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Real Exchange Rate Dynamics and Trade Balance in WAEMU Countries: Evidence from Panel Nonlinear ARDL Approach

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Abstract

This study estimates the impact of real exchange rate on the trade balance of seven countries of the West African Economic and Monetary Union (WAEMU). In examining this issue, most previous studies assume the relationship to be symmetric. In this paper, we relax this assumption by extending the nonlinear ARDL approach to panel data framework. We filter appreciations from depreciations in the real exchange rate and estimate their respective effects on the trade balance using the Pooled Mean Group (PMG) estimator. The results for the panel show that the long-run relationship between real exchange rate and trade balance is asymmetric. More precisely, the trade balance was found to respond stronger to depreciations in the real exchange rate than to appreciations in the long-run. In the short-run, however, the trade balance is not sensitive to the real exchange rate regardless of whether it appreciates or depreciates. The results for individual country estimation reveal cross-country heterogeneity in the short-run relationship between the real exchange rate and the trade balance.

Keywords: *Nonlinear ARDL; Asymmetry; Trade Balance; Real Exchange Rate; WAEMU.*

JEL Classification: *C23, F10, F31, O55.*

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1. Introduction

The impact of the real exchange rate on the trade balance has received a great deal of attention in the economic literature. The Marshall-Lerner condition postulates that the adjustment of trade balance is closely knitted with the elasticity of demand. Currency devaluation will improve the trade balance only if the sum of the elasticities of exports and imports is greater than one (Marshall, 1923; Lerner, 1944). Theoretically, devaluation brings about an increase in exports since the domestic goods become cheaper for the trading partners. On the other hand, imports decrease as they become more expensive for domestic agents. However, exports and imports may not respond instantaneously to devaluation as market participants could take some time to adjust to changes in relative prices. Magee (1973) explains that production and delivery delays, recognition lag, fixed contracting and negotiating terms of exporters prevent devaluation from improving the trade balance instantaneously. Generally, the real exchange rate depreciation initially worsens the trade balance and then improves it afterwards, resulting in a J-curve pattern. A growing body of empirical studies examined the effects of the real exchange rate on the trade balance using various dataset, variables and estimation methods. This literature yielded mixed and inconclusive results. A plethora of studies provided evidence supporting that real exchange rate depreciation improves the trade balance (e.g., Rawlins, 2011; Igue and Ogunleye, 2014; Anning *et al*., 2015; Hunegnaw and Kim, 2017; Keho, 2021). On the other side of the same mirror, other studies discovered unfavorable or insignificant impact of the real exchange rate depreciation on the trade balance (e.g., Rose, 1990; Akpansung and Babalola, 2013; Alege and Osabuohien, 2015; Kamugisha and Assoua, 2020).

In examining the relationship between real exchange rate and trade balance, most previous studies have assumed that appreciations and depreciations are transmitted in the same magnitude to trade balance. Recently, it has been argued that the trade balance may respond differently to exchange rate appreciation and depreciation. This could be attributed to many factors including adjustment costs, price rigidities, quantity restrictions, and market power (Bussiere *et al*., 2013). As a result, estimates from linear models may be inconsistent. Consequently, another strand of empirical studies relaxes the assumption of symmetry using nonlinear models. Some of these studies confirmed the asymmetric effects of exchange rate on the trade balance. However, empirical studies especially those employing panel data techniques, are scanty in relation to Sub-Saharan African countries.

This study examines the exchange rate pass-through to the trade balance for the West African Economic and Monetary Union (WAEMU) over the period 1975–2017. We find out whether the responsiveness of the trade balance to the real exchange rate changes is subject to non-linearity due to currency appreciation and depreciation. More specifically, we seek to answer to the following questions: does exchange rate depreciation lead to a significant improvement in the trade balance? Do exchange rate depreciation and appreciation have distinct effects on the trade balance? Which of depreciation and appreciation of the real exchange rate has greater effect on the trade balance? To answer these questions, we adapt the non-linear ARDL approach proposed by Shin *et al*. (2014) into panel data framework to analyze the relationship between trade balance and real exchange rate movements. Another novelty of this study is that it considers cross–country heterogeneity in the nexus between the two variables. To the best of our knowledge, no known study has empirically examined the asymmetric effect of real exchange rate on the trade balance for this part of Sub-Saharan Africa. Therefore, the results of this study will contribute to the existing literature on the impact of the real exchange rate changes on the trade balance in African countries.

The rest of the paper is organized as follows. Section 2 reviews the empirical literature on the effect of real exchange rate on the trade balance. Section 3 presents the econometric framework of the study. Section 4 reports and discusses the empirical results of the study. Section 5 concludes the study and provides some lines of future research.

