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## Article

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RESEARCH

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# Asymmetric effect of exchange rate changes on cross-border trade in Nigeria

Olumuyiwa Tolulope Apanisile<sup>1\*</sup> and Olusola Mathew Oloba<sup>2,3</sup>

## Abstract

This paper investigates the asymmetric effect of exchange rate changes on cross-border trade in Nigeria. The investigation becomes necessary because several studies have reported insignificant results in attempting to establish a link between these two variables using symmetric specification. Whereas, there are strong evidence of nonlinear mean-reverting association because some exchange rate changes of the same magnitude exhibit different effects on other variables of interest. Having separated the real effective exchange rate into both depreciation and appreciation regimes using the partial sum processes based on logistic smooth-transition and exponential smooth-transition, results from the nonlinear autoregressive distributed lags show that exchange rate appreciation had a statistically significant negative relationship with cross-border trade in Nigeria. The study concludes that the relationship between real effective exchange rate and cross-border trade is asymmetric. (Depreciation and appreciation of equal magnitude do not have the same effect on cross-border trade in Nigeria.) The study recommends that policy makers should consider models that allow a nonlinear adjustment of exchange rates which may produce outcomes supporting an effective devaluation or appreciation policy, at least against some trading partners.

**Keywords:** Cross-border, Asymmetry, Exchange rate, NARDL, Nigeria

## Introduction

Cross-border trade (CBT) is a global phenomenon. In the European Union, cross-border trade forms a substantial part of normal market activities, not only for the presence of common currency (the Euro) which is expected to facilitate trade, but for the effective implementation of various laws aimed at removing all impediments to trade. In North America, a two-way cross-border trade in homogenous goods such as electricity has existed between the USA and Canada for decades [2]. Similarly in the Asian world, the Association of South East Asian Nations (ASEAN) comprises the third fastest growing economy in the world. Ahmed et al. [1] point out that this high economic growth is not unconnected with vast cross-border trading in energy resources among countries in the ASEAN sub-region.

Theoretical literature on exchange rate emphasizes how the link between exchange rate and cross-border trade is established. The theory of international trade stipulates that, real devaluation/depreciation of a local currency would make exports cheaper and imports dearer and thus result in a general improvement in a country's trade balance. However, empirical literature has reported mixed results at best in establishing a relationship between exchange rate changes and trade balance both descriptively and empirically [5]. In a reaction to this, Arize et al. [4] opined that various authors modeling nonlinear dynamics with linear or symmetry specification might be the origin of the mixed views from various authors. Symmetry effect suggests that if exchange rate depreciation improves CBT, appreciation worsens it. However, asymmetry can occur in two scenarios. One, it can occur the moment positive and negative deviations revert back to the mean. Two, it can occur in the speed of reversion when positive and negative deviations from equilibrium interact with each other in a nonlinear manner [3]. Recent contributions from the econometric

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literature recommend asymmetric autoregressive distributed lag (AARDL) approach proposed by Shin et al. [38] in analyzing the dynamic effect of exchange rate on foreign trading activities. According to them, checking for asymmetry between positive and negative exchange rate is important because some exchange rate movements exhibit different effect than others of the same scale (see [41]).

Even though, the link between exchange rate and cross-border trade has been established in the literature, the dynamic interaction of these two variables is much more than has been reported by several researchers. For instance, Hayakawa [21] claims that movements in the exchange rate are expected to have effects on cross-border imports and exports, and nominal depreciation or appreciation of the exchange rate is presumed to change the real exchange rate and, thus, have a direct effect on a country's cross-border trade balance but this study observes that a lot of growing issues have not been addressed in the literature. Unlike the previous studies, this study dwells majorly on the individual but not collective effects of exchange rate appreciation and depreciation on cross-border trade in Nigeria. To the best of our knowledge, no known study has recently empirically examined the asymmetric effect of exchange rate movements on cross-border trade in this part of the world. It is on this platform that this paper attempts to investigate the asymmetric effect of exchange rate dynamics on cross-border trade in Nigeria.

