The Asymmetric Relationship between ECOWAS-Eurozone Trade (EET) and Exchange Rate Volatility.

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#### Abstract

This paper focuses on the asymmetric effects of exchange rate volatility on trade between ECOWAS and Eurozone. Export and import equations of nine ECOWAS countries are estimated by using monthly data from 1999-2017 period. Based on a Nonlinear Autoregressive Distributed Lag (NARDL) model, long run asymmetric trade-volatility relationship is confirmed for six countries for the export equation and seven countries for the import equation. Real income is established to be the most important factor influencing the EET. Furthermore, the study finds that inferior goods have dominated the trade sector of Benin. Exchange rate volatility is found to exert negative impact on trade of all ECOWAS countries but Benin and Cote D’Ivoire. Therefore, free-floating exchange rate regime is recommended for Benin and Cote D’Ivoire, while exchange rate control is recommended for the rest of the ECOWAS members. For this reason, Eurozone needs be able to persuade the ECOWAS countries to opt for liberalization of trade and foreign exchange market. The persuasion can be in the form of incentives such as foreign aid, or signing trade agreements favourable to both ECOWAS and Eurozone.

**Keywords:** exchange rate,asymmetric volatility, trade, ARCH,ECOWAS, NARDL

**JEL classification:** C50, F14, F31

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# Introduction

The collapse of the Bretton Wood exchange rate system in 1973 did not only lead to the establishment of a flexible exchange rate system, but also brought uncertainty in international trade due to high volatility in the exchange rate (Adom, Morshed, & Sharma, [2012](#ref-adom2012sources); Hall, Hondroyiannis, Swamy, Tavlas, & Ulan, [2010](#ref-hall2010exchange)). Exchange rate volatility refers to the unexpected and sudden swing or movement in the rate of currency exchange (Bouoiyour & Rey, [2005](#ref-bouoiyour2005exchange); McKenzie, [1998](#ref-mckenzie1998impact)). The Economic Community of West African States (ECOWAS) is a regional economic bloc of fifteen (15) member countries[[1]](#footnote-1). The establishment of the Economic Partnership Agreement (EPA) has provided a free trade area between Europe and West Africa (ECOWAS + Mauritania) in accordance with Article XXIV of General Agreement on Trade and Tariff (GATT). Although the EPA may lead to the removal of some trade barriers, uncertainty surrounding sudden exchange rate changes may impede the smooth flow of exports and imports of ECOWAS countries to/from the Eurozone[[2]](#footnote-2). Towards this end, this study aims to model the relationship between the ECOWAS-Eurozone Trade (EET) and exchange rate volatility.

This empirical work attempts to answer some questions regarding modelling the relationship between exchange rate volatility and trade. For example, can the trade-volatility relationship for EET be modelled as a symmetric or asymmetric model? What factors determine the EET? How can the outcome of this study influence the decision of policy makers and businessmen in ECOWAS? The answers to these questions can help policy makers, analysts and businessmen determine the best model that relates EET and exchange rate volatility. In regard to the first question, some previous studies assume that trade-volatility relationship is symmetric, in the sense that effect of increased volatility on trade is as same as the effect of reduced volatility. Asymmetric relationship, on the other hand, assumes that the effects of increased volatility and reduced volatility on trade are different. Bahmani-Oskooee & Aftab ([2017](#ref-bahmani2017)) point out that changes in expectation and new information determine how traders respond to a currency volatility; trade could be lower (higher) in the face of increased volatility (decreased volatility). Autoregressive Distributed Lag (ARDL) model and other econometric techniques that assume linearity are used to establish the symmetric trade-volatility relationship, while Nonlinear ARDL (NARDL) model is employed to establish asymmetric trade-volatility dynamics. Hence the main aim of this study is to determine whether the established relationship is symmetric or asymmetric, as trade and exchange rate policies guided by wrong trade-volatility relationships can be harmful to an economy.

The outcome of this study is expected to provide a greater insight on the subject matter, based on the fact that previous studies in this area assume linearity of the trade-volatility relationship (Adom et al., [2012](#ref-adom2012sources); Asteriou, Masatci, & Pılbeam, [2016](#ref-asteriou2016exchange); Ozturk & Kalyoncu, [2009](#ref-ozturk2009exchange)). Moreover, other studies that consider non-linearity focus on other regions than ECOWAS and Eurozone (see for example Bahmani-Oskooee & Aftab, [2017](#ref-bahmani2017)). In short, this study differs from all the previous ones as it incorporates recent developments in the volatility measure and econometric methodology. Specifically, it incorporates the procedure suggested by McKenzie ([1998](#ref-mckenzie1998impact)), Enders ([2015](#ref-enders2015applied)) and Asteriou et al. ([2016](#ref-asteriou2016exchange)) to generate the volatility measure; follows Bahmani-Oskooee & Aftab ([2017](#ref-bahmani2017)) in terms of trade model, choice of variables and econometric methodology; follows Asteriou et al. ([2016](#ref-asteriou2016exchange)) in regard to the proxy of some variables; and adopts general-to-specific approach for the estimation of NARDL as suggested by Katrakilidis & Trachanas ([2012](#ref-katrakilidis2012drives)) and Cheah, Yiew, & Ng ([2017](#ref-cheah2017nonlinear)). This study serves as a hybrid of the good contributions made by the previous studies; hence, it is expected to improve the understanding of trade-volatility relationship and to provide a good guide for trade and exchange rate policies in the ECOWAS and Eurozone countries.

