(0.249)	(0.129)
	[-1.390]	[-1.603]	[-0.034]	[-2.198]	[-1.178]	[-3.897]
C	0.008	0.023	0.025	0.350	-0.274*	-0.130*
	(0.051)	(0.043)	(0.033)	(0.223)	(0.143)	(0.074)
	[0.158]	[0.528]	[0.755]	[1.568]	[-1.913]	[-1.747]
R-squared						0.488
Adj. R-squared						0.397
F-statistic						5.391

Note: *, ** and *** indicate significance at 10%, 5% and 1% level, respectively. Standard errors are in parenthesis while t-values are in brackets. Lag selections were done based on the AIC and SIC.
Source: Author's computation from E-view (2016).

TABLE 4 - Asymmetric Effect of Real Exchange Rate Volatility on Coffee Export

VARIABLES	TOP	INR	INF	RERVPOS	RERVNEG	EXCOF
	-0.189	0.252**	0.015	-0.818	-0.453	0.234
TOP(-1)	(0.196)	(0.128)	(0.097)	(0.852)	(0.512)	(1.340)
	[-0.966]	[1.967]	[0.158]	[-0.961]	[-0.885]	[0.171]
	0.191	0.327**	0.213**	1.599*	1.130**	0.329
TOP(-2)	(0.210)	(0.138)	(0.104)	(0.915)	(0.550)	(1.439)
	[0.908]	[2.375]	[2.038]	[1.748]	[2.054]	[0.229]
	-0.129	-0.438***	-0.140	-0.715	0.214	0.174
INR(-1)	(0.237)	(0.155)	(0.118)	(1.032)	(0.620)	(1.623)
	[-0.545]	[-1.342]	[-1.186]	[-0.693]	[0.345]	[0.107]
	-0.022	-0.170	0.242**	-0.613	0.020	-0.139
INR(-2)	(0.194)	(0.127)	(0.096)	(0.843)	(0.507)	(1.326)
	[-0.115]	[-1.342]	[2.521]	[-0.728]	[0.039]	[-0.105]
	0.019	0.746***	0.757	-0.230	-0.420	-1.115
INF(-1)	(0.309)	(0.203)	(0.154)	(1.346)	(0.809)	(2.116)
	[0.061]	[3.685]	[4.931]	[-0.171]	[-0.519]	[-0.527]
	0.168	-0.624***	-0.238*	1.170	0.632	1.153
INF(-2)	(0.253)	(0.166)	(0.126)	(1.103)	(0.663)	(1.734)
	[0.664]	[-3.758]	[-1.895]	[1.061]	[0.953]	[0.663]
	0.087*	-0.025	0.006	0.461**	0.002	0.217
RERVPOS(-1)	(0.047)	(0.031)	(0.023)	(0.205)	(0.123)	(0.323)
	[1.845]	[-0.819]	[0.275]	[2.246]	[0.019]	[0.672]
	-0.049	0.039	-0.002	-0.396*	-0.087	-0.057
RERVPOS(-2)	(0.049)	(0.032)	(0.024)	(0.212)	(0.128)	(0.334)
	[-1.005]	[1.209]	[-0.078]	[-1.864]	[0.679]	[-0.170]
	-0.037	0.194***	-0.117***	0.169	0.366*	-1.274**
RERVNEG(-1)	(0.079)	(0.051)	(0.039)	(0.342)	(0.206)	(0.538)
	[-0.469]	[3.772]	[-3.012]	[0.495]	[1.780]	[-2.368]
	0.100	0.081	0.073*	0.596	-0.186	-0.020
RERVNEG(-2)	(0.085)	(0.055)	(0.042)	(0.369)	(0.222)	(0.580)
	[1.183]	[1.464]	[1.728]	[1.618]	[-0.841]	[-0.034]
	0.010	-0.013	0.012	-0.077	-0.096	0.174
EXCOF(-1)	(0.023)	(0.015)	(0.012)	(0.102)	(0.061)	(0.160)
	[0.424]	[-0.844]	[1.047]	[-0.761]	[-1.573]	[1.088]
	-0.049**	-0.009	-0.002	-0.041	-0.064	0.694***
EXCOF(-2)	(0.023)	(0.015)	(0.011)	(0.101)	(0.061)	(0.158)
	[-2.127]	[-0.616]	[-0.134]	[-0.404]	[-1.065]	[-4.384]
	0.006	0.106	0.058	0.466	-0.382	-0.707
C	(0.064)	(0.042)	(0.032)	(0.280)	(0.168)	(0.440)
	[0.097]	[2.525]	[1.808]	[1.666]	[-2.269]	[-1.604]
R-squared						0.491
Adj. R-square						0.265
F-statistics						2.174

Note: *, ** and *** indicate significance at 10%, 5% and 1% level, respectively. Standard errors are in parenthesis while t-values are in brackets. Lag selections were done based on the AIC and SIC.
Source: Data analysis, 2016.