## Methods

### Model

This paper makes use of the nonlinear autoregressive distributed lag (NARDL) model to establish the presence or otherwise of asymmetry in the relationship between exchange rate and cross-border trade in Nigeria. The choice of this methodology is informed by the fact that the nonlinear cointegrating model has the undoubted benefit of giving room for short- and long-run asymmetry which can help us address the issue surrounding the subject matter of this paper as alluded in the preceding section. The nonlinear autoregressive distributed lag (NARDL) technique supports a dynamic error correction illustration linked to asymmetric long-run cointegrating regression, and the technique permits a relationship to display long-run asymmetry, short-run asymmetry and combined short and long-run asymmetries.

### Data sources

Secondary data were used in this study. Given the fact that procedures for the collection of data on cross-border trade are marred with gross biasness and inconsistency due to numerous unrecorded or informal activities

at the border, this study relied on a number of secondary sources to obtain data on cross-border trade. The sources include National Institute of Statistics (NIS), Benin Republic, Nigeria Custom Service (NCS), COMTRADE UN Data (CD-ROM 2015), World Development Indicators (WDI), 2015. All other data were sourced from WDI, 2015.

## Theoretical and empirical issues

Cross-border trade is an offshoot of bilateral trade. The link between the real exchange rate component and bilateral trade is often analyzed using gravity model of international trade which was first introduced by Isard [26]. A simple form of gravity model was presented by Timbergen [40] into the field of international trade. Originating from Newton's gravity law, the theory states that trade between two countries is directly proportional to the economic masses of the two trading partner countries and indirectly proportional to the distance between them [14].

Literature points at some major factors influencing CBT such as trading partners' income, exchange rate, transport and technical infrastructural facilities, the nature of the financial system, membership of the same regional bloc, border effects, etc. From the foregoing, exchange rate constitutes one determinant with a controversial and dynamic behavior that researchers have always been keen to investigate its impact on macroeconomic variables. Thus, the real exchange rate dynamics and its impact on cross-border trade have been established in the literature (see [7, 8, 19, 20, 25]). Exchange rate movement has impacts on exports and imports while nominal appreciation/depreciation in the exchange rate are expected to alter real exchange rate and, therefore, have a straight influence on a country's cross-border trade (Hayakawa 2017). The theory of international trade stipulates that real devaluation/depreciation of a local currency would make exports cheaper and imports dearer and thus result in a general improvement in a country's trade balance. The overvaluation of the currency consequent upon exchange controls lessen price of exports and thus turn as inherent taxes on exports. The exchange measures favor the alterations of recorded trade inspiring overpricing of imports and under-invoicing of exports giving way to capital flight. This overvalues authorized imports and undervalues exports [31].

Real exchange rate dynamics is an imperative and extensively researched subject in economics. Most studies conducted on its impact on bilateral trade have been predicated on testing the validity of the J-Curve theory, the Marshal Lerner's condition and the purchasing power parity (PPP) hypothesis [6, 32]. The J-curve theory, theoretically introduced in 1973 by Magee, asserts

that depreciation deteriorates the trade balance initially but improves it later on as a result of lag structure. The Marshal Lerner's condition stipulates that the addition of the export and import demand price elasticities must be greater than one, backing up the capability of devaluation in enhancing a country's cross-border trade balance. PPP hypothesis says, once transformed to an identical currency, national price level ought to be the same across board.

The literature on exchange rates has not clearly addressed the issues that bother on the relationship between trade and currency overvaluation or undervaluation directly. Simple reasoning on economic thought proposes two opposite effects. A currency undervaluation has a clear inverse influence on the exports of those additional economies which focus in the manufacturing of goods that have comparatively close substitution and struggle for market share in the same markets. The opposite obtains for currency overvaluation. Ultimately, the question whether exchange rates undervaluation will ensure a significant impact on trade in the long or the short run has to be tested empirically. Also, the question of maybe the long-run impacts would occur depends on whether the market failures arguments are empirically important. Regardless of findings of various authors on this, economic theory suggests two important caveats. First, according to the "targeting principle," policies that target market failures directly are best and efficient. Therefore, other policies that address distortions indirectly only cannot be more than second-best. Specifically, real undervaluation causes unnecessary distortions through imposition of consumption tax on tradable goods. The other caveat is that the degree to which currency undervaluation is expected to have trade effects would depend on what the trading partners will do [5]. Even though it has been critically established in the literature or otherwise that exchange rate undervaluation has a direct long-run effect on exports, this may not hold if all the countries undervalue at once.