# Literature review

Both theoretical and empirical literature on the relationship between exchange rate volatility and trade points to the possibility of both negative and positive relationships. Theoretically, the impact of exchange rate volatility could be negative (Ethier, [1973](#ref-ethier1973international); Hooper & Kohlhagen, [1978](#ref-hooper1978effect)), and insignificant (Giovannini, [1988](#ref-giovannini1988exchange)) or postive (Dellas & Zilberfarb, [1993](#ref-dellas1993real)). On the other hand, empirical literature also supports the theoretical literature in the sense that effects of exchange rate volatility on trade are mixed (see for example McKenzie, [1998](#ref-mckenzie1998impact); Asteriou et al., [2016](#ref-asteriou2016exchange); Bahmani-Oskooee & Aftab, [2017](#ref-bahmani2017)). Asteriou et al. ([2016](#ref-asteriou2016exchange)) use GARCH(1,1) and ARDL to investigate the effect of exchange rate volatility on the trade volumes for Mexico, Indonesia, Nigeria and Turkey (MINT). Their results show that, apart from the case of Turkey, there is no long run effects of exchange rate volatility on international trade. Bahmani-Oskooee & Aftab ([2017](#ref-bahmani2017)) utilizes GARCH(1,1) and NARDL to estimate the asymmetric trade-volatility relationship in the light of US-Malaysia trade at the industry level. Their findings support asymmetric effect of exchange rate volatility in about one-third of the industries. The study further identifies industries affected by increased volatility and those affected by decreased volatility.

Various measures of volatility exist in the literature (Brooks, [2008](#ref-brooks2008introductory); McKenzie, [1998](#ref-mckenzie1998impact)), but one of the most recent measures is the Autoregressive Conditional Heteroscedastic (ARCH) model (see for example, Bahmani-Oskooee & Aftab, [2017](#ref-bahmani2017); Asteriou et al., [2016](#ref-asteriou2016exchange); Bahmani-Oskooee & Harvey, [2011](#ref-bahmani2011exchange); Baum & Caglayan, [2010](#ref-baum2010sensitivity); Gür & Ertuğrul, [2012](#ref-gur2012doviz)). Bollerslev ([1986](#ref-bollerslev1986generalized)) pioneered the Generalized ARCH (GARCH) families to serve as an extension to the ARCH model proposed by Engle ([1982](#ref-engle1982autoregressive)), and also extended to Integrated GARCH (IGARCH) by Nelson ([1990](#ref-nelson1990stationarity)). Moreover, it is more important to measure volatility using a measure that relies on prediction errors (McKenzie, [1998](#ref-mckenzie1998impact)).

There are a number of econometric methodologies used to estimate the trade-volatility relationship. Chowdhury ([1993](#ref-chowdhury1993does)), Vergil ([2002](#ref-vergil2002exchange)), Aqeel & Nishat ([2006](#ref-aqeel2006effect)) and Zorlubas ([2011](#ref-zorlubas2011exchange)) have used the Vector Error Correction Model (VECM). Some studies, on the other hand, have employed different methodologies such as Multiple Regression (see Hayakawa & Kimura, [2009](#ref-hayakawa2009effect); and Baak, [2004](#ref-baak2004exchange)). Asteriou et al. ([2016](#ref-asteriou2016exchange)) use the ARDL model to estimate the trade-volatility relationship. However, studies that are more recent have assumed nonlinearity in the trade-volatility relationship and therefore employed NARDL for the estimation (Arize, Malindretos, & Igwe, [2017](#ref-arize2017exchange); Bahmani-Oskooee & Aftab, [2017](#ref-bahmani2017)). The NARDL estimation gives room for isolating the effect of increased volatility from the effect of decreased volatility on trade. This will guide policy makers to adopt more appropriate policies when volatility increases or decreases.

The review of the above studies implies that various studies have employed several econometric models to examine the trade-volatility relationship in different countries (see for example Bahmani-Oskooee & Aftab, [2017](#ref-bahmani2017); Asteriou et al., [2016](#ref-asteriou2016exchange)). One common feature of these studies is that they model exchange rate as GARCH(1,1) to measure the volatility. Therefore, it is important to consider and choose from other variants of the GARCH families such as Integrated GARCH (IGARCH), Threshold ARCH (TARCH), and Exponential GARCH (EGARCH) to measure the volatility. Moreover, some previous studies assume linear trade-volatility relationships and those that assume non-linearity focus on other regions than ECOWAS and Eurozone. Additionally, the previous studies adopt GARCH(1,1) as the measure of volatility, without considering other variants of ARCH families. This study deems that choosing the most reliable of the ARCH models along with NARDL to examine trade between ECOWAS and Eurozone will shed more light on the trade-volatility relationship[[3]](#footnote-3).

# Data and econometric methodology

## Econometric model

This study follows Bahmani-Oskooee & Harvey ([2011](#ref-bahmani2011exchange)) and Bahmani-Oskooee & Aftab ([2017](#ref-bahmani2017)) to estimate the following trade model

Where , , and stand for ECOWAS member’s export to Eurozone, import from Eurozone, Eurozone income and ECOWAS member’s income respectively. and represent ECOWAS member’s real exchange rate and volatility measure respectively. All the variables are in natural logarithm and the error terms and are white noise. The expected signs of and are positive because increased income is expected to foster trade. The signs of and are expected to be positive and negative respectively, as real depreciation of domestic currency is expected to increase exports and reduce imports. Finally, the estimates of and could be negative or positive depending on the risk attitude of the economic agents.

Two econometric techniques will be used to estimate the import and export equations. The econometric techniques considered in this study include the ARDL model that assumes symmetry (linearity) of trade-volatility relationship, and the NARDL model that considers the trade-volatility relationship to be asymmetric (nonlinear). The ARDL approach is developed by Pesaran, Shin, & Smith ([2001](#ref-pesaran2001bounds)) and it can be applied to a mixture of I(1) and I(0), or purely I(1) regressors. In simple form, the ARDL modelling approach involves estimating the following conditional error correction models (see Asteriou & Hall, [2011](#ref-asteriou2011applied)):

In Equation (3), is the difference operator, is the dependent variable, is a set of independent variables and is a serially independent random error term with zero mean. The F-test is used for investigating one or more long-run relationships among the variables in the equation. The null hypothesis of no co-integration () is tested against the alternative hypothesis of co-integration ().

In the case of co-integration based on the bounds test, the error correction model (ECM) can be estimated. The ECM is a re-parametrization of the ARDL (Asteriou & Hall, [2011](#ref-asteriou2011applied); Pesaran et al., [2001](#ref-pesaran2001bounds)). Therefore, the most informative way to write the error correction models can be specified as follows:

In Equation (4), denotes the difference operator, is the white-noise error term, is the coefficient of adjustment derived from the long-run co-integration relationship. In fact, reveals how much of the equilibrium error is corrected each period and it is expected to be negative and statistically significant. If , then there is no adjustment and therefore there is no long-run relationship (Pesaran et al., [2001](#ref-pesaran2001bounds)).

