ASYMMETRIC EFFECT OF REAL EFFECTIVE EXCHANGE RATE AND TRADE BALANCE ADJUSTMENT: THE CASE OF RWANDA

Emmanuel Bahati Ngarambe[3]
Wilberforce Nuwagira[4]
Wilson Kamali[5]

[3] Senior Statistician, Statistics Department, National Bank of Rwanda

[4] Senior Principal Economist, Research Department, National Bank of Rwanda

[5] Director, Statistics Department , National Bank of Rwanda

ABSTRACT

This paper investigates the empirical evidence of the impact of exchange rates on the trade balance in Rwanda. A novel feature of the study is the focus on examining whether the relationship between real exchange rate and trade balance is symmetric or asymmetric by comparing results from linear and nonlinear Autoregressive Distributed Lag (ARDL) models respectively. The non-linear ARDL approach to cointegration and the associated error correction methodologies examines whether Rwandan francs appreciations affect trade differently than does Rwandan francs depreciations. We use quarterly data spanning the period 2000Q1 to 2020Q4. Results from the linear model reveal that the real exchange rate does not affect trade balance in the short-run whereas it improves trade balance in the long run, partially confirming the J-curve phenomenon. The empirical findings from the non-linear model revealed that depreciations improve the trade balance in the long run whereas appreciations have no impact. The Wald test results indicate the existence of significant long-run asymmetric effects of REER on the trade balance, while short-run asymmetry was not supported. In light of the results obtained, policymakers should be aware of the consequences of asymmetric impacts of Rwandan francs' appreciation and depreciation in the development of trade policies so that international competitiveness is not adversely affected.

Keywords: Real effective exchange rate, Trade balance adjustments, Asymmetry.

JEL classification: F31, F32

1. INTRODUCTION

The importance of real effective exchange rate (REER) in correcting trade imbalance has been studied extensively. Theoretically, to improve the country's trade balance, two approaches are at the disposal of policymakers to change the country's competitiveness. The internal approach relies on supply-side policies, such as influencing labor productivity or wages by curbing inflation, decreasing taxes, or relaxing rigid labor market conditions. Alternatively, the external approach consists of devaluing/depreciating the currency (Stucka, 2004). The external approach stipulates that a devaluation or depreciation of a currency pushes domestic prices of goods down, increases exports and reduces imports, and eventually improves the country's trade balance. However, the response of an economy's trade balance to currency depreciation is believed to follow a J-curve, i.e. a depreciation of the domestic currency initially worsens the trade balance because of adjustment lags such as recognition lags, production lags, delivery lags, etc., but ultimately the trade balance improves as demand and supply adjust (Bleaney and Tian, 2014).

Several empirical studies analyzed the relationship between REER and trade balance adjustment and revealed mixed results. A strand of studies identified a stable link between REER and trade balance. The empirical model of Bahmani-Oskoee (1985) suggested that following a currency depreciation the trade balance deteriorates due to lag structure on exchange rates and then improves it in the long run. In analyzing this behavior, Schaling and Kabundi (2014) revealed that real depreciation enhances the South Africa–US trade balance in the long run, hence supporting a J-curve phenomenon. Another strand of researchers has shown that the response of trade flows to REER depends on the level of disaggregation of the trade data. Studies in this group argue that aggregated flows suffer from aggregation bias in that one industry may react favorably to depreciation than another industry, hence, advocated the J-curve test at the industry level (Bahmani-Oskooe and Gelan, 2019 ; Chiloane et al., 2014; Yazici & Klasra, 2010 ; Durmaz, 2015) . These studies are based on the assumption that the real exchange rates impact trade balance linearly. However, recent studies have shown that exchange rates have asymmetric effects on exports and imports and hence on trade balance (Bahmani-Oskooee & Fariditavana, 2015, 2016). They argue that the reactions of traders (i.e exporters and importers) to currency appreciation and depreciation are different. Arize et al. (2017) argue that during currency appreciation if traders do not exit their market, the rate at which their export receipts decline is different from the rate at which these receipts increase when the currency depreciates. Furthermore, Bussiere (2013) evidenced that the response of prices of traded goods to exchange rate is asymmetric, and ultimately trade balance follows suit.