2. Literature Review

The relationship between real exchange rate and the trade balance has stimulated a burgeoning empirical studies. A first group of studies have relied on traditional econometric methods to examine the issue for both developed and developing countries. The evidence from this literature is mixed. For instance, Baharumshah (2001) estimated the effect of exchange rate on the bilateral trade balances of Malaysia and Thailand with the US and Japan over the period 1980–1996. The results revealed a favorable effect of real exchange rate depreciation on the trade balance of both countries in the long-run. Applying cointegration technique, Bahmani-Oskooee (2001) found that real depreciation of exchange rate improves the trade balance in Bahrain, Egypt, Jordan, Morocco, Syria, Tunisia, and Turkey. Musila and Newark (2003) for Malawi, Narayan (2006) for China, Halicioglu (2008) for Turkey, Tsen (2011) for Malaysia, Igue and Ogunleye (2014) for Nigeria, Anning *et al*. (2015) for Ghana, Caporale *et al.* (2015) for Kenya, and Keho (2021) for Cote d'Ivoire also found evidence that real exchange rate depreciation has an improving effect on the trade balance. Yol and Baharumshah (2007) relied on panel cointegration technique to scrutinize the bilateral trade balances of 10 African countries with the U.S. for the period 1977–2002. The results showed that real exchange rate depreciation improves the trade balance of six countries (i.e., Botswana, Egypt, Kenya, Nigeria, Tunisia, and Uganda), while worsening that of Tanzania and has no effect in Ghana, Morocco and Senegal. Adeniyi *et al*. (2011) examined the case of four member countries of the West African Monetary Zone (WAMZ) countries, namely: The Gambia, Ghana, Nigeria and Sierra Leone. The results from the bounds testing approach to cointegration supported the J-curve effect only in Nigeria. Meanwhile, in the cases of The Gambia and Ghana, real devaluation initially improves the trade balance and then deteriorates it later. Hunegnaw and Kim (2017) studied the effects of the real exchange rate on the trade balance in East African countries, using the ARDL bounds testing approach. The results for individual country showed that real exchange depreciation significantly improves trade balance in the long-run in four countries (Ethiopia, Madagascar, Mauritius, and Rwanda). A significantly negative effect was not found in any of the countries. The results for the panel also showed a positive long-run effect of the real exchange rate on the trade balance. The short-run effect was positive but insignificant.

On the other hand, studies by Loto (2011) for Nigeria, and Kamugisha and Assoua (2020) for Uganda reported that depreciation of the exchange rate does not improve the trade balance. Shahbaz *et al*. (2011) found that devaluation worsens the trade balance in Pakistan. Bahmani-Oskooee and Gelan (2012) found no support for the J-Curve effect in a study of nine African countries comprising Burundi, Egypt, Kenya, Mauritius, Morocco, Nigeria, Sierra Leone, South Africa, and Tanzania. Akpansung and Babalola (2013) found a negative but insignificant relationship between the trade balance and real exchange rate in Nigeria. Applying panel cointegration techniques to selected African countries, Genemo (2017) found that the real exchange rate depreciation worsens the trade balance in the long-run.

All the aforementioned studies assume the effect of real exchange rate on the trade balance to be linear or symmetric in the sense that depreciation and appreciation of the real exchange rate have the same effect, in absolute value, on the trade balance. With the development of new econometric methods, attempts have been made to examine asymmetry in the relationship between the real exchange rate and the trade balance. The threshold cointegration designed by Enders and Siklos (2001) and the nonlinear autoregressive distribution lag

(NARDL) approach introduced by Shin *et al*. (2014) have inspired a growing empirical studies. The NARDL approach filters appreciations from depreciations and estimates their respective effects on the trade balance using the ARDL bounds testing approach to cointegration proposed by Pesaran *et al*. (2001). Most of the studies using those approaches found asymmetry in the response of the trade balance to the exchange rate changes. For instance, in a case study of Nigeria, Aliyu and Tijjani (2015) employed the threshold cointegration technique and showed that the trade balance adjusts slowly in response to exchange rate depreciations, whereas it reacts quickly to appreciations. Iyke and Ho (2017) examined the case of Ghana by using the linear and nonlinear ARDL models. The results from the linear model showed no evidence in support of the short-and long-run impact of the exchange rate changes on the trade balance. In the nonlinear model, however, real depreciation of the exchange rate causes an improvement in the trade balance in the long-run, while real appreciation does not have any significant effect. Bawa *et al*. (2018) scrutinize the short-run and long-run effects of real exchange rate changes on the Nigeria's trade balance over the period 1994–2018. Using linear model they documented that real depreciation of the exchange rate improves the trade balance. And using nonlinear ARDL model they confirmed asymmetry in the nexus between the real exchange rate and the trade balance. Precisely, depreciation of the real exchange rate has a significant effect on the trade balance while appreciation is not significant. Employing the NARDL approach, Bahmani-Oskooee and Fariditavana (2015), Bahmani-Oskooee and Fariditavana (2016), Bahmani-Oskooee and Baek (2016), Arize *et al.* (2017), Bahmani-Oskooee and Kanitpong (2017), Bahmani-Oskooee *et al.* (2017), Nusair (2017) and Iyke and Ho (2018) also provided evidence confirming asymmetric effects of the real exchange rate changes on the trade balance.