The export and import equations can be transformed in the form of the ARDL model using Equation (5) , where stands for in the case of export equation and in the case of import equation. Similarly, represents and in the export and import equations respectively.

The second approach is the NARDL model, which considers one or more of the regressors as nonlinear (Shin, Yu, & Greenwood-Nimmo, [2011](#ref-shin2011modelling)). This involves decomposing changes in volatility measure into positive and negative change. After that, partial sum of positive change in volatility measure is generated to represent the increased volatility, while partial sum of negative change in volatility measure is created to represent reduced volatility. Algebraically, the decomposition of the change in volatility measure can be done as follows:

and

Where and are the partial sums of positive and negative changes in volatility measure respectively. Replacing with l and in Equation (5), the export and import equations can be written in the form NARDL model using Equation (6).

Where and represent and respectively in the export equation, and also represent and in the import equation. Shin et al. ([2011](#ref-shin2011modelling)) contend that Equation (6) is non-linear due to the presence of partial sum processes, and that bounds test proposed by Pesaran et al. ([2001](#ref-pesaran2001bounds)) can be equally applied. Wald test can be used to test for cointegration among the level variables, that is by imposing . Long run symmetry can be established by imposing restriction such that , while short run symmetry can be determined using restriction. We follow Katrakilidis & Trachanas ([2012](#ref-katrakilidis2012drives)) and Cheah et al. ([2017](#ref-cheah2017nonlinear)) to trim the optimal lag lengths using general-to-specific approach, which has the advantage of dropping all insignificant stationary regressors.

## Volatility measure

This section provides theoretical background of ARCH model and its variants. It begins by estimating the best Autoregressive Integrated Moving Average (ARIMA) model proposed by Box & Jenkins ([1976](#ref-box1976time)). The ARIMA(p,d,q) model is represented by Equation (7). The letters p, d and q indicate the autoregressive order, order of integration and moving average order respectively.

is the stationary dependent variable, is the white noise error term,

and and is the lag operator.

The simplest form of the class of ARCH process proposed by Engle ([1982](#ref-engle1982autoregressive)) is:

Where is the white-noise error term from the best ARIMA(p,d,q) model, is also white-noise such that its variance is unity (), and are constants such that and .

Bollerslev ([1986](#ref-bollerslev1986generalized)) proposed the GARCH(p,q) model, which is an extension of Engle’s original work that allows the conditional variance to be an ARMA process. In simple form, the GARCH(p,q) is given by:

Where

Nelson ([1990](#ref-nelson1990stationarity)) argued that restricting the sum of the coefficients to unity (that is ) can lead to parsimonious representation. The outcome of this restriction is called IGARCH and forces the conditional variance to behave like a unit root process (Enders, 2015).

Glosten, Jagannathan, & Runkle ([1993](#ref-glosten1993)) proposed the Threshold-GARCH (TARCH) process as follows:

Where is a dummy variable that assigns one if and zero if .

The volatility measure is generated from the series of the most reliable ARCH model.

## Data

This research work utilizes monthly time series data from January 1999 to December 2017. This sample period has been chosen as it reflects the establishment of the Euro Area. The International Financial Statistics (IFS) database is the source of all the variables in this study. Nine countries are considered in this study: Nigeria, Ghana, Senegal, Niger, Burkina Faso, Cote D’Ivoire[[4]](#footnote-4), Mali, Benin, and Togo.

The nominal values of export and import are denominated in United States dollars; hence, they are converted to real values by multiplying each series by the amount of local currency per dollar and then dividing by the domestic CPI. The real value of exports (imports) of each ECOWAS country to (from) the Euro Area represents the export (X) and import (M) variables. The industrial production index of the Euro Area represents foreign income (Y), similar to Bahmani-Oskooee & Aftab ([2017](#ref-bahmani2017)). The real Gross Domestic Product indexed to 2010 and converted to monthly series using ‘quadratic-match average’ represents the domestic income, similar to Asteriou et al. ([2016](#ref-asteriou2016exchange)). Following Adom et al. ([2012](#ref-adom2012sources)) and Bahmani-Oskooee & Aftab ([2017](#ref-bahmani2017)), real exchange rate (R) is calculated as the product of the nominal exchange rate (E) and the ratio of foreign prices to domestic prices[[5]](#footnote-5). The consumer price index (CPI) for each country represents the domestic prices, while the Eurozone CPI is the proxy of foreign prices (CPI\*). Following McKenzie ([1998](#ref-mckenzie1998impact)), Enders (2015) and Asteriou et al. ([2016](#ref-asteriou2016exchange)), the logarithmic change of R is employed to fit the reliable ARCH model for each country[[6]](#footnote-6). Subsequently, the volatility measure (V) is generated from the variance series of the reliable ARCH model for each country in contrast to Bahmani-Oskooee & Aftab ([2017](#ref-bahmani2017)), Asteriou et al. ([2016](#ref-asteriou2016exchange)), Gür & Ertuğrul ([2012](#ref-gur2012doviz)), Aqeel & Nishat ([2006](#ref-aqeel2006effect)), and Baum & Caglayan ([2010](#ref-baum2010sensitivity)).

# Empirical results

## ARIMA(p,d,q) for the real exchange rate

After calculating the real exchange rate for each country, a formal unit root test is conducted and it is found that it is integrated of order one for all the countries[[7]](#footnote-7) . Thus, transformation of the series is required for the ARIMA(p,d,q). To that end, we consider taking the natural logarithm and first difference of each of the series to make it stationary. The best fitting ARIMA(p,d,q) for each country is given in Equation (8). Although ARIMA(0,1,1) has lower SIC value for some of the countries except Ghana, Senegal and Burkina, it is more reasonable to work with the reported ARIMA models because their correlograms resemble the theoretical ARIMA(1,1,0) model[[8]](#footnote-8). For Burkina Faso, Cote d’Ivoire and Benin, ARIMA(1,1,1) happens to be the best model.