In understanding the J-curve effect, following some textbooks in international economics (for instance, Krugman and Obstfeld [28]), real exchange rate depreciation often goes hand in hand with a worsened trade balance in any given country in the short-run owing to the fact that most export and import orders are usually booked some months in advance. The worth of the pre-booked imports increases in terms of domestic goods, which connotes an initial decrease in the current account.

According to OECD (2011), in an attempt to investigate the theoretical justification of the popular J-Curve debate, aggregate short-run exchange rate movements have an ambiguous effect on trade. They claim that "their impact is hard to interpret; in certain situations,

the effect is positive, while in some other, it is negative. These arrangements agree with other authors who conclude that short-run impacts seem not to follow a definite design." They discover a significant effect of exchange rates on agricultural exports than that of manufactured products. The authors claim that one of the reasons why we have this might be the relatively "higher convenience to change sellers of agricultural commodities than manufacturing, mainly because the former are more identical than the latter." Besides, "the price transmission mechanisms may not be the same in agriculture in comparison with manufacturing products." The study shows that value of trade between the USA and China could be affected more by exchange rate variations than what obtains in the US–eurozone or the eurozone–China. The framework uses a hypothetical 10% depreciation of the several currencies on bilateral trade using 2008 trade data. From the model results, a hypothetical 10% depreciation of USD (or 10% appreciation of the Yuan) would mean an increase in the US agricultural trade surplus of around 5 billion USD and a decrease in the manufacturing trade deficit of some 30 billion USD. The OECD emphasizes that this outcome supports selected latest studies signifying that the disparity in the trade between China and the USA is as a result of several factors while exchange rate is just one of them (see OECD, 2011).

There is a growing evidence of nonlinear mean-reverting behavior in real exchange rates in the literature [30]. Evidence of mean-reversion or its absence helps identify the shocks that characterize real exchange rate dynamics. For example, evidence of mean-reversion implies that nominal disturbances have only transitory impact on real exchange rate while its absence implies that permanent real shocks are the reason for the real exchange rate movements [23]. Nonlinearities in the real exchange rate adjustment may arise from high international transactions costs. Heckscher [22], in his book, emphasizes the idea that transaction costs should create "commodity points" has brought a renewed interest in the PPP hypothesis, theoretically and empirically. Theoretically, some researchers specify theoretical models that incorporate this transaction costs view (see [16, 37]). On the average, in those models, transport costs give a band of inaction for the real exchange rate. If transportation cost, for instance, exceeds the benefit of arbitrage, price differentials will not be removed; the force of arbitrage pushes the real exchange rate toward its equilibrium only when arbitrage becomes profitable enough to outweigh cost of shipping. Consequently, the exchange rate displays nonlinear dynamics: a non-stationary random walk process within the band and a stationary mean-reverting process out of the band (see [15]).

Literature has also recommended the Taylor's rule framework to most economies of the world as the model has been widely recognized and used to solve contemporary economic problems of many advanced as well as developing nations. Engel and West [17] introduce Taylor's rule into the monetary model to investigate the behavior of exchange rate between deutsche mark-dollar in 1978–2001. Following this approach, Beckmann and Wilde [9] build a Taylor's rule exchange rate model where exchange rate is determined by the fundamentals. Using an exponential smooth transition (ESTR) regressive model, they show that deutsche mark-dollar real exchange rates adjust much faster to their equilibria. Engel et al. [18] examines Taylor rule fundamentals for real exchange rate determination. His results support that a simple learning model provides plausible understanding of the real deutsche mark-dollar exchange rate dynamics in 1973–2005. It has also been reported in the literature that both short- and long-run exchange rate dynamics have certain links with export performance in the short run as well as economic performance in the long run. Real depreciation, for instance, is found to boost export growth which in turn, boosts the real growth in an economy (see [35]).