Recently, Akoto and Sakyi (2019) examined the case of Ghana for the period 1984–2015 by using symmetric and asymmetric models. Their results failed to support the Marshall-Lerner condition and the J-curve effect. Therefore, depreciation of the Ghana cedi cannot improve its trade balance. Bahmani-Oskooee *et al*. (2019) studied the dynamics of the trade balance of Tunisia. The results from linear model showed no significant effect of real effective exchange rate on the trade balance. Conversely, when nonlinear approach is adopted, real exchange rate depreciation improves the trade balance while appreciation has no effect. Olufemi (2019) also confirmed that the exchange changes have asymmetric impact on the trade balance in both short and long-run in Nigeria over the period 1999–2017. Bahmani-Oskooee and Arize (2020) applied the NARDL approach to 13 African countries and found asymmetric effects in many of the countries.

Bahmani-Oskooee and Fariditavana (2020) investigated the bilateral trade balance of the US with Canada for 161 industries. They found asymmetric short-run real exchange rate effects on the trade balance in all industries and significant long-run asymmetric effects in 62 industries. Bahmani-Oskooee and Gelan (2020) considered the bilateral trade balance of South Africa with the US for 25 industries. They found asymmetric short-run effects of the exchange rate movements on the trade balance in 19 industries, which last into long-run asymmetric effects in 14 industries. Ben Doudou *et al*. (2020) relied on the threshold regression approach to test for threshold effect in the exchange rate and trade balance nexus in Tunisia over the period 1984–2016. The results showed that above a certain threshold dinar depreciation improves the Tunisia's trade balance, while appreciation worsens it. For Nigeria, Nathaniel (2020) found that positive and negative shocks in the exchange rate are associated with negative impact on the trade balance, but only the impact of positive shocks is significant. Finally, Shuaibu and Isah (2020) examined the experience of five African countries (Algeria, Cameroon, Nigeria, South Africa, and Uganda) using both linear and nonlinear ARDL models for the period 1980–2018. Their results provided evidence supporting asymmetric pass-through of the real exchange rate into the trade balance. As can be seen from this review, the role of asymmetries in explaining the relationship between the trade balance and the real exchange rate has not received much attention in the Sub-Saharan African context. This study tries to fill the gap in the empirical literature by examining the case of the West African Economic and Monetary Union (WAEMU).

3. Econometric Framework

3.1. Model Specification

Following existing studies, the trade balance is related to three explanatory variables namely, domestic income, foreign income and real exchange rate. Therefore, we specify the empirical model as follows:

$$lnTB_{it} = \beta_{0i} + \beta_{1i} lnY_{it} + \beta_{2i} lnYF_{it} + \beta_{3i} lnRER_{it} + \beta_{4i} D_{it} + \mu_{it} \qquad (1)$$

where ln represents natural logarithm, TB_{it} denotes the trade balance on goods and services, Y_{it} is real gross domestic income, YF_{it} is foreign real income, RER_{it} is the real effective exchange rate defined in a way that a decrease (increase) reflects a real depreciation (appreciation) of the domestic currency, D_{it} is a vector of deterministic variables which may include a time trend and a shift dummy variable that takes the value of zero for the period before 1994 (the year of the currency devaluation) and one otherwise, and μ_{it} is an error term assumed to be a white-noise process.

The coefficient of domestic income is expected to be negative as it is likely to increase the demand for imports and consequently worsening the trade balance. World income is expected to have positive impact on the trade balance as it increases exports and thus improving the trade balance. The coefficient of real exchange rate is expected to be negative as its depreciation is expected to have favorable impact on the trade balance.