Where R stands for the real exchange rate, is the difference operator and ln is the natural logarithm.

## The GARCH models

In this section, reliable ARCH model is determined for each country and volatility measure is generated afterwards. The maximum likelihood technique is used to estimate the variance equation of the ARCH model for each country, with the respective best ARIMA(p,d,q) model as the mean equation[[9]](#footnote-9). The choice of the reliable ARCH model is determined by the minimum value of the Schwarz Information Criterion (SIC), and absence of autocorrelations among standardized residuals and standardized residuals squared. Table 1 presents the reliable ARCH model for each country. The variance series of each reliable ARCH model represents the volatility measure for the respective country.

Table 1: Variance equations of the GARCH

|  |  |  |
| --- | --- | --- |
| **Country** | **GARCH(p,q) Order** | **GARCH Estimation** |
| Nigeria | GARCH(1,1) |  |
| Ghana | GARCH(1,1) |  |
| Senegal | GARCH(1,1) |  |
| Niger | GARCH(1,1) |  |
| Burkina Faso | GARCH(1,1) |  |
| Cote D’Ivoire | TARCH(1,1,1) |  |
| Mali | IGARCH(1,1) |  |
| Benin | GARCH(1,1) |  |
| Togo | GARCH(1,1) |  |

## Bounds test for export and import functions

After generating the volatility measure, we then take the natural logarithm of all the variables and test for the presence of a unit root. The natural logarithm of real exports, real imports, real exchange rate, domestic income and foreign income are I(1) for all the countries. The natural logarithm of volatility is I(0) for all the countries, apart from that of Mali and Togo which is I(1)[[10]](#footnote-10). After that, the bounds test, based on Equations (3) and (6) for ARDL and NARDL respectively, is conducted to establish the existence of a long-run relationships among the variables in the export and imports equations for each country. As shown in Table 2, the F-value obtained from this test is then compared with the lower and upper critical values for the F-statistic found in Pesaran et al. ([2001](#ref-pesaran2001bounds)). There is no cointegration if the F-value is lower than I(0), cointegration exists if the F-value is greater than the I(1) critical value, and it is inconclusive if the F-value lies between these two extreme critical values. In addition to this, ARDL and NARDL are compared in order to choose a better model between them.

Table 2: F-Statistic of Cointegration Relationship for Export and Import Equations

|  |  |  |  |
| --- | --- | --- | --- |
| **Country** | **Test Statistic** | **F(X)** | **F(M)** |
| Nigeria | Symmetric Model (ARDL) | 3.814962\*\*\* | 5.658581\*\*\* |
|  | Asymmetric Model (NARDL) | 3.299078\*\* | 9.808900\*\*\* |
| Ghana | Symmetric Model (ARDL) | 4.129421\*\* | 4.070918\*\* |
|  | Asymmetric Model (NARDL) | 4.030163\*\* | 6.249545\*\*\* |
| Mali | Symmetric Model (ARDL) | 4.655057\*\*\* | 3.839534\*\* |
|  | Asymmetric Model (NARDL) | 12.11891\*\*\* | 17.22698\*\*\* |
| Senegal | Symmetric Model (ARDL) | 4.780203\*\*\* | 6.015015\*\*\* |
|  | Asymmetric Model (NARDL) | 24.03283\*\*\* | 18.64755\*\*\* |
| Niger | Symmetric Model (ARDL) | 33.87029\*\*\* | 3.221813\* |
|  | Asymmetric Model (NARDL) | 36.05614\*\*\* | 4.066335\*\*\* |
| Togo | Symmetric Model (ARDL) | 1.704217 | 4.949618\*\*\* |
|  | Asymmetric Model (NARDL) | 3.836103\*\* | 6.846612\*\*\* |
| Benin | Symmetric Model (ARDL) | 7.851413\*\*\* | 13.07237\*\*\* |
|  | Asymmetric Model (NARDL) | 7.703778\*\*\* | 9.113890\*\*\* |
| Burkina Faso | Symmetric Model (ARDL) | 3.826867\*\* | 9.534956\*\*\* |
|  | Asymmetric Model (NARDL) | 8.604747\*\*\* | 9.113890\*\*\* |
| Cote D’Ivoire | Symmetric Model (ARDL) | 9.722075\*\*\* | 7.933167\*\*\* |
|  | Asymmetric Model (NARDL) | 15.90104\*\*\* | 5.861461\*\*\* |
| Note: \*,\*\* and \*\*\* denote “rejection” of the null hypothesis that there is no long-run relationship at 10%, 5% and 1% level of significance. The critical value bounds are obtained from Pesaran et al. ([2001](#ref-pesaran2001bounds)). The ARDL lower (upper) critical values for 1%, 5% and 10% are 3.65 (4.66), 2.79 (3.67) and 2.37 (3.20), respectively. While the NARDL lower (upper) critical values for 1%, 5% and 10% are 3.29 (4.37), 2.56 (3.49) and 2.20 (3.09), respectively. F(X) and F(M) are the F-values for export equation and import equation respectively. | | | |

Table 2 reveals the presence of cointegration for the export equation at the conventional levels for all the countries, for the ARDL and NARDL models. The import equation supports the rejection of the null hypothesis of no cointegration for all the countries, as shown in In summary, the export and import equations for each country have a long-run relationship with other regressors in the ARDL and NARDL equations at the conventional significance levels. Hence, the long-run relationship for the export and import equations can be computed from the estimates of Equation (6) for the NARDL model.

## Model Selection and Residual Diagnostics

Tables 3 and 4 aim to compare ARDL and NARDL of export equation and import equation respectively, with a view to choosing a better model. The measures used include Schwarz information criteria (SIC); residual diagnostics such as serial correlation (SC), Heteroscedasticity (H), normality (N) and arch form heteroscedasticity (ARCH) tests; and stability measures, which include CUSUM (CQ) and CUSUM of Squares (CS) tests. Smaller SIC values imply that the respective model is more parsimonious than the other. As shown in Table 3, NARDL has a lower SIC value than ARDL for all the countries except Burkina Faso and Benin. Thus, SIC chooses NARDL over ARDL for all the export equations of all the countries other than Burkina Faso and Benin. However, estimation of the NARDL model for each of these three countries indicates that at least one of the volatility measures is significant in the short run or long run, as shown in Table 7. Hence, it will be more reasonable to model the exports of these countries as NARDL instead of ARDL. In the case of the import equations presented in Table 4, NARDL appears to be better for each country as it has a lower SIC value.