In a notable study by OECD (2011), the OECD simulated hypothetical appreciations or depreciations of 10 percent of Chile and New Zealand's exchange rates to see their impacts on their bilateral trade with the USA, the eurozone and China. It found that smaller, open economies such as New Zealand and Chile have to tolerate the full adjustment of exchange rate changes, relative to less trade-dependent, large economies. One reason is that smaller economies have less a diversified production and export base, and hence are less in a position to move into exports that have greater price elasticity, when exchange rate appreciation results in potentially more costly exports. The argument is symmetrical for depreciations, i.e., the number of domestic producers is smaller and hence insufficient to substitute for imports when prices increase. In the long run, though, the relationship seems to be less certain (see [5]).

Arize et al. [4] examines the impact of real effective exchange rate on trade balance of eight countries using the nonlinear autoregressive distributed lag (NARDL) model. From their results, long-run cointegration analysis provides evidence indicating that when depreciation is separated from appreciation, depreciation is shown to have significant effects on the trade balance but in an asymmetric model. In a similar fashion, Bahmani-Oskooee and Fariditavana [7] examined the asymmetric effects of exchange rate changes on the Turkish bilateral trade balances using the asymmetric cointegration approach. Result from the long-run asymmetric autoregressive distributed lag (AARDL) shows that once appreciation is separated from depreciation using the

partial sum processes, exchange rate changes of equal magnitude do not have similar effects on cross-border trade balances. Results show that the effects of exchange rate changes are asymmetric. More precisely, while Lira appreciation does not have any significant effect on Turkish bilateral trade balances, Lira depreciation has significantly favorable effects on Turkish trade balance with her European partners individually (France, Germany, Italy, Portugal and Great Britain).

## Model specification and results

### Model specification

The study employs the gravity model to establish a relationship between real effective exchange rate and cross-border trade balance. The gravity model represents the bilateral trade model pioneered by Timbergen [40], Poyhonen [34] and Linneman [29]. Bergstrand [12, 13] demonstrated its empirical robustness. The bilateral trade model adopted in this study follows Kodongo and Ojah [27], Boke and Doganay [14], Bahmani-Oskooee and Fariditavana [7] and Arize et al. [4]. This is represented below

$$\text{NCBT}_{ij} = \beta_0 Y_i^{\beta_1} Y_j^{\beta_2} \text{REX}_i^{\beta_3} U_{ij} \quad (1)$$

where  $\text{NCBT}_{ij}$  is the net cross-border trade between country  $i$  and  $j$ .  $i$  is the country under investigation (Nigeria) while  $j$  is the cross-border trading partner country (i.e., Benin Republic). In this paper, our definition of cross-border trade includes the trading activities that take place between two different nationals at the various markets close to the border. Also, any recorded merchandise goods that crosses the border from country  $i$  to country  $j$  and vice versa is taken into consideration. For the purpose of this study, CBT is measured as the value of export of country  $i$  to country  $j$  divided by the value of import from country  $j$  to country  $i$ . This is similar to the measure adopted in Hop et al. (2013), Antweiler [2], Bahmani-Oskooee and Fariditavana [7] and Arize et al. [4].  $\text{RER}_i$  represents the real exchange rate in country  $i$ , proxied by real effective exchange rate (REER). The choice of using real effective exchange rate in place of real exchange rate in this study is justified in the literature as being appropriate for a bilateral trade analysis (see [4]). Real effective exchange rate is a measure of average of exchange rates between two countries and shows the fluctuation in the general value of the currency. Taking natural log of both sides, we have;

$$\ln \text{NCBT}_{ij} = \ln \beta_0 + \beta_1 \ln Y_i + \beta_2 \ln Y_j + \beta_3 \ln \text{REER}_i + U_{ij} \quad (2)$$