4.4 Asymmetric Effect of Real Exchange Rate Volatility on Cotton Export

The results in table 5 show that cotton exports are not significantly affected by real exchange rate volatility shock in neither appreciation nor depreciation. It is however observed that during depreciation, the effect of exchange rate volatility was negative in the first year but positive in the second year while the effect during appreciation was positive in the first year and negative in the second year. Consistent with this the Wald test in table 7 cannot reject the null hypothesis of symmetric effect of exchange rate volatility on cotton export. This symmetric result may be due to maturity of cotton exporters. In a related study, Nishimura and Hirayama (2013) explore the impact of Renminbi against Japanese Yen exchange rate volatility on international trade between Japan and China with a focus on the impact of the Renminbi reform. The two measures of exchange rate volatility used, namely the Exponential Generalized ARCH (EGARCH) model (specifically the AR(1)-EGARCH(1,1) model) and the standard deviation. The results show that Japanese exports to China are not affected by exchange rate volatility but Chinese exports to Japan are affected by exchange rate volatility. In addition, the exchange rate level is found not to have a significant impact on Japanese exports but has a significant impact on Chinese exports.

4.5 Asymmetric Effect of Real Exchange Rate Volatility on Rubber Export

The result in table 6 shows that real exchange rate volatility affects rubber export positively and significantly in depreciation for the first previous year as expected. From the result also it is evident that rubber export responds to real exchange volatility shock negatively and significantly in appreciation for both the first and second previous years. This implies that both depreciation and appreciation of real exchange rate volatility shock affects rubber export greatly. It is evident from the result that real exchange rate volatility appreciation has a larger effect on the rubber export than depreciation. The Wald test in table 7 provides evidence of the two forms of asymmetric effect. That is, the coefficient sum of exchange rate volatility in appreciation is statistically different from zero at 1% level and also the difference between the coefficient sum of exchange rate risk in depreciation and appreciation is significantly different from zero at 1% level. The effects in appreciation appear to dominate that of depreciation since the difference in the coefficient sum of both is negative.

TABLE 5 – *Asymmetric Effect of Real Exchange Rate Volatility on Cotton Export*

VARIABLES	TOP	INR	INF	RERVPOS	RERVNEG	EXCOT
	-0.193	0.206*	0.049	-1.052	-0.747	0.234
TOP(-1)	(0.201)	(0.116)	(0.093)	(0.820)	(0.521)	(7.016)
	[-0.962]	[1.771]	[0.530]	[-1.282]	[-1.433]	[0.033]
	0.106	0.283**	0.233**	1.409	0.873	14.342*
TOP(-2)	(0.221)	(0.128)	(0.102)	(0.901)	(0.572)	(7.703)
	[0.479]	[2.218]	[2.294]	[1.565]	[1.524]	[1.862]
	-0.186	-0.461***	-0.166	-0.681	0.265	-0.548
INR(-1)	(0.255)	(0.148)	(0.118)	(1.041)	(0.661)	(8.900)
	[-0.731]	[-3.123]	[-1.413]	[-0.654]	[0.401]	[-0.062]
	-0.043	-0.166	0.233**	-0.511	0.156	-4.768
INR(-2)	(0.207)	(0.120)	(0.096)	(0.847)	(0.538)	(7.240)
	[-0.207]	[-1.383]	[2.441]	[-0.604]	[0.290]	[-0.659]
	-0.016	0.701***	0.819**	-0.505	-0.782	6.487
INF(-1)	(0.330)	(0.191)	(0.152)	(1.347)	(0.856)	(11.519)
	[-0.050]	[3.674]	[5.387]	[-0.375]	[-0.913]	[0.563]
	0.102	-0.697***	-0.273**	1.221	0.747	2.520
INF(-2)	(0.279)	(0.161)	(0.129)	(1.139)	(0.724)	(9.738)
	[0.365]	[-4.320]	[-2.126]	[1.072]	[1.032]	[0.259]
	0.091*	-0.017	-0.000	0.511**	0.067	-0.030
RERVPOS(-1)	(0.049)	(0.028)	(0.023)	(0.200)	(0.127)	(1.711)
	[1.848]	[-0.610]	[-0.030]	[2.553]	[0.527]	[-0.017]
	-0.028	0.041	0.003	-0.398*	-0.085	0.852
RERVPOS(-2)	(0.051)	(0.030)	(0.024)	(0.210)	(0.133)	(1.791)
	[-0.538]	[1.377]	[0.114]	[-1.899]	[-0.642]	[0.476]
	0.003	0.183	-0.100	0.128	0.329	1.174
RERVNEG(-1)	(0.081)	(0.047)	(0.038)	(0.332)	(0.211)	(2.841)
	[0.033]	[3.894]	[-2.667]	[0.386]	[1.558]	[0.413]
	0.069	0.076	0.065	0.591	-0.198	-2.744
RERVNEG(-2)	(0.090)	(0.052)	(0.042)	(0.368)	(0.234)	(3.148)
	[0.763]	[1.454]	[1.572]	[1.607]	[-0.848]	[-0.872]
	0.000	0.003	-0.002	0.001	-0.000	-0.094
EXCOT(-1)	(0.005)	(0.003)	(0.002)	(0.021)	(0.013)	(0.178)
	[0.080]	[0.967]	[-0.834]	[0.067]	[-0.035]	[-0.527]
	-0.000	0.005*	0.001	0.005	0.002	0.072
EXCOT(-2)	(0.005)	(0.003)	(0.002)	(0.021)	(0.013)	(0.178)
	[-0.090]	[1.796]	[0.372]	[0.217]	[0.135]	[0.405]
	0.025	0.121	0.057	0.485	-0.362	-2.634
C	(0.070)	(0.040)	(0.032)	(0.285)	(0.181)	(2.437)
	[0.364]	[2.992]	[1.765]	[1.702]	[-2.001]	[-1.081]
R-squared						0.245
Adj. R-square						-0.091
F-statistics						0.729