One major assumption of Eq.(1) is that the relationship between real exchange rate and trade balance is linear in the sense that appreciation and depreciation of the real exchange rate have the same effect on the trade balance. Accordingly, this model does not allow potential asymmetry in the relationship between the two variables. It may fail to establish a significant relation if the trade balance responds asymmetrically to depreciation and appreciation of the real exchange rate. Our objective in this study is to investigate possible asymmetric pass-through of the real exchange rate into the trade balance. To that end, we follow the approach suggested by Shin *et al*. (2014) by decomposing the real exchange rate variable into positive changes (appreciation) and negative changes (depreciation) as follows:

$$lnRER = RER^0 + POS + NEG \quad (2)$$

where POS and NEG denote, respectively, partial sums of positive and negative changes in real exchange rate. They are calculated as follows:

$$POS_t = \sum_{i=1}^{t} \max(\Delta lnRER_i, 0) \quad (3)$$

$$NEG_t = \sum_{i=1}^{t} \min(\Delta lnRER_i, 0) \quad (4)$$

Therefore, the empirical model for investigating the asymmetric impact of real exchange rate on the trade balance is specified as follows:

$$lnTB_{it} = \theta_{0i} + \theta_{1i} lnY_{it} + \theta_{2i} lnYF_{it} + \theta_{3i} lnPOS_{it} + \theta_{4i} lnNEG_{it} + \beta_{5i} D_{it} + \mu_{it} \quad (5)$$

If the two partial sums have the same coefficients, i.e. $\theta_{3i} = \theta_{4i,}$ then the effect of real exchange rate is symmetric, otherwise, it is asymmetric. The following section outlines the estimation method used to estimate the above equation.

3.2. Estimation Method

To estimate the relationship between real exchange rate and trade balance, we rely on panel ARDL framework. The panel ARDL approach has the advantages of the traditional time-series ARDL model. More specifically, it allows the short and long-run parameters to be estimated jointly. Also, it alleviates the problems of endogeneity of the regressors and serial correlation through the inclusion of sufficient lags of the variables. Furthermore, this approach provides consistent estimates when applied on variables with different orders of integration. Finally, the ARDL approach allows for the introduction of different lags on the variables.

The ARDL dynamic specification for Eq.(5) is expressed as follows:

$$y_{it} = \sum_{j=1}^{m} \phi_{ij} y_{it-j} + \sum_{j=0}^{n} \gamma_{ij}^{'} X_{it-j} + \alpha_i + \mu_{it} \tag{6}$$

where y_{it} is the trade balance, and X_{it} is the vector of explanatory variables including domestic income, foreign income and real exchange rate, *i.e*. X_{it}=(lnY_{it}, lnYF_{it}, POS_{it}, NEG_{it}). The parameter α_i is the fixed effects, and μ_{it} is the normal error term. The lags included in the model are captured by *m* and *n* for dependent and independent variables, respectively. They are determined using information criteria.

The ARDL model can be re-parameterized as an error-correction equation as follows:

$$\Delta y_{it} = \lambda_i \left(y_{it-1} - \theta_i^{'} X_{it} \right) + \sum_{j=1}^{m-1} \phi_{0ij} \Delta y_{it-j} + \sum_{j=0}^{n-1} \phi_{ij}^{'} \Delta X_{it-j} + \alpha_i + \mu_{it} \tag{7}$$

Applying this panel ARDL error-correction model in assessing the impact of real exchange rate on the trade balance, the empirical model is re-stated as:

$$\begin{aligned} \Delta \ln TB_{it} &= \alpha_i + \lambda_i \left(\ln TB_{it-1} - \theta_{1i} \ln Y_{it} - \theta_{2i} \ln YF_{it} - \theta_{3i} POS_{ti} - \theta_{4i} NEG_{it} \right) + \gamma_i D_{it} \\ &+ \sum_{j=1}^{m-1} \phi_{0ij} \Delta \ln TB_{it-j} + \sum_{j=0}^{n-1} \phi_{1ij} \Delta \ln Y_{it-j} + \sum_{j=0}^{p-1} \phi_{2ij} \Delta \ln YF_{it-j} + \sum_{j=0}^{q-1} \left(\phi_{3ij} \Delta POS_{it-j} + \phi_{4ij} \Delta NEG_{it-j} \right) + \mu_{it} \end{aligned} \tag{8}$$

where φ_0, φ_1, φ_2, φ_3 and φ_4 are the short-run coefficients of the lagged dependent variable, domestic income, foreign income and positive and negative changes in real exchange rate, respectively. The long-run coefficients are θ_1, θ_2, θ_3 and θ_4 for domestic income, foreign income and positive and negative changes in real exchange rate. Lastly, the parameter λ_i measures the speed of adjustment of the trade balance to its long-run value.