Table 3: Model selection and diagnostic tests for the export equation

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Test Statistic** | **SC** | **H** | **ARCH** | **CQ** | **CS** | **SIC** |
| Nigeria ARDL | 0.85(0.65) | 15.19(0.09) | 0.02(0.90) | S | S | 0.1542 |
| Nigeria NARDL | 6.07(0.19) | 33.95(0.86) | 0.02(0.88) | S | S | 0.0955 |
| Ghana ARDL | 0.63(0.73) | 4.90(0.84) | 0.02(0.88) | S | S | 0.6615 |
| Ghana NARDL | 6.04(0.20) | 119.22(0.00) | 0.09(0.76) | S | S | 0.5182 |
| Senegal ARDL | 6.62(0.04) | 23.20(0.01) | 9.43(0.00) | S | S | 0.2675 |
| Senegal NARDL | 10.79(0.03) | 81.57(0.00) | 5.45(0.02) | S | U | 0.1439 |
| Niger ARDL | 0.18(0.91) | 16.79(0.05) | 1.39(0.24) | S | S | 3.6427 |
| Niger NARDL | 0.78(0.94) | 36.43(0.36) | 0.66(0.42) | S | S | 3.5838 |
| Cote ARDL | 2.99(0.22) | 24.05(0.00) | 6.29(0.01) | S | S | 1.0839 |
| Cote NARDL | 9.83(0.04) | 126.83(0.06) | 8.71(0.00) | S | S | 0.9872 |
| Burkina ARDL | 0.06(0.97) | 18.11(0.03) | 6.38(0.01) | S | U | 1.4324 |
| Burkina NARDL | 0.31(0.99) | 84.91(0.04) | 4.12(0.04) | S | U | 1.4265 |
| Togo ARDL | 0.27(0.87) | 33.85(0.00) | 12.82(0.00) | S | U | 2.0345 |
| Togo NARDL | 4.93(0.29) | 88.85(0.03) | 12.01(0.00) | S | U | 2.0035 |
| Benin ARDL | 0.55(0.76) | 42.84(0.00) | 12.70(0.00) | S | U | 2.0480 |
| Benin NARDL | 1.36(0.85) | 153.17(0.02) | 6.21(0.01) | S | U | 2.1015 |
| Mali ARDL | 2.02(0.36) | 10.20(0.33) | 0.18(0.67) | S | S | 1.7148 |
| Mali NARDL | 1.97(0.74) | 49.72(0.56) | 0.31(0.58) | S | S | 1.7132 |
| SC, H, ARCH, CQ, CS and SIC stand for Serial Correlation (LM), Heteroscedasticity (BPG), Normality, Arch, CUSUM, CUSUM of Squares test, and Schwarz Information Criterion respectively. S stands for “stable” and U for “unstable”. Probabilities are given in parenthesis. | | | | | | |

The CUSUM test, as suggested by Brown, Durbin, & Evans ([1975](#ref-brown1975techniques)), is a good tool that provides an insight into the stability of the export and import parameters. The summary of the CQ and CS tests, which show the stability of the parameter and variance estimates, is presented in Table 3 for the export equation and Table 4 for the import equation. If the CUSUM plot falls within the 5 per cent significance boundary, the model is stable; otherwise, it is unstable. As indicated by the CQ and CS, both ARDL and NARDL models are stable for all the countries except Senegal, Burkina Faso, Togo and Benin for the export equation, and except Niger, Togo and Mali for the import equation. In short, NARDL is more suitable for modelling EET for both export and import equations.

Table 4: Model selection and diagnostic tests for the import equation

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Test Statistic** | **SC** | **H** | **AR** | **CQ** | **CS** | **SIC** |
| Nigeria ARDL | 4.00(0.14) | 9.02(0.44) | 1.09(0.30) | S | S | -0.4687 |
| Nigeria NARDL | 9.50(0.05) | 43.67(0.84) | 1.19(0.28) | S | S | -0.4436 |
| Ghana ARDL | 1.80(0.41) | 7.53(0.58) | 2.60(0.11) | S | S | 0.0217 |
| Ghana NARDL | 4.02(0.40) | 57.28(0.35) | 1.18(0.28) | S | S | 0.0139 |
| Senegal ARDL | 2.09(0.35) | 13.98(0.12) | 5.90(0.02) | S | S | -0.6855 |
| Senegal NARDL | 1.44(0.84) | 89.09(0.02) | 0.34(0.56) | S | S | -0.8500 |
| Niger ARDL | 0.54(0.76) | 23.87(0.00) | 6.82(0.01) | S | U | 0.7083 |
| Niger NARDL | 5.49(0.24) | 71.94(0.04) | 8.81(0.00) | S | U | 0.6813 |
| Cote ARDL | 4.83(0.09) | 19.67(0.02) | 2.27(0.13) | S | S | 0.6017 |
| Cote NARDL | 3.85(0.43) | 187.07(0.00) | 0.27(0.61) | S | S | 0.4238 |
| Burkina ARDL | 1.89(0.39) | 16.37(0.06) | 0.01(0.91) | S | S | -0.0344 |
| Burkina NARDL | 2.04(0.73) | 59.84(0.62) | 0.05(0.82) | S | S | -0.0400 |
| Togo ARDL | 2.28(0.32) | 21.92(0.01) | 1.38(0.24) | S | U | 0.0641 |
| Togo NARDL | 2.88(0.58) | 74.01(0.04) | 0.37(0.54) | S | U | -0.0007 |
| Benin ARDL | 0.07(0.97) | 2.75(0.97) | 0.02(0.89) | S | S | -0.1703 |
| Benin NARDL | 3.00(0.56) | 91.28(0.11) | 0.02(0.88) | S | S | -0.2425 |
| Mali ARDL | 1.39(0.50) | 20.07(0.02) | 7.43(0.01) | U | S | 0.5921 |
| Mali NARDL | 11.29(0.02) | 153.27(0.00) | 18.81(0.00) | S | S | 0.4583 |
| SC, H, ARCH, CQ, CS and SIC stand for Serial Correlation (LM), Heteroscedasticity (BPG), Normality, Arch, CUSUM, CUSUM of Squares test, and Schwarz Information Criterion respectively. S stands for “stable” and U for “unstable”. Probabilities are given in parenthesis. | | | | | | |