We begin the specification of the long-run relationship between real effective exchange rate cross-border trade and, enhanced with real domestic and foreign income by rewriting Eq. (2) in the following way [4];



$$\ln \text{NCBT}_t - \ln \beta_0 - \beta_1 \ln Y_i - \beta_2 \ln Y_j - \beta_3 \ln \text{REER}_t = U_t \quad (3)$$

$$\text{ncbt}_t - \beta_0 - \beta_1 y_i - \beta_2 y_j - \beta_3 \text{reer}_t = \varepsilon_t \quad (4)$$

where  $\text{ncbt}_t$  represents the natural log of the value of Nigeria's export divided by the value of its import from cross-border trading partner;  $\text{reer}_t$  measures real effective exchange rate and it is described in a way that its increase would mean effective depreciation;  $y_i$  is a series of real domestic income while  $y_j$  represents that of trading partner country.  $\varepsilon_t$  represents the disturbing variable. All variables in abridged form of Eq. (4) are converted into natural log. This allows their slope coefficients to represent the elasticity of the regressand in line with the regressors. The unobservable term calculates the extent of disequilibrium and is given as;

$$\text{ec}_t = \text{ncbt}_t - \hat{\beta}_0 - \hat{\beta}_1 y_i - \hat{\beta}_2 y_j - \hat{\beta}_3 \text{reer}_t \quad (5)$$

We further generate a one-lagged error-correction term to estimate parameters associated with the short-run model as;

$$\text{ec}_{t-1} = \text{ncbt}_{t-1} - \hat{\beta}_0 - \hat{\beta}_1 y_{it-1} - \hat{\beta}_2 y_{jt-1} - \hat{\beta}_3 \text{reer}_{t-1} \quad (6)$$

According to Arize et al. [4], the effect of the exchange rate fluctuation on trade does not seem to have a priori direction or is multi-faceted, that is,  $\hat{\beta}_3$  might be either negative or positive. If  $\text{reer}_t$  falls, competitiveness in prices increases in the local country, which might result in more export with less import (volume effect). On the other hand, an increase in  $\text{reer}_t$  increases the values of each import units (import value effect), which is capable of reducing the trade balance. In testing for nonlinear readjustment or the presence of asymmetry in the relationship between exchange rate and bilateral/cross-border trade in Nigeria, we begin by incorporating likelihood of asymmetric nonlinear re-adjustments to equilibrium. In achieving this, this study employs alternative functional form of  $f(\text{ec}_t)$  to model the likely nonlinear outcome of  $\text{ec}_t$  on the net cross-border trade as follows;

$$f(\text{ec}_t) = \begin{cases} \delta \text{ec}_{t-1}^3 + \delta \text{ec}_{t-1}^4 \\ \delta \text{ec}_{t-1}^2 + \delta \text{ec}_{t-1}^4 \\ \delta \text{ec}_{t-1}^2 + \delta \text{ec}_{t-1}^3 + \delta \text{ec}_{t-1}^4 \end{cases} \quad (7)$$

The Eq. (7) above agrees with the error correction cum autoregressive distributed lag (ARDL) model discussed in Eq. (10). Equation (7) is a nonlinear model based on Sollis [39]. It is not the model we have estimated but it can be used to capture how a nonlinear relationship can be eventually derived from an asymmetric processes. It suggests that a deviation from equilibrium is initially

an asymmetric phenomenon. This means that an asymmetric error process is the main source of any possible nonlinearity. Equation (7) merely helps us to acknowledge the presence of asymmetry in the speed of reversion within positive and negative deviations or asymmetry at the point which positive and negative reverts back to the mean (see [4]). This is not to conclude that any nonlinear process is completely asymmetric but two variables with supposedly nonlinear relationship initially exhibit asymmetric behavior (see [10]).

As mentioned in "Methods" section, the nonlinear cointegrating model popularized recently by Shin et al. [38] has the undoubted benefit of giving room for short- and long-run asymmetry. The nonlinear autoregressive distributed lag (NARDL) technique supports a dynamic error correction illustration linked to asymmetric long-run cointegrating regression, and the technique permits a relationship to display long-run asymmetry, short-run asymmetry and combined short- and long-run asymmetries. It similarly supports the probability of quantifying the successive responses of the regressands to negative and positive shocks of the regressors from the asymmetric dynamic multipliers.