This study employs the Mean Group (MG) and the Pooled Mean Group (PMG) estimators introduced by Pesaran and Smith (1995) and Pesaran *et al*. (1999). The MG estimator allows all parameters of the model to change across countries in the short and long-run. It estimates the model for each country and computes the coefficients for the whole panel as simple averages of the individual coefficients. On the other hand, the PMG estimator constrains the long-run coefficients to be homogeneous, while allowing the short-run coefficients, the speed of adjustment, and the error variance to vary across countries. According to Pesaran *et al*. (1999), under the null hypothesis of long-run homogeneity, the PMG estimator is consistent and more efficient as compared to the MG estimator. The Hausman test was used to test whether there is a significant difference between PMG and MG estimates.

The panel nonlinear ARDL error-correction model allows us to test the existence of asymmetry in the relationship between real exchange rate and trade balance. In particular, the long-run symmetry can be tested by means of Wald test of the null hypothesis that $\theta_{3i}= \theta_{4i}$ in Eq. (8). The short-run symmetry can equally be tested by using a Wald test of the null hypothesis that $\varphi_{3ij} = \varphi_{4ij}$, for all *j*. Eq. (8) is reduced to the traditional panel linear ARDL error-correction model if both null hypotheses of short-run and long-run symmetry cannot be rejected.

3.3. Data Description

The study uses annual time series data covering the period 1975-2017. The analysis includes seven member countries of the West African Economic and Monetary Union (WAEMU), namely: Benin, Burkina Faso, Cote d'Ivoire, Mali, Niger, Senegal, and Togo. The dependent variable of the study is trade balance defined as exports divided by imports. An increase in this ratio reflects an improvement in the trade balance. The explanatory variables are domestic real GDP in constant US dollar as a proxy for domestic income, world real GDP in constant US dollar as a proxy for foreign income, and the real effective exchange rate. All variables were transformed into natural logarithm in the empirical analysis. Data on the trade balance, domestic real GDP, and world real GDP were extracted from the 2019 World Development Indicators database of the World Bank. Data on the real effective exchange rate (RER) were retrieved from the Central Bank of West African States (BCEAO). The real effective exchange rate is such that an increase (decrease) signifies a real appreciation (depreciation) of the domestic currency. We decompose the real effective exchange rate into positive (POS) and negative (NEG) changes using Eq.(3) and Eq.(4). Positive and negative changes cover 48.3% and 51.7% of the sample, respectively.

Table 1 displays the descriptive statistics and correlation matrix among the variables. This Table shows a wide disparity among countries. For instance, domestic income averages 22.467 and ranges between 21.107 and 24.399. Over the sample period, real exchange rate appreciation averages 34.9% while depreciation averages 70.7%. Based on the standard deviation, domestic income is more volatile than the other variables under study.

The correlation matrix shows that the trade balance is positively and significantly associated with domestic income, foreign income and positive changes in real exchange rate (POS), while negatively correlated with negative changes (NEG). The correlation matrix also shows a high level of correlation between foreign income (YF) and real exchange rate changes (POS and NEG) with correlation values of 0.836 and -0.940, respectively. For this reason, we disregard foreign income from the empirical analysis.

Table 1. Descriptive Statistics and Correlation Matrix

Variables	lnTB	lnY	lnYF	POS	NEG
Panel A: Summary statistics					
Mean	4.205	22.467	31.415	0.349	-0.707
Median	4.227	22.351	31.406	0.336	-0.894
Maximum	4.986	24.399	32.015	0.967	0.000
Minimum	3.193	21.107	30.772	0.000	-1.402
Std. dev.	0.352	0.792	0.363	0.234	0.412
Panel B: Correlation matrix					
lnTB	1.000				
lnY	0.515*	1.000			
lnYF	0.155*	0.512*	1.000		
POS	0.419*	0.642*	0.836*	1.000	
NEG	-0.090	-0.422*	-0.940*	-0.744*	1.000

Note: TB, Y, YF, POS and NEG denote trade balance, real GDP, world real GDP, positive and negative partial sums of real effective exchange rate, respectively. (*) indicates statistical significance at the 5% level.

4. Results and Discussion

Prior to estimating the effect of real exchange rate on the trade balance, we test for the order of integration of the variables. To this end, we employ the IPS test developed by Im *et al*. (2003) and the ADF-Fisher test suggested by Maddala and Wu (1999). The results presented in Table 2 suggest the presence of unit root for all variables at the 5 percent level of significance. However, when applied to the first differences of the variables, both IPS and ADF-Fisher tests reject the null hypothesis of unit root. Therefore, the variables under study can be regarded as being integrated of order one. Consequently, it is necessary to perform cointegration tests among them to check for the possible existence of a long-run relationship.