Rwanda has recorded a sizeable and persistent current account deficit over the period under study largely driven by the merchandise trade deficit. This trade deficit in goods is a result of higher imports compared to stagnant and less diversified exports. However, despite this persistent trade deficit the size of Rwanda's trade elasticities has not been studied extensively. Nuwagira and Muvunyi (2016) examined the presence of the Marshall-Lerner condition i.e. the requirements for depreciation to improve the trade balance and found that the condition does not hold for Rwanda using quarterly data spanning the period 2000 to 2015. The regression results of their export models found that the improvement of Rwanda's trade balance is determined by external demand and less by the fluctuation of REER. Similarly, Muvunyi et al. (2019) examined trade elasticities of exports and imports separately and showed that that income is a more important determinant of trade flows than the REER.

The main purpose of this study is to contribute to the broader debate on the role of the exchange rate in restoring external balance and empirically examine the drivers of trade balance adjustment in Rwanda. Rwanda was chosen for two reasons. First, there is a limited number of empirical studies that assessed the relationship between exchange rate and trade balance in Rwanda. Apart from the two studies reviewed previously, that examined the impact of exchange rate on exports and imports separately, to the best of our knowledge no study on the real exchange rate and trade balance relationship has been conducted. Second, previous studies on Rwanda's trade elasticities used linear models, which assumed the asymmetric effect of real exchange rate on trade flows. In this study, we extend the analysis on Rwanda' trade balance adjustment by re-visiting this linear specification using recent data by employing the ARDL model developed by Pesaran et al. (2001) and introduce the non-linear ARDL model developed by Shin et al. (2014) to examine the asymmetric effects of exchange rates changes.

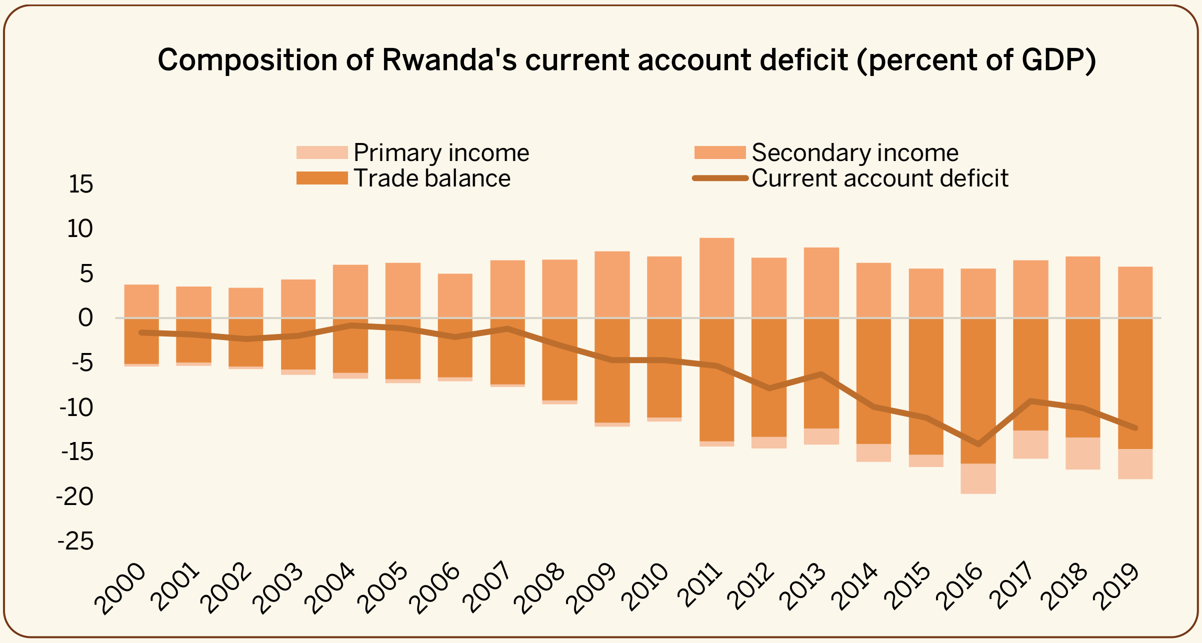
The rest of the paper is organized as follows. Section 2 describes the developments in trade balance and real effective exchange rates. In section 3, we provide brief theoretical and empirical reviews. Section 4 explains the models and econometric methodology discusses data source and definition. Section 5reports empirical results and Section 6 concludes.