From Schodert [36], Shin et al. [38], Arize et al. [4], we begin the NARDL technique by building new variables that explain instances of appreciation and depreciation. The simple idea involves disintegrating the time series,  $\text{reer}_t$ , into two, namely  $(\text{reer}_t^+)$  and  $(\text{reer}_t^-)$  as follows;

$$\text{reer}_t^+ = \sum_{j=1}^t \Delta \text{reer}_t^+ = \sum_{j=1}^t \max(\Delta \text{reer}_t, 0) \quad (8)$$

$$\text{reer}_t^- = \sum_{j=1}^t \Delta \text{reer}_t^- = \sum_{j=1}^t \min(\Delta \text{reer}_t, 0) \quad (9)$$

where  $\Delta \text{reer}_t^+$  and  $\Delta \text{reer}_t^-$  represent fractional sums of depreciations and appreciations, respectively. Following Shin et al. [38], the trade balance equality is denoted by the asymmetric ARDL model in Eq. (10);

$$\begin{aligned} \Delta \text{ncbt}_t = & \omega_0 + \omega_1 \text{ncbt}_{t-1} + \omega_2^+ \text{reer}_{t-1}^+ + \omega_2^- \text{reer}_{t-1}^- \\ & + \omega_3 y_{i-1} + \omega_4 y_{j-1} + \sum_{t=1}^p \rho_i \Delta \text{ncbt}_{t-i} \\ & + \sum_{t=0}^r \rho_i^+ \Delta \text{reer}_{t-i}^+ + \sum_{t=0}^r \epsilon_i^- \Delta \text{reer}_{t-i}^- \\ & + \sum_{t=0}^q \epsilon_i \Delta y_{i(t-1)} + \sum_{t=0}^s \epsilon_i \Delta y_{j(t-1)} + \mu_t \end{aligned} \quad (10)$$

where for instance,  $-\frac{\omega_2^+}{\omega_1^+}, -\frac{\omega_2^-}{\omega_1^-}$ , give coefficients of long-run real effective exchange rate. Equation (10) allows the possibility that the process being modeled can exhibit asymmetries in the short run, the long run, long run and short run only. The level terms in Eq. (10) represent the long-run association. Short-run asymmetries are then captured by the lags of asymmetric exchange rate terms that show in the first-differenced setup. We can now estimate the autoregressive distributed lag (ARDL) model in Eq. (10) and subsequently test for the presence of asymmetric nonlinear (cointegrating) long-run association. This could be done using two techniques: one, conduct a  $t$  test on the coefficient of the error-correction term (ECT) where the null is set as  $\omega_1 = 0$ , and the alternative hypothesis as  $\omega_1 \neq 0$ . If the null hypothesis cannot be rejected, Eq. (10) will reduce to the linear regression with only first differences signifying that there is no long-run relationship among the levels of  $ncbt$ ,  $reer_t^+$ ,  $reer_t^-$ ,  $y_{t-1}$  and  $y_{t-2}$ .

The critical value of the said  $t$  test of  $\omega_1 = 0$  is stated in Shin, Pesaran et al. [33]. The other test is known as  $F_{PSS}$ . We base this on  $F$ -test for the joint null hypothesis that coefficients of all variables are jointly equal to 0 ( $H_0 : \omega_1 = \omega_2^+ = \omega_2^- = \omega_3 = \omega_4 = 0$ ) against the alternative hypothesis that the coefficients of lagged leveled variables are not equal to 0 jointly ( $H_1 : \omega_1 \neq \omega_2^+ \neq \omega_2^- \neq \omega_3 \neq \omega_4 \neq 0$ ) or ( $H_1 : \omega_1$  or  $\omega_2^+$  or  $\omega_2^-$  or  $\omega_3$  or  $\omega_4 \neq 0$ ). Also as reported in Pesaran et al. [33], the critical values are reported. The long-run coefficients of real effective exchange rate are obtained thus;  $L_r^+ = -\frac{\omega_2^+}{\omega_1^+}$  and  $L_r^- = -\frac{\omega_2^-}{\omega_1^-}$ . The long-run asymmetry can be investigated using the popular Wald test, where symmetry implies that;

$$L_r^+ = L_r^-$$

## Results

Table 3 in the appendix shows the short- and long-run estimate of the nonlinear relationship that exists between exchange rate movements and cross-border trade in Nigeria. The essence of the analysis is premised not only on the unending insignificant relationships that exist between exchange rate and bilateral trade as reported by many authors but also on the high probability of model misspecification.