Table 2. Results of Panel Unit Root Tests

	Level		**First difference**	
	IPS test	**ADF test**	**IPS test**	**ADF test**
lnTB	-0.834 [0.201]	24.386 [0.041]	-13.364* [0.000]	161.200* [0.000]
lnY	8.451 [1.000]	0.111 [1.000]	-12.328* [0.000]	148.615* [0.000]
POS	1.120 [0.868]	8.641 [0.853]	-11.182* [0.000]	137.782* [0.000]
NEG	0.503 [0.692]	7.668 [0.905]	-13.913* [0.000]	169.632* [0.000]

Notes: TB, Y, and RER, denote trade balance, domestic real GDP, and real effective exchange rate, respectively. The tests equations include individual effects and *p-values* are given in brackets. Optimal lag length was determined using AIC with a maximum of 5. The asterisk * denotes rejection of the null hypothesis of unit root at the 5% significant level.

As the second step of the empirical analysis, we employ Pedroni (1999) residual-based test for cointegration. The results summarised in Table 3 show that six of the seven test statistics support the existence of a long-run relationship among the variables at the 5 percent level of significance.

Table 3. Results of Pedroni Panel Cointegration Tests

Statistics	Without trend		With trend	
	Statistic	Prob.	Statistic	Prob.
Within-dimension				
Panel v-Statistic	0.151	0.439	-1.039	0.850
Panel rho-Statistic	-2.912*	0.001	-2.262*	0.011
Panel PP-Statistic	-4.576*	0.000	-5.816*	0.000
Panel ADF-Statistic	-3.502*	0.002	-5.362*	0.000
Between dimension				
Group rho-Statistic	-2.419*	0.007	-1.171	0.120
Group PP-Statistic	-5.718*	0.000	-6.699*	0.000
Group ADF-Statistic	-3.949*	0.000	-5.121*	0.000

Note: The lag orders are chosen by Akaike information criterion with a maximum set to five. The asterisks * and ** denote significance at the 5% and 10% levels, respectively.

To affirm further about the existence of a long-run relationship among the variables, Johansen and Juselius (1990) cointegration test was conducted. As shown in Table 4, both Trace and Max-Eigen statistics identify one cointegrating vector in the whole panel. Therefore, the overall results of cointegration tests conclude that there is a long-run relationship between trade balance, domestic income and real exchange rate.

Table 4. Johansen Cointegration Test Results

Hypothesis	Trace test		Max-Eigen test	
	Fisher stat.	Prob.	Fisher stat.	Prob.
r=0	55.89*	0.000	64.82*	0.000
r=1	11.78	0.624	9.799	0.776
r=2	7.489	0.914	6.409	0.955
r=3	6.849	0.940	6.849	0.940

Note: * denotes rejection of the null hypothesis at the 5% significance level. The model includes a time trend variable.

The next step of our analysis is to estimate the long and short-run coefficients associated to explanatory variables. As previously stated, the panel ARDL model was estimated using the Pooled Mean Group (PMG) and the Mean Group (MG) estimators. The results are summarized in Table 5. As the PMG estimator is only consistent and efficient when the long-run coefficients are the same across countries (long-run homogeneity), we test this restriction using the Hausman test. The results reported in Panel B of Table 5 indicate that the null hypothesis of homogeneity restriction cannot be rejected ($\chi^2(3)$=1.930 with *p-value*=0.586). Thus, the PMG estimator is more efficient and preferable to the MG estimator. In what follows we therefore focus on the PMG results.

The results reveal that in the long-run, positive and negative changes in the real exchange rate have significant negative impacts on the trade balance. The long-run coefficient on NEG is -1.118, implying that a 1% decrease in the real exchange rate results in a 1.118% increase in the trade balance. The long-run effect of positive changes is -0.489, implying that a 1% increase in the real exchange rate leads to a 0.489% decrease in the trade balance. The test for symmetry reports F-statistic of 18.752 with a *p-value* of 0.000, indicating the rejection of the null hypothesis of symmetric long-run effect of the real exchange rate on the trade balance. Consequently, these findings suggest that the trade balance responds stronger to depreciations in the real exchange rate than to appreciations. This finding confirms those of Bahmani-Oskooee and Fariditavana (2016) and Iyke and Ho (2017) who found that real appreciations and depreciations have distinct impacts on the trade balance. Further, the coefficient on domestic income is negative and significant, indicating that increases in domestic income will worsen the trade balance in the long-run.