2. STYLIZED FACTS OF RWANDA'S REAL EFFECTIVE EXCHANGE RATE AND TRADE BALANCE

In this section, we describe the development of Rwanda's trade deficit and real effective exchange rates. The real effective exchange rate is calculated for Rwanda's ten trading countries based on the consumer price index (CPI). An increase in the exchange rate denotes depreciation and vice versa.

Over the last two decades, Rwanda has been running a persistent current account deficit mainly driven by the trade deficit, which outstrips massive inflows from official and private transfers. The growing trade deficit has been driven by stagnant and less diversified exports coupled with strong imports necessary to satisfy the domestic demand for consumption and investment. However, in recent years, Rwanda has put in place various policies aimed at diversifying its exports base, notably value addition for its traditional commodities, improving Rwanda's manufacturing base supported by the "Made in Rwanda" program and investments in key services like tourism and travel as well as passenger transports.

Figure 1: Composition of Rwanda's current account deficit (percent of GDP)



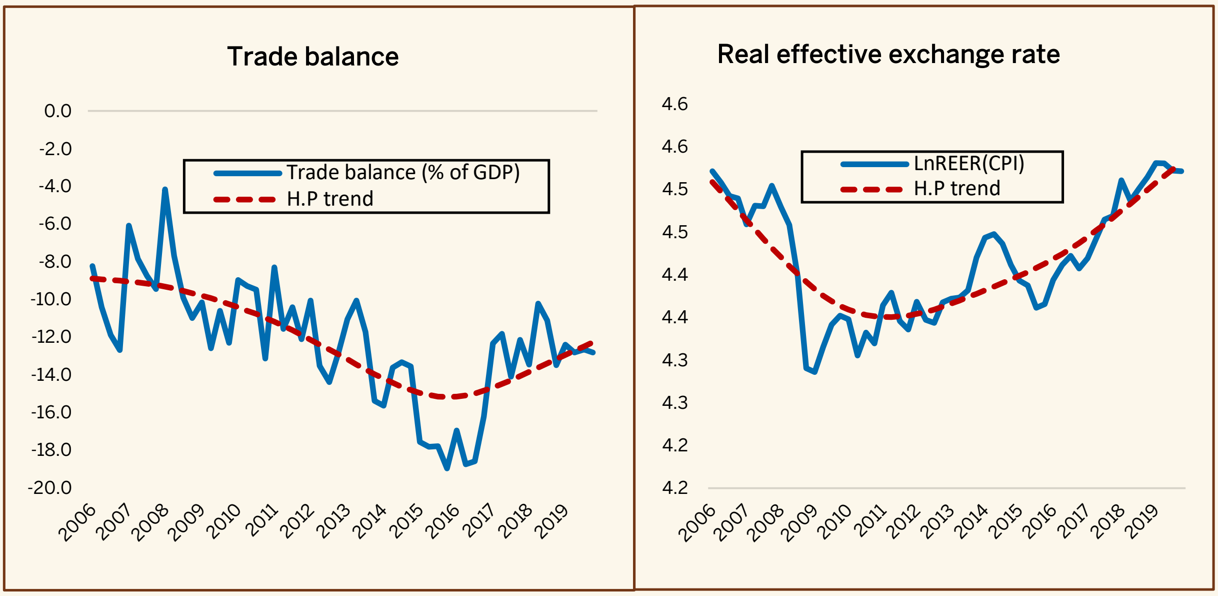
Source: Authors' calculation

Over the period under review, exports represent 14.8 percent of GDP on average, nearly a half of imports share to GDP (27 percent). Rwanda's trade deficit continued to widen, reaching its peak in the last quarter of 2015, about19 percent of GDP due to decreased exports on account of the decline in international commodity prices. However, since 2017, the trade deficit has started to improve mainly supported by improving commodity prices and higher receipts from service exports, albeit continued higher imports, reflecting government efforts to diversify its exports base by reducing its overreliance on traditional commodity exports mainly composed of coffee, tea, and minerals, which are vulnerable to fluctuations in international prices. Receipts from travel and tourism have grown significantly averaging 4.2 percent of GDP over 2016-2019. Rwanda's travel and tourism revenues, which account for nearly half of all service exports, surpassing revenues collected from traditional exports to become the country's top foreign exchange earner. The government of Rwanda in partnership with the private sector has been working on diversifying tourism attractions and products to boost revenues from the sector. Traditionally, Rwanda's tourism revenues have been looked at through visiting gorillas, Nyungwe, and Akagera national parks. In 2014, the government launched a tourism product 'MICE: Meetings, Incentives, Conferences and Exhibitions' to diversify the sector. Following higher investment in the sector through the construction of hotels, the country's efforts are paying off. The International Congress and Convention Association (ICCA) ranked Rwanda as Africa's number three tourism destination for meetings, incentives, conferences, and exhibitions. As a result, over the last decade, revenue generated by MICE grew by 180 percent, and the number of delegates visiting Rwanda for such events jumped from 15,000 to 28,300. Similarly, revenues from air transports have grown considerably following government investment in the national airline operator (i.e. Rwandair).

The real effective exchange rates have been appreciating over the period 2006-2010 before relinquishing most of these gains through 2019 (Figure 1, left panel). During the appreciation phase in line with theory, the trade deficit widened, averaging 9.7 percent of GDP (Figure 1, left panel). However, the trade deficit hardly reversed despite a depreciation of the REER in the second phase. This could be explained by the structure of the country's trade flows. First, despite a significant decline in the share of traditional exports to total exports, from 90 percent in 2006, they still represent a