In the short run, exchange rate depreciation increases cross-border trade by 23% but not statistically significant. Also, worthy of note is that there is a positive relationship between foreign GDP (YBN) and cross-border trade in the short-run. In the long-run where most models of trade usually draw inferences from; it is observed that when real effective exchange rate appreciates by a percentage, cross-border

trade volume decreases by 42%. The unique thing about this relationship is that it is significant at 5% level. This is contrary to the results obtained by various authors who have worked with linear models (see [11, 14]). Also, one percent increase in domestic GDP (YNG) and foreign GDP (YBN) will increase cross-border trade by 3 and 9%, respectively. This result indicates that Beninese GDP has more impact on cross-border trade in Nigeria than does Nigeria's GDP itself. The above findings are in the same line of thought with Hoffman and Melly [24], Kodongo and Ojah [20], Hashim and Meagher [27] where it was discovered that Beninese GDP determines cross-border trade more than that of any of her regional cross-border trading partners. Further, our error-correction term (ECT), as an important long-run phenomenon, assumes the expected negative sign and it shows that 96% of the error in the short period disequilibrium is corrected in the long run. This value suggests that there is a considerable very high speed of adjustment to the last period's disequilibrium.

## Cointegration test

A cointegration test approach to ARDL analysis is necessary here mainly because our analysis is based on the nonlinear ARDL Model. It is therefore very important to test for asymmetric cointegration. We have employed the Wald Test to achieve this simple but all important task. Table 1 in the appendix presents the results from the asymmetric cointegration test. Here, a null hypothesis of no cointegration is set against the alternative hypothesis of presence of cointegration. It is evident from Table 1 that the value of the  $F$ -cal is greater than that of  $F$ -tab using the critical value based on the appropriate degree of freedom in the Pesaran et al. [33] statistical table (i.e.,  $6.083 > 4.35$ ). The result confirms that asymmetric cointegration exists among the variables in the nonlinear model. This is similar to the findings of Arize et al. [4] but contrary to Bahmani-Oskooee and Fariditavana [7].

## Testing for the presence of asymmetry

In this study, for us to conclude that the exchange rate of equal changes (either appreciation or depreciation) will have different effect on cross-border trade, we necessarily have to discover the presence of asymmetry in the nonlinear model. Table 2 presents the results from the test for the presence or absence of asymmetry using the Wald Test. This results exhibit the computation of the long-run coefficients of the real effective exchange rate as demonstrated in Eq. (10) back in chapter three. Table 1 shows that there is long-run asymmetry in the relationship that exists between real effective exchange rate (appreciation and depreciation) and cross-border trade in Nigeria.

Following Verheyen [41] and Arize et al. [4], for us establish the absence of asymmetry based on the Wald

Test, the values of the  $t$ -stat and  $F$ -stat must be equal but in this case, they are not equal. Also, Bahmani-Oskooee and Fariditavana [7] posit that asymmetry occurs when long-run coefficient of real effective exchange rate appreciation ( $L_R^-$ ) is not equal to the long-run coefficient of real exchange rate depreciation ( $L_R^+$ ). That is;

$$(L_R^- \neq L_R^+)$$

From our analysis,  $L_R^+$  is found to be 43.9 while ( $L_R^-$ ) is 40.2. This further confirms the presence of asymmetry in the relationship that exists between these two variables that form the center of this study. The fresh findings can go a long way in clearing the air on the debate on whether exchange rate movement has any impact on bilateral trade in the literature.