In terms of the short-run dynamics, the results reported in panel C of Table 5 show that domestic income and real exchange rate do not have significant impact on the trade balance. This finding is not consistent with the J-curve relationship between the trade balance and the real exchange rate. The error-correction coefficient which represents the speed of convergence is negative and significant, providing additional evidence of a long-run relationship between the variables.

Table 6 shows the short-run results for individual country estimation based on the PMG estimator. From this Table, it can be noted that a significant long-run relationship exists between the variables for five out of the seven countries as evidenced by negative and significant error-correction terms. The effects of domestic income and real exchange rate on the trade balance yield mixed results. Domestic income has a negative effect on the trade balance in Burkina Faso and Cote d'Ivoire. This finding may be attributed to the fact that these countries have propensity for imported goods and services whenever their incomes increase, as argued by the Keynesian theory. Conversely, domestic income has a positive effect on the trade balance in Senegal. A one percent increase in gross domestic product is associated with 0.84 percent increase in the trade balance. Based on these findings, Senegal needs to stimulate its economic growth to improve its trade balance whereas Burkina Faso and Cote d'Ivoire should reduce their imports.

Table 5. Estimation Results from PMG and MG Estimators

Variables	PMG			MG		
	Coef.	**t-stat.**	**Prob.**	**Coef.**	**t-stat.**	**Prob.**
Panel A: Long-run Coefficients						
lnY	-0.400*	-4.933	0.000	-0.508*	-3.574	0.000
POS	-0.489*	-2.510	0.012	2.614	0.927	0.354
NEG	-1.118*	-6.261	0.000	-0.227	-0.308	0.758
Panel B: Diagnostic Tests						
Hausman Test	1.930 [0.586]					
Test for Long-run Symmetry	18.752* [0.000]					
Panel C: Short-run Coefficients						
ECT_{t-1}	-0.414*	-3.390	0.000	-0.727*	-4.095	0.000
ΔTB_{t-1}	-0.051	-0.552	0.581	0.110	1.015	0.310
ΔTB_{t-2}	-0.025	-0.223	0.823	0.048	0.414	0.679
ΔlnY_t	-0.207	-0.531	0.595	-0.057	-0.142	0.886
ΔPOS_t	0.004	0.008	0.993	0.116	0.205	0.837
ΔNEG_t	0.008	0.061	0.951	-0.076	-0.402	0.687
D94	-0.116*	-2.208	0.028	-0.136	-2.867	0.004
Intercept	5.368*	3.396	0.000	9.224*	5.521	0.000

Note: The dependent variable is the trade balance (TB) defined as log(100*X/M), where X and M denote exports and imports, respectively. Y is domestic real GDP, POS and NEG denote positive and negative partial sums of real effective exchange rate, respectively. The lag structure is ARDL(3,1,1,1) based on AIC selection with maximum lag set to 3. The model includes a dummy variable D94 taking value 1 from 1994 to 2017 and zero otherwise. The asterisks * and ** indicate significance at 5% and 10% levels, respectively. Under the long-run slope homogeneity, the Hausman test reports the chi2 test statistic and the corresponding *p-value* for systematic differences in coefficients of the PMG estimator vs. the MG estimator.

With regard to the real exchange rate, the coefficient on NEG is negative and significant in Senegal. This implies that a real depreciation of the real effective exchange rate will improve the Senegal's trade balance. Meanwhile, the coefficient on NEG is positive in the case of Mali, implying that a real depreciation of the real effective exchange rate will deteriorate its trade balance. The coefficient on POS is negative in Burkina Faso and positive in Niger. Therefore, appreciation of the real exchange rate will improve the trade balance of Niger while deteriorating that of Burkina Faso.

Table 6. Country-level short run results from PMG estimator

Country	ECT_{t-1}	ΔlnY_t	ΔPOS_t	ΔNEG_t	D94	Intercept
Benin	-0.855* (-4.906)	0.552 (0.919)	0.337 (0.394)	0.118 (0.345)	0.004 (0.065)	10.484* (4.246)
Burkina Faso	0.058 (1.005)	-2.320* (-3.426)	-1.802** (-1.785)	-0.246 (-0.828)	0.045 (1.179)	-0.554 (-0.797)
Cote d'Ivoire	-0.778* (-5.451)	-0.489** (-1.762)	-0.158 (-0.391)	0.044 (0.246)	-0.211* (-3.149)	10.918* (4.566)
Mali	-0.482* (-4.197)	-0.213 (-0.612)	-0.776 (-0.973)	0.519** (1.907)	-0.052 (-0.914)	5.955* (3.956)
Niger	-0.387* (-3.097)	-0.029 (-0.077)	1.928* (2.036)	0.346 (1.006)	-0.364* (-3.598)	4.991* (2.883)
Senegal	-0.244* (-2.767)	0.840* (2.263)	0.602 (1.297)	-0.520* (-2.957)	-0.122* (-2.657)	3.141* (2.413)
Togo	-0.209 (-1.428)	0.206 (0.501)	-0.104 (-0.139)	-0.203 (-0.564)	-0.109 (-1.192)	2.642 (1.408)