significant share to total exports, 30 percent in 2019. Prices of these traditional raw commodities are internationally determined and, hence, are less sensitive to the changes in REER. On the other hand, Rwanda's imports are highly dominated by investment goods and intermediary goods, where the latter category comprises imports used as inputs to manufacture exports. Kharroubi (2011) argued that when a country is vertically specialized its exports depend much on imports volume since some exporters use these imports as inputs to produce exports, resulting in a co-movement between exports and imports. Therefore, a tighter co-movement between imports and exports decreases the response of the trade balance to a change in the real exchange rate[6].

[6] We found a strong correlation between imports of intermediary goods and non-traditional exports of 0.89.

Figure 2: Trade balance and real effective exchange rate



Source: Authors' calculation

3. LITERATURE REVIEW

3.1. Theoretical literature

Theoretically, the link between the real exchange rate and trade balance is analyzed via three theories. The first aspect of this literature examining the relationship between real exchange rate and trade balance dates back to Bickerdike (1920), Robinson (1947), and Metzler (1948) which has come to be the sources of what is commonly known as Bickerdike-Robinson-Metzler (BRM) condition or elasticity approach to the balance of payments. This condition relates the response of the trade balance to exchange rate changes and the domestic and foreign price elasticities of imports and exports. The approach was further extended into the Marshall-Lerner condition (Marshall, 1923; Lerner, 1944), referred to ML henceforth, which states that a currency devaluation (or real depreciation) will lead to an improvement in the trade balance if the sum of the elasticities (in absolute values) of the demand for imports and exports with respect of the real exchange rate exceeds a unit. If this condition is satisfied, then the real devaluation of a currency can lead to an improvement in the current account. The ML condition is analyzed using two methods. The elasticities method involves directly estimating the import and export demand price elasticities while the indirect method entails estimating the dynamic reaction of the trade balance to a real domestic depreciation. The indirect method is generally referred to as the J-curve phenomenon, which explains how a devaluation of a country's exchange rate affects its trade balance over time.

Generally, since the short-run elasticities are thought to be low, the trade balance initially worsens before eventually improving, thus tracing the shape of a J. In the short-run, following a currency devaluation domestic importers face inflated import prices as paid in domestic currency, leading to a decrease in net exports. In addition, as the demand for exports and imports is fairly inelastic in the short-run due to sluggishness in the change of consumer's behavior and the lag of changing old contracts, domestic exporters in the country devalue their currency in the face of lower exports prices. The trade balance worsens by the value of total imports in foreign currency multiplied by the magnitude of the rise in the price of foreign currency since contracts made before the depreciation force fixed prices and volumes. The short-run period is commonly known as the "exchange rate pass-through period". In the long run, as domestic demand starts to shift from foreign to domestic production of substitution goods as a reaction to the higher prices of imports, the trade balance improves. Furthermore, the markets in the home country experience an increase in export volume due to the decrease in export prices. The period of these two long-run factors is commonly known as the "volume adjustment period" and they have a favorable impact on the trade balance.