### Conclusion and recommendation

The morale behind the nonlinear ARDL analysis is premised not only on the unending insignificant relationships that exist between exchange rate and bilateral trade as reported by many authors but also on the high probability of model misspecification. In this analysis, it is assumed that if exchange rate is dissipated simultaneously into depreciation and appreciation regimes, equal magnitude of appreciation and depreciation will have different effects on cross-border trade. Consequently, either appreciation or depreciation will have a significant effect on cross-border trade.

From the results, having separated the real effective exchange rate into both depreciation and appreciation regimes using the partial sum processes based on logistic smooth transition (LSTAR) and exponential smooth transition (ESTAR) employed recently by Bahmani-Oskooee and Fariditavana [7] and Arize et al. [4], it was found that exchange rate appreciation had a statistically significant negative relationship with cross-border trade in Nigeria. This is however a fresh evidence on the trade situation between Nigeria and Republic of Benin.

The study concludes that the relationship between real effective exchange rate and cross-border trade is asymmetric (depreciation and appreciation of equal magnitude do not have the same effect on cross-border trade in Nigeria) and to be precise, only real effective exchange rate appreciation yields a significant negative relationship with cross-border trade in the long run. Based on this result, there is a strong indication that the J-Curve theory does not align with its conventional definitions but by a new and more recent definition, i.e., a short-run deterioration of the trade balance combined with long-run improvement only due to real appreciation and nonlinear

adjustment. Thus, the new definition, which is based on separating depreciations from appreciations, yields more evidence of the J-Curve rather than the traditional definition which is based on exchange rate and trade in a linear adjustment.

The study recommends that policy makers should take exchange rate changes and their effects on the economy, especially on trading activities, very serious. When the effects of exchange rate changes on cross-border trade balance are insignificant, policy makers should not restrict themselves to such findings and should consider models that allow a nonlinear adjustment of exchange rates which may produce outcomes supporting an effective devaluation or appreciation policy, at least against some trading partners. However, effective appreciation will favor Nigerian traders more in cross-border trading activities with the Republic of Benin.

#### Authors' contributions

OMO is a PhD student in the Department. The paper is extracted from his PhD thesis. OTA supervised the thesis of OMO. All authors read and approved the final manuscript.

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#### Availability of data and materials

Data used for this study are available upon request with other materials.

#### Competing interests

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### Appendix

See Tables 1, 2, 3 and 4.

**Table 1 Asymmetric cointegration test Source: Author's computation based on e-views**

Wald test			
Test statistic	Value	Degree of freedom	Probability
F-statistic	6.083480	(5, 6)	0.04538
Chi square	25.417402	5	0.3671



**Table 2 Testing for the presence of asymmetry Source: Author's computation based on e-views**

Test statistic	Value	Degree of freedom	Probability
<i>t</i> -statistic	0.226073	6	0.8286
<i>F</i> -statistic	0.051109	(1, 6)	0.8286
Chi square	0.051109	1	0.8211
$L_R^-$	40.2251		
$L_R^+$	43.9618		

**Table 3 Nonlinear autoregressive distributed lag (NARDL) model Source: Author's computation based on e-views**

	Lags	
	0	1
Panel A: short-run estimates based on ARDL		
$\Delta \logreer\_n$	− 30.43** (2.71)	
$\Delta \logybn$	6.39 (1.34)	
$\Delta \logyng$		− 3.42 (1.40)
$\Delta \logreer\_p$		23.09 (1.67)
Panel B: long-run estimate based on ARDL		
Constant	− 284.30 (1.71)	
Logcbit		− 0.96** (2.85)
Logreer_p		− 38.66 (1.92)
Logreer_n		− 42.27** (2.66)
Logyng		3.41 (1.54)
Logybn		9.20 (1.74)

Objects in parenthesis are the various *t*-statistics

\*, \*\*, \*\*\*Implies 1%, 5%, and 10% level of significance, respectively

**Table 4 Lag selection criterion Source: Author's computation based on e-views**

Lag	LogL	LR	FPE	AIC	SC	HQ
0	16.38969	NA	2.74e−06	− 1.457611	− 1.261560	− 1.438123
1	62.02746	64.42979*	8.99e−08*	− 4.944407*	− 3.964156*	− 4.846968*

\*Indicates lag order selected by the criterion

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