Note: The dependent variable is ΔTB=Δlog(X)-Δlog(/M), where X and M are exports and imports, respectively. Y is domestic real GDP, POS and NEG denote positive and negative partial sums of real effective exchange rate, respectively. The lag structure is ARDL(3,1,1,1) based on AIC selection with maximum lag set to 3. The model includes a dummy variable (D94) taking value 1 from 1994 to 2017 and zero otherwise. The asterisks * and ** indicate significance at 5% and 10% levels, respectively.

5. Conclusion

This study was motivated by the mixed evidence from the existing empirical literature on the relationship between real exchange rate and trade balance. The relationship was found to be positive in some studies and non-significant or even negative in others. The mixed results may be attributed to country-specific characteristics, dataset, estimation techniques and the restrictive assumption that the nexus between the two variables is linear. It is on this background that this study applies the nonlinear ARDL model developed by Shin *et al.* (2014) to examine the asymmetric impact of real exchange rate on the trade balance in a panel comprising seven countries of the West African Economic and Monetary Union (WAEMU) over the period 1975-2017. The trade balance was defined as the ratio of exports to imports. The control variables were the real effective exchange rate and real gross domestic product as measure for domestic income. By relying on the concept of partial sum, we decomposed the real effective exchange rate into positive and negative changes and estimated their respective effects on the trade balance. As estimation technique, we employed the Pooled Mean Group (PMG) estimator to derive the long and short-run responses of the trade balance to the real exchange rate changes. This panel estimation method deals with both endogeneity and cross-country heterogeneity. The results from the Hausman test showed that PMG estimator was preferred over the Mean Group estimator.

The results from cointegration tests revealed that there is a long-run relationship between exchange rate, domestic income and trade balance. It was found that domestic income has a significant negative effect on the trade balance in the long-run. The results confirmed that the impact of the real exchange rate changes on the trade balance is asymmetric in the long-run. More specifically, real depreciations of the exchange rate significantly improve the trade balance, while real appreciations have significant worsening impacts. Such findings are consistent with the Marshall-Lerner condition. In the short-run, however, real exchange rate does not significantly impact on the trade balance, regardless of whether the exchange rate appreciates or depreciates.

The results for individual country estimation showed cross-country heterogeneity in the short- run relationship between real exchange rate and trade balance. It was found that the real exchange rate depreciation will significantly improve the Senegal's trade balance while worsening that of Mali. The results also revealed a negative relationship between the trade balance and domestic income in Burkina Faso and Cote d'Ivoire while a positive relation was found in the case of Senegal.

The findings of this study imply that real exchange rate can be used as a tool for correcting trade deficits in WAEMU area. However, as economic growth hurts the trade balance, policy efforts should be made towards import substitution strategies in order to reduce the demand for imports. To achieve this, WAEMU countries should create environment encouraging foreign direct investment. In many countries, the sectoral allocation of foreign direct investment inflows is predominated by services that are relatively less exportable while requiring import inputs to be produced. While attracting foreign direct investment, WAEMU countries should focus on FDI in sectors with better export performance and low import content.

This study is not free of shortcomings. First, we used the aggregate trade balance between WAEMU countries with the rest of the world. As each trade partner (France, UK, USA, China, Japan, etc.) of WAEMU countries has its nominal exchange rate, the impact of the exchange rate on the trade balance may vary across trade partners. The exchange rate depreciation may improve the trade balance with some countries, but at the same time, it may worsen the trade balance with others. Using aggregated trade data, the results may suffer from aggregation bias. Second, the nonlinear approach developed by Shin *et al.* (2014) used in this paper filters appreciations from depreciations. Such a decomposition implies a zero threshold model depending only on the direction of the real exchange rate growth (positive or negative). This approach could be improved by using threshold nonlinear ARDL model in which the real effective exchange rate is decomposed into large depreciations, large appreciations and small changes, depending upon the sign and size of real exchange rate growth. We intend to investigate these lines of research in future works.

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