## Estimation results and discussion

As mentioned earlier, the dependent variables are the real exports (and real imports), while the independent variables are the Eurozone income (for export equation only), domestic income (for import equation only), real exchange rate and volatility. For the NARDL model, the maximum lag order is determined by the number of lags that whiten the error term in the unrestricted Vector Autoregressive (VAR) model[[11]](#footnote-11). The order of the NARDL is determined automatically by Akaike Information Criteria (AIC). Then general-to-specific method is used to drop all the insignificant stationary regressors similar to Katrakilidis & Trachanas ([2012](#ref-katrakilidis2012drives)) and Cheah et al. ([2017](#ref-cheah2017nonlinear)).

Table 5 reports the long run estimates of the export equation. Burkina Faso does not have significant long run coefficients. The reason for this might be the fact that Burkina Faso has low volume of export to the Eurozone (total volume over the whole sample is 18.11 billion units, and its maximum amount of export volume is 895.57 million units). Additionally, long run asymmetry of export-volatility relationship is confirmed for all the ECOWAS countries except for Burkina Faso, Cote D’Ivoire and Niger, as indicated by the values of . The lack of long run cointegration could be due to the heavy reliance of these countries on seasonal agricultural products for exports. On the other hand, Table 6 provides the long-run estimates of the import equation. The values of indicate that long run asymmetry of import-volatility relationship is confirmed for all the ECOWAS countries except for Niger and Burkina Faso. Therefore long run asymmetry cannot be confirmed for Burkina Faso in both the export and import equations. Again, this might be due to the low volume of their imports from the Eurozone.

Table 5: Long-run estimates of the export: NARDL

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **Intercept** |  |  |  |  |  |
| Benin | 39.019 | -9.649\*\*\* | 0.753 | 1.525 | 0.113 | 19.372\*\*\* |
| Burkina | -69.026 | 3.007 | 9.087 | -0.058 | -0.124 | 0.002 |
| Cote | -0.575 | 0.498 | 0.79 | 0.405 | 0.409\* | 0.005 |
| Ghana | -16.599\*\* | 3.983\*\* | 1.142 | 0.03 | 0.424 | 4.478\*\* |
| Mali | 30.72 | 7.885\*\*\* | -9.013\*\* | -7.539\*\*\* | 1.44 | 20.596\*\*\* |
| Niger | -100.880\*\*\* | -3.109 | 17.838\*\*\* | -0.167 | -0.648\*\*\* | 1.377 |
| Nigeria | -3.853 | 2.119\* | 0.574 | -0.244 | -0.182 | 2.904\* |
| Senegal | -29.622\*\*\* | 0.83 | 4.832\*\*\* | -0.163\* | -0.051 | 4.224\*\* |
| Togo | -4.004 | 2.588 | -0.539 | -0.572\*\* | -0.372 | 6.190\*\* |
| Note that \*, \*\* and \*\*\* indicate significance at 10%, 5% and 1% respectively. The long run coefficients are calcualated as , , and . While refers to the Chi-square value for the Wald test for the null hypothesis of long run symmetry. | | | | | | |

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Table 6: Long-run estimates of the import: NARDL

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **Intercept** |  |  |  |  |  |
| Benin | 17.288\* | -1.953\*\*\* | -0.581 | -0.388 | -0.762\*\* | 13.811\*\*\* |
| Burkina | 12.587 | 0.534 | -1.446 | -0.359\*\* | -0.417\*\* | 0.102 |
| Cote | 22.847 | 1.251\*\* | -3.268 | -0.109 | 0.01 | 4.856\*\* |
| Ghana | -7.262\*\*\* | 1.775\*\*\* | 0.982\*\*\* | 0.152 | 0.262 | 4.236\*\* |
| Mali | 0.426 | 8.601\*\*\* | -4.706\*\*\* | -3.373\*\*\* | 3.007\*\*\* | 52.136\*\*\* |
| Niger | -0.939 | 0.223 | 0.623 | 0.042 | -0.095 | 0.419 |
| Nigeria | -5.310\*\* | 1.605\*\*\* | 1.035\*\*\* | 0.099 | 0.131\* | 5.251\*\* |
| Senegal | 3.55 | -0.894\* | 0.993 | 0.171\*\*\* | 0.055 | 12.787\*\*\* |
| Togo | 0.099 | -1.005\*\* | 1.376\*\* | -0.204\*\*\* | -0.278\*\*\* | 14.736\*\*\* |
| Note that \*, \*\* and \*\*\* indicate significance at 10%, 5% and 1% respectively. The long run coefficients are calcualated as , , and . While refers to the Chi-square value for the Wald test for the null hypothesis of long run symmetry. | | | | | | |

Looking at the short run coefficients for the export equation from Table 7, it is clear that both negative and positive volatility coefficients exert influence on Ghana, Senegal and Benin only. Based on this, exchange rate volatility does not affect the export of most ECOWAS countries in the short run.