The second theoretical postulation is the monetary approach to the balance of payments, which focuses on the effect of monetary variables on the balance of payments. This theoretical approach contends that the balance of payments disequilibrium represents an imbalance between the supply and demand for money, suggesting that excess money supply encourages imports, resulting in the trade deficit and outflow of foreign exchange reserves (Carbaugh, 2004).

The literature on the theoretical foundations of this approach originates from the work of Mundell (1968), Dornbusch (1971), and Frankel (1971). This theoretical approach is strongly supported by the empirical literature (Jimoh, 2004; Dausa, 2005).

The third is the Keynesian Absorption Approach, which was first modeled by Meade (1951) and Alexander (1952). This approach is the combination of Keynesian macroeconomics and the elasticities approach. It conjectures that there will be an improvement in the trade account if domestic absorption is less than domestic output growth (Dunn and Mutti, 2000). In other words, if the domestic expenditure on consumption and investment is greater than the national income, the trade balance worsens.

In conclusion, the theoretical postulations are dependent on the assumptions about the types of trade, the presence of adjustment costs, market structure, and the presence of hedging opportunities. In this case, the link between the real exchange rate and trade balance remains analytically inconclusive, thus this relationship becomes an empirical issue.

3.2. Empirical literature

On the empirical front, several studies have investigated the role of real exchange in improving trade balance. Guechari (2012) examined the effects of REER on Algeria's trade balance and revealed a significant positive impact of the real effective exchange rate on Algeria's bilateral trade balance with the US and France, and on Algeria's total trade balance in long-run, and a significant negative impact on trade balance for all cases in the short-run. The study found that the real effective exchange rate helps in predicting the trade balance and the real depreciation has a long-run positive impact on the total trade balance of Algeria.

Lossifov and Fei (2019) assessed the role of exchange rates in restoring external balance in Turkey in the-post-2008 period. Their study found that the REER has been an important determinant of real trade flows but the effect is not symmetric. During the period of REER appreciation through 2008Q3, the transmission channel operated mainly through increasing imports from Turkey's higher purchasing power in terms of foreign goods baskets. In the period of REER depreciation, the transmission channel has operated through both export promotion and import compression through their price elasticities, as the REER depreciation appears to have overshot the slightly negative total factor productivity growth in the post-2006 period.

Begovic and Kreso (2017) investigated the adverse effect of real effective exchange rates on the trade balance in European transition countries. Their study found that the depreciation of REER deteriorates the trade balance in European transition countries, which could be explained by high import dependence and low export capacity and competitiveness of transition countries, and by the fast transmission of higher import prices into domestic prices. Findings in this paper imply that policymakers in European transition countries should not use exchange rate policy to improve the trade balance.

Individual country studies have also shown that results can be different depending on the level of aggregation of trade flows. Ziramba and Chifamba (2014) used aggregated trade flows for South Africa and found no significant effect of a rand depreciation on South Africa's aggregate trade balance. In the same country, using data on the South African manufacturing sector, Chiloane et al. (2014) found that rand depreciation has favorable effects on the sector's trade balance. Similarly, Yazici and Klasra (2010) investigated the response of two sectors of the Turkish economy, i.e., manufacturing and mining, and found an inverse of the J-curve pattern in both sectors. Durmaz (2015) investigated the response of REER to 58 Turkish industries that trade with the rest of the world and found support for short-run deterioration combined with long-run improvement of the trade balance in 11 industries. Bahmani-Oskooee and Kovyryalova (2008) using cointegration and error correction techniques for the period 1971 to 2003 analyzed the impact of the real exchange rate volatility on international trade, considering 177 commodities traded between the United States (US) and the United Kingdom (UK). Their results show the volatility of the real bilateral dollar-pound rates has a short-run significant effect on imports of 109 and exports of 99 industries. In the long run, the study revealed that the number of significant cases is reduced, with imports of 62 and exports of 86 industries.