Note: *, ** and *** indicate significance at 10%, 5% and 1% level, respectively. Standard errors are in parenthesis while t-values are in brackets. Lag selections were done based on the AIC and SIC.
Source: Author's computation from E-view (2016).

TABLE 6 – *Asymmetric Effect of Real Exchange Rate Volatility on Rubber Export*

VARIABLES	TOP	INR	INF	RERVPOS	RERVNEG	EXRUB
TOP(-1)	-0.252**	0.228*	0.057	-1.096**	-0.873	0.287
	(0.209)	(0.131)	(0.099)	(0.864)	(0.543)	(0.314)
	[-1.207]	[1.741]	[0.576]	[-1.269]	[-1.609]	[0.911]
TOP(-2)	0.088	0.307**	0.226**	1.317	0.867	0.700**
	(0.223)	(0.140)	(0.106)	(0.921)	(0.579)	(0.335)
	[0.396]	[2.196]	[2.134]	[1.430]	[1.497]	[2.087]
INR(-1)	-0.250	-0.423**	-0.143	-0.641	0.123	-1.272***
	(0.258)	(0.162)	(0.122)	(1.066)	(0.670)	(0.388)
	[-0.968]	[-2.617]	[-1.172]	[-0.601]	[0.183]	[-3.277]
INR(-2)	-0.026	-0.135	0.214**	-0.651	0.258	-0.142
	(0.220)	(0.138)	(0.104)	(0.908)	(0.571)	(0.330)
	[-0.120]	[-0.979]	[2.054]	[-0.717]	[0.453]	[-0.431]
INF(-1)	-0.101	0.703***	0.815***	-0.481	-1.047	1.270**
	(0.338)	(0.211)	(0.160)	(1.394)	(0.876)	(0.507)
	[-0.299]	[3.327]	[5.101]	[-0.345]	[-1.195]	[2.503]
INF(-2)	0.125	-0.593***	-0.279**	1.174	0.902	-0.684*
	(0.274)	(0.172)	(0.130)	(1.133)	(0.712)	(0.412)
	[0.456]	[-3.458]	[-2.147]	[1.037]	[1.267]	[-1.659]
RERVPOS(-1)	0.093*	-0.016	-0.001	0.505**	0.078	-0.202***
	(0.049)	(0.030)	(0.023)	(0.201)	(0.126)	(0.073)
	[1.924]	[-0.527]	[-0.046]	[2.518]	[0.621]	[-2.768]
RERVPOS(-2)	-0.006	0.034	-0.002	-0.387	-0.040	0.066
	(0.056)	(0.035)	(0.026)	(0.230)	(0.144)	(0.084)
	[-0.114]	[0.977]	[-0.078]	[-1.682]	[-0.278]	[0.794]
RERVNEG(-1)	0.024	0.187***	-0.111***	0.126	0.378*	-0.276**
	(0.082)	(0.051)	(0.039)	(0.339)	(0.213)	(0.123)
	[0.292]	[3.640]	[-2.847]	[0.372]	[1.776]	[-2.237]
RERVNEG(-2)	0.047	0.077	0.075*	0.637	-0.268	-0.316**
	(0.095)	(0.060)	(0.045)	(0.394)	(0.248)	(0.143)
	[0.491]	[1.291]	[1.657]	[1.617]	[-1.081]	[-2.202]
EXRUB(-1)	0.106	-0.012	-0.025	-0.025	0.277	-0.066
	(0.122)	(0.076)	(0.058)	(0.503)	(0.316)	(0.183)
	[0.872]	[-0.164]	[-0.425]	[-0.049]	[0.875]	[-0.360]
EXRUB(-2)	0.032	-0.033	0.004	0.208	-0.016	0.004
	(0.113)	(0.071)	(0.053)	(0.466)	(0.293)	(0.170)
	[0.281]	[-0.466]	[0.070]	[0.446]	[-0.055]	[0.026]
C	0.030	0.104	0.060	0.513	0.369	0.202
	(0.071)	(0.044)	(0.033)	(0.292)	(0.183)	(0.106)
	[0.424]	[2.344]	[1.791]	[1.758]	[-2.011]	[1.899]
R-squared						0.447
Adj. R-square						0.201
F-statistics						1.819

Note: *, ** and *** indicate significance at 10%, 5% and 1% level, respectively. Standard errors are in parenthesis while t-values are in brackets. Lag selections were done based on the AIC and SIC.
Source: Author's Computation from E-view (2016).

TABLE 7 – *Wald Test Result for Asymmetric Effect*

	SUM (RERVPOS)=0		SUM (RERVNEG)=0		SUM (RERVPOS+RERVNEG)=0	
Variable	Chi-Square Stat	P-value	Chi-Square Stat	P-value	Chi-Square Stat	P-value
EXCOC	6.068***	0.014	8.371***	0.004	10.531***	0.003
EXCOF	0.261	0.610	3.082*	0.079	2.519	0.113
EXCOT	1.428	0.232	1.265	0.261	1.836	0.175
EXRUB	1.874	0.171	10.538***	0.001	9.705***	0.002

Note: *, and *** indicate rejection of symmetric effect at10% and 1% level respectively.
Source: Author's Computation from E-view (2016).

5. CONCLUSION AND POLICY IMPLICATION

The aim of this paper is to examine the effect of real exchange rate volatility on agricultural products export in Nigeria. This paper applies GARCH(1, 1) model to measure exchange rate volatility and subsequently used VAR to evaluate the symmetric and asymmetric effects of real exchange rate volatility on agricultural products export, using annual time series data covering 1970-2013. The result of the unit root tests using the Augmented Dickey-Fuller (ADF) and Phillip-Peron tests confirm that all the variables were not stationary in their level form but became stationary in their first differences. This implies that the null hypothesis of non-stationarity cannot be rejected for the variables in level. The asymmetric effects tests reveal that in Nigeria, real exchange rate volatility exacts significant effects on agricultural products export negative or positive in periods of depreciation or appreciation but the magnitude of the effects during appreciation or depreciation differ depending on the export product in question.

The paper recommends stable exchange rate policy as well as of promotion of the production of export crops to expand the national export basket. More so, adding value to our primary agricultural products is expedient and imperative because it will not only command higher prices but will enhance patronage at the international market. The variability of exchange rate shocks could be harmful, given the presence of asymmetric effect. While adhering to a flexible exchange rate policy, managing fundamentals to reduce excessive volatility over time should be given priority.

REFERENCES

Awokuse, T.O. and Y. Yuan (2006), "Impact of Exchange Rate Volatility on U.S. Poultry Exports", *Agribusiness*, 22 (2), 233-245.

Aye, G.C., R. Gupta, P.S. Moyo and N. Pillay (2015), "Impact of Exchange Rate Uncertainty on Exports in South Africa", *Journal of International Commerce, Economics and Policy,* 6(1), 1-14.

Bahmani-Oskooee, M. and H. Harvey (2011), "Exchange-Rate Volatility and Industry Trade between the U.S. and Malaysia", *Research in International Business and Finance*, 25(2), 127-155.

Bahmani-Oskooee, M., H. Harvey and S.W. Hegerty (2013), "The Effects of Exchange Rate Volatility on Commodity Trade between the U.S. and Brazil", *The North American Journal of Economics and Finance*, 25(August), 70-93.

Cho, G., I. Sheldon and S. McCorriston (2002), "Exchange Rate Uncertainty and Agricultural Trade", *American Journal of Agricultural Economics*, 84(4), 931-942.

De Vita, G. and A. Abbott (2004), "The Impact of Exchange Rate Volatility on UK Exports to EU Countries", *Scottish Journal of Political Economy,* 51(1), 62-81.

Fang, W., Y. Lai and S.M. Miller (2009), "Does Exchange Rate Risk Affect Exports Asymmetrically? Asian Evidence", *Journal of International Money and Finance*, 28(2), 215-239.

Foragasi, J. (2011), "The Effect of Exchange Rate Volatility upon Foreign Trade of Hungarian Agricultural Products", *Studies in Agricultural Economics*, 113(1), 85-96.

Grier, K.B. and A.D. Smallwood (2013), "Exchange Rate Shocks and Trade: A Multivariate GARCH-M Approach", *Journal of International Money and Finance*, 37(October), 282-305.

Huchet-Bourdon, M. and J. Korinek, (2011), "To What Extent do Exchange Rates and their Volatility Affect Trade?", OECD Trade Policy Papers No. 119, OECD Publishing: Paris, <http://dx.doi.org/10.1787/5kg3slm7b8hg-en>.

Kafle, R. and P.L. Kennedy (2012), "Exchange Rate Volatility and Bilateral Agricultural Trade Flows: The Case of the United States and OECD Countries", Southern Agricultural Economics Association, Paper No. 119736, 2012 Annual Meeting, February 4-7, Birmingham: Alabama.

Kandilov, I.T. (2008), “The Effects of Exchange Rate Volatility on Agricultural Trade”, *American Journal of Agricultural Economics*, 90(2), 1028-1043.

Kristinek, J. and D.P. Anderson (2002), “Exchange Rates and Agriculture: A Literature Review”, AFPC Working Paper No. 02-2, Agricultural and Food Policy Center, Texas A&M University.

Lee, K., S. Ni and R.A. Ratti (1995), “Oil Shocks and the Macroeconomy: The Role of Price Variability”, *The Energy Journal*, 16(4), 39-56.

Mackinnon, J.G. (1991), *Critical Values for Cointegration Tests*, in: R.F. Engle, C.W.J. Granger (Eds), “Long-run Economic Relationships: Readings in Cointegration”, Ch. 13, pp. 267-276, Oxford University Press: Oxford.

Mendoza, O. and D. Vera (2010), “The Asymmetric Effects of Oil Shocks on an Oil-exporting Economy”, *Cuadernos de Economía*, 47(135), 3-13.

Mesike, C.S., R.N. Okoh and O.E. Inoni (2010), “Supply Response of Rubber Farmers in Nigeria: An Application of Vector Error Correction Model”, *Journal of American Science*, 6(9), 52-56.

Nishimura, Y. and K. Hirayama (2013), “Does Exchange Rate Volatility Deter Japan-China Trade? Evidence from Pre- and Post-Exchange Rate Reform in China”, *Japan and the World Economy*, 25-26(January-March), 90-101.

Oguro, Y., K. Fukao and Y. Khatri (2008), “Trade Sensitivity to Exchange Rates in the Context of Intra-Industry Trade”, IMF Working Paper 08/134, Retrieved from <http://www.imf.org>, accessed on 21/06/2008.

Orden, D. (2002), “Exchange Rate Effects on Agricultural Trade”, *Journal of Agricultural and Applied Economics*, 34(2), 303-312.

Oseni, I.O. (2016), “Exchange Rate Volatility and Private Consumption in Sub-Saharan African Countries: A System-GMM Dynamic Panel Analysis”, *Future Business Journal*, 2(2), 103-115.

Pick, D. (1990), “Exchange Rate Risk and U.S. Agricultural Trade Flows”, *American Journal of Agricultural Economics*, 72(3), 694 -700.

Schuh, G.E. (1974), “The Exchange Rate and U.S. Agriculture”, *American Journal of Agricultural Economics*, 56(1), 1-13.

Umaru, A., M.B. Sa'idu and S. Musa (2013), "An Empirical Analysis of Exchange Rate Volatility on Export Trade in a Developing Economy", *Journal of Emerging Trends in Economics and Management Sciences (JETEMS)*, 4(1), 42-53.

Wang, K-L. and C.B. Barrett (2007), "Estimating the Effects of Exchange Rate Volatility on Export Volumes", *Journal of Agricultural and Resource Economics*, 32(2), 225-255.

Yusuf, S.A. and A.O. Falusi (1999), "Incidence Analysis of the Effects of Liberalization Tradeand Exchange Rate Policies on Cocoa in Nigeria: An ECM Approach", *Rural Economic Development*, 13, 3-14.