Table 7: Short run estimates of the export equation: NARDL

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Nigeria** | **Ghana** | **Mali** | **Senegal** | **Niger** | **Togo** | **Benin** | **Burkina** | **Cote** |
|  | -0.078 | -0.211 | -1.215 | 0.294 | -1.905 | -0.357 | -0.477 | -0.155 | 0.464 |
|  |  |  |  | 0.818\*\* |  |  | 5.018\* |  |  |
|  |  |  |  |  |  |  | -6.943\*\*\* |  |  |
|  | -0.023 | 0.832\* | 0.85 | -0.237 | -0.752 | -1.31 | -0.507 | 0.644 | -0.276 |
|  |  |  |  |  |  |  | 1.627\*\* |  |  |
|  |  | -0.836\*\* |  |  |  |  | 1.473\*\* |  |  |
|  |  |  |  |  |  |  | 1.188\*\* |  |  |
| Note that \*, \*\* and \*\*\* indicate significance at 10%, 5% and 1% respectively. | | | | | | | | | |

As shown in Table 8, Nigeria, Senegal, Benin and Burkina Faso have significant coefficients for the positive volatility measure, while significance is confirmed for the negative volatility measure for Nigeria, Mali, Burkina Faso and Cote D’Ivoire. In short, six countries are affected by at least one of the volatility measures, three of which are affected by both the positive and negative volatility measures. In other words, exchange rate volatility affect the import of most ECOWAS countries in the short run.

Table 8: Short run estimates of the import equation: NARDL

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Nigeria** | **Ghana** | **Mali** | **Senegal** | **Niger** | **Togo** | **Benin** | **Burkina** | **Cote** |
|  | -0.097\*\* | -0.029 | -1.937 | -0.007 | -0.321 | -0.125 | -2.335\*\* | -0.114 | 0.116 |
|  |  |  |  | -0.559\*\* |  |  |  |  |  |
|  |  |  |  | -0.954\*\*\* |  |  | 0.387\*\* |  |  |
|  |  |  |  | -0.480\*\* |  |  |  | 0.426\*\* |  |
|  | 0.106 | 0.214 | -2.072312 | 0.085 | 0.059 | -0.155 | -0.202 | 0.823 | -0.107 |
|  | -0.116\*\* |  |  |  |  |  |  | 1.135\*\* | -0.301\*\* |
|  |  |  | -9.854\*\* |  |  |  |  |  |  |
| Note that \*, \*\* and \*\*\* indicate significance at 10%, 5% and 1% respectively. | | | | | | | | | |

The foregoing analysis indicates the suitability of modelling the export-volatility and import-volatility relationships as asymmetric rather than symmetric, thereby addressing the first research question, which attempts to establish whether trade-volatility relationship is symmetric or asymmetric. Table 5 shows that asymmetry of volatility effect on the ECOWAS export in the long run is confirmed for six of the ECOWAS countries, while Table 6 indicates that seven countries have asymmetric import-volatility relationship. The next task is to identify the countries with short-run asymmetry of trade-volatility relationship. As shown in Table 7, Ghana, Senegal and Benin have at least one significant coefficient of the volatility measure in the export equation. On the other hand, Table 8 indicates that Nigeria, Mali, Senegal, Benin, Burkina Faso and Cote D’Ivoire have at least one significant coefficient of the volatility measure in the import equation. In other words, six countries have asymmetric export-volatility relationship and seven countries face import-volatility relationship.

The second research question is about the factors that really determine the EET. If an independent variable is statistically significant, it implies that it is an important factor in determining the EET for that country, and vice versa. According to Table 5, in the long run, the factors that affect exports from the ECOWAS countries to Eurozone are Eurozone income for Benin, Nigeria and Ghana; Eurozone income, real exchange rate and positive volatility for Mali; real exchange rate and positive volatility for Senegal; real exchange rate and negative volatility for Niger; positive volatility for Togo; negative volatility for Cote D’Ivoire. No factor affects the exports of Burkina Faso in the long run. On the other hand, the factors determining imports in the long run, as shown in Table 6, are domestic income, real exchange rate and negative volatility for Nigeria; domestic income and real exchange rate for Ghana; domestic income, real exchange rate, positive volatility and negative volatility for Mali and Togo; domestic income and positive volatility for Senegal; domestic income and negative volatility for Benin; positive volatility and negative volatility for Burkina Faso; domestic income for Cote D’Ivoire. Niger’s exports are affected by no factor in the long run. If we consider the number of countries with significant coefficient of a particular variable as a measure of influence, we can say that Eurozone income is the most influential factor of ECOWAS exports, followed by real exchange rate and increased volatility. Similarly, domestic income is the most influential factor of ECOWAS imports, followed by real exchange rate and decreased volatility.

As mentioned earlier, the expected signs, in the export equation, of foreign income (Y), real exchange rate (R) are positive and that of volatility measures (V) is negative or positive . For the import equation, the expected sign of foreign income is positive, real exchange rate is negative, volatility is negative or positive. As shown in Table 5, the long run coefficients of Eurozone income, in the export equations, has the expected sign for all the countries except for Niger and Benin, indicating that inferior goods dominate the exports of these countries[[12]](#footnote-12). Apart from Mali, the significant long run coefficients of real exchange rate for all the countries have the theoretically expected signs, reflecting the consequence of political instability in the country. Cote D’Ivoire, Niger, Mali and Togo have at least one significant. Political instability in Mali is likely to cause massive capital exodus, which may consequently cause currency depreciation and reduction in export simultaneously. As indicated in Table 6, the long-run significant coefficients of domestic income, in the import equations, have the expected sign for all the countries except for Senegal, Togo and Benin. Therefore, the imports of these countries are dominated by the inferior goods, or that these countries imports from other trade partners such as China as their income rises. The table also shows that Ghana, Nigeria and Togo do not have the expected negative sign for the coefficients of the real exchange rate. The explanation for this is that these countries have officially devalued their currencies in recent years and that they are the signatories of EPA, which requires the signatories to liberalize some of their imports. The liberalization translates into higher imports of these countries from the Eurozone, thus negating the protectionist role of their currency devaluation.

The last question attempts to establish the policy implications of the findings of this study. In general, a negative (positive) coefficient of the volatility measure in the export equation requires the ECOWAS country to control (liberalise) its exchange rate movement by implementing policies such as a managed floating (purely floating) exchange rate regime. Thus, Benin, Cote D’Ivoire and Ghana should liberalise their exchange rate because volatility is likely to result in a rise in their exports to the Eurozone, and that Mali, Niger, Nigeria, Senegal and Burkina Faso should control their exchange rate. On the other hand, a negative (positive) coefficient of the volatility measure in the import equation requires the ECOWAS country to liberalise (control) its exchange rate movement by implementing policies such as a managed floating (purely floating) exchange rate regime. Therefore, Benin, Burkina, Cote D’Ivoire, Mali and Togo should liberalise their exchange rates as volatility reduces their imports from the Eurozone. Hence, liberalisation of foreign exchange market is the best option for Benin and Cote D’Ivoire as volatility is likely to increase their exports and at the time reduce their imports.