Zakaria (2013) examined the link between exchange rate and trade using regression analysis of standard export demand models as well as the GARCH (1,1) model spanning the period 2000M1-2012M8. The results indicated that Malaysian exports to the US and Japan are significantly linked to exchange rate volatility. In a study of the exchange rate volatility and exports using Johansen's cointegration framework, Mordecki and Miranda (2018) found that commodity exports do not only depend on the global demand and prices but also the variability in the real exchange rates.

The studies reviewed above rely on the assumption that the relationship between real exchange rate and trade balance is linear. However, a strand of recent studies has analyzed and demonstrated a non-linear relationship between these variables, which implies that the linear approach used by the previous studies may be inappropriate. These studies argue that the trade balance may respond differently to real appreciations and depreciations. Hence, if appreciations are filtered from depreciation, the support for the J-curve may become clearer. In analyzing the existence of the J-curve phenomenon in the U.S and her six major trading partners, Bahmani-Oskooee and Fariditavana (2016) find nonlinear specifications of the trade balance model to be more supportive of the J-curve than the linear specifications.

Mahmood et al. (2017) explored the impact of devaluation and appreciation on Saudi Arabian services sector trade. Their study found short-term and long-term asymmetric effects in all sectors. Overall devaluation confirms the existence of J-curve after some lag. This study also found that appreciation of a Saudi currency has adverse effects on the trade balance in all services sectors except travel, construction, and tourism. They also showed that the increase in world income enhances exports of Saudi Arabia, while the rise in Saudi Arabia's incomes had negative effects on the trade balance of all services sectors except travel and tourism.

Bahmani-Oskooee and Gelan (2019), using data for 23 industries in South Africa, analyzed symmetric effects of rand using the linear ARDL approach of Pesaran et al. (2001) and the nonlinear ARDL approach Shin et al. (2014) to assess asymmetric effects of exchange rate changes. The results from the linear models yielded significant short-run effects of the real rand-dollar rate on the trade balance of all the industries. In the long run, only seven industries had lasting short-term and favorable effects. On the other hand, the results from nonlinear models found that rand depreciation or appreciation had significant asymmetric short-run effects in 18 industries. The important policy implication that emerged out of the study is that the exchange rate policy that fosters either rand depreciation or appreciation benefits some industries and/or worsen others, vice versa. The study recommended mixing up the monetary policy with other commercial policies such as trade negotiations, subsidies, and tariffs to promote South African trade. Similarly, Bahmani-Oskooee and Durmaz (2016) tested the effects of exchange rate changes on the trade balance of 57 industries that trade between Turkey and the EU using the nonlinear approach. The results from their study found short-run asymmetry effects in all industries, short-run adjustment asymmetry in 24 industries, short-run impact asymmetry in 17 industries, and long-run asymmetry effects in 23 industries.

Iyke and Ho (2017) examined the effects of real exchange rate changes on the trade balance of Ghana during the period 1986Q1 to 2016Q3 using both the linear and nonlinear specifications. The study results of their linear specification found no support of the short- and long-run impact of exchange rate changes on the trade. In contrast, in the nonlinear specification, exchange rate changes affected the trade balance. They found that while depreciations have short-run and long-run effects on the trade balance, appreciations have no impact. In the short run, real depreciation appears to harm the trade balance at lags zero and one, while in the long run, the impact is reversed, hence, supporting the J-curve phenomenon.

Given the limited number of studies in the Rwandan context and taking into account the notion that the relationship between trade balance and the real effective exchange rate could be nonlinear, we investigated the relationship between exchange rate and trade balance using both linear and nonlinear ARDL specifications by focusing on Rwanda.

4. METHODOLOGY

4.1. Model specification and estimation strategy

To capture the asymmetric effect of the real exchange rate on Rwanda's trade balance, we follow both linear (ARDL) and non-linear autoregressive distributed lag model (ARDL), akin to Bahmani-Oskooee and Gelan (2019) in a log-log specification. The choice of this model is premised on the fact that the ARDL technique runs both the long-run effect and the short-run effects in one step. Secondly, the ARDL model does not require