The outcomes of this study agree and also differ from some of the previous studies. In the long run, the outcomes are inline with the theoretical postulates of Dellas & Zilberfarb ([1993](#ref-dellas1993real)) for Benin, Cote D’Ivoire and Ghana as their exports are positively related with exchnage rate volatility. The long run negative relationship between exchange rate volatility and exports of Nigeria, Burkina Faso, Mali, Niger, Senegal and Togo is inline with the theoretical underpinnings of Ethier ([1973](#ref-ethier1973international)) and Hooper & Kohlhagen ([1978](#ref-hooper1978effect)). Benin, Burkina Faso, Ghana and Nigeria do not have significant coefficients for exchange rate volatility, thus justifying the trade-volatility theory of Giovannini ([1988](#ref-giovannini1988exchange)). On the other hand, the imports of Benin, Burkina and Togo have negative relationship with exchange rate volatility in the long run, thus confirming the theory of Ethier ([1973](#ref-ethier1973international)) and Hooper & Kohlhagen ([1978](#ref-hooper1978effect)). Nigeria, Senegal and Ghana have positive relationship between volatility and import, as suggested by Dellas & Zilberfarb ([1993](#ref-dellas1993real)). Cote D’Ivoire, Niger and Mali have mixed relationship between volatility and import. These outcomes are also similar to emprical studies such as McKenzie ([1998](#ref-mckenzie1998impact)), Asteriou et al. ([2016](#ref-asteriou2016exchange)) and Bahmani-Oskooee & Aftab ([2017](#ref-bahmani2017)). These outcomes imply that most ECOWAS countries have their exports negatively affected by the exchange rate volatility.

# Conclusion

This study attempts to establish the existence of the asymmetric effects of exchange rate volatility on trade between ECOWAS countries and Eurozone. The measure of exchange rate volatility used for all the countries is variance series from the reliable ARCH model. The most parsimonious ARCH model without redundant coefficients in both the mean and variance equations is chosen to be the most reliable for each country. Export equation is estimated with foreign income, real exchange rate and volatility measure as regressors, while import equation is estimated with the same regressors except foreign income, which is replaced by domestic income. Export and import equations are estimated for all the countries in the form of ARDL and NARDL models, and the latter model happened to be better than the former for all the countries.

Long-run asymmetry is confirmed for six countries in the export equation and seven countries in the import equation. The study also shows that exports and imports of the ECOWAS countries are affected in the long run by some of the variables; no country records significant coefficients for all the variables. The study further finds that Benin and Cote D’Ivoire are the only country whose total trade benefits from exchange rate volatility. Inferior goods dominate the exports of Niger and Benin and the imports of Senegal, Togo and Benin. Therefore, inferior goods have dominated the trade sector of Benin. In addition to this, the study recommends that Benin and Cote D’Ivoire should liberalise their foreign exchange markets, as volatility is likely to increase their exports and at the time reduce their imports.

The export-volatility relationship of six countries is found to be in line with theoretical explanation of Ethier ([1973](#ref-ethier1973international)) and Hooper & Kohlhagen ([1978](#ref-hooper1978effect)), while findings for three countries agree with the suggestion of Dellas & Zilberfarb ([1993](#ref-dellas1993real)) that export-volatility relationship is positive. Out of these countries, four countries do not have significant volatility coefficients, as implied by Giovannini ([1988](#ref-giovannini1988exchange)).

Eurozone should be able to persuade the ECOWAS countries to implement exchange rate policies that are favourable to the Eurozone, given the outcome that most of the countries in this study should control their foreign exchange market in order to mitigate the negative effect of the volatility. The persuasion can be in the form of incentives such as foreign aid, or signing trade agreements such as the EPA.

Although no study exists that has examined the asymmetric impact of exchange rate volatility on EET, this study is not exhaustive. It employs only one measure of exchange rate volatility and analyses the asymmetric impact of volatility on the economy as a whole, not on the individual sectors that make the whole. Therefore, this study suggests that future research should consider the inadequacies of this study such as the use of sector-specific or firm-level data trade data.

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1. See this site for more details: <http://www.ecowas.int/member-states/> [↑](#footnote-ref-1)
2. Exports stands for export volume of an ECOWAS country to the Eurozone, while “imports” means import volume of an ECOWAS country from the Eurozone [↑](#footnote-ref-2)
3. ‘Reliable’ is used as defined by McKenzie ([1998](#ref-mckenzie1998impact)) to mean the best of the ARCH models. Moreover, ‘ARCH’ is used in general sense to mean any variants such as GARCH, IGARCH, TARCH and so on. [↑](#footnote-ref-3)
4. Ivory Coast is another name for Cote D’Ivoire. [↑](#footnote-ref-4)
5. Specifically where R, E, CPI and CPI\* stand for real exchange rate, nominal exchange rate (amount of domestic currency per dollar), domestic CPI and foreign CPI. [↑](#footnote-ref-5)
6. The mean equation for the ARCH model of each country is the best ARIMA model for natural logarithm of R. [↑](#footnote-ref-6)
7. To save space, the unit root test result is not reported. [↑](#footnote-ref-7)
8. Graphs of correlograms are not presented here for economy of space. Data and Figures are available from authors upon request. [↑](#footnote-ref-8)
9. This procedure is the same as in McKenzie ([1998](#ref-mckenzie1998impact)) and Asteriou et al. ([2016](#ref-asteriou2016exchange)) [↑](#footnote-ref-9)
10. Again, the result for this unit root is not reported, but it is available on request [↑](#footnote-ref-10)
11. The highest lag order indicated by the lag selection criteria is 9. However, we consider using a maximum of 7 lags for all the countries to avoid losing many degrees of freedom. [↑](#footnote-ref-11)
12. The coefficients represent elasticity estimates because all the variables are in natural logarithms. [↑](#footnote-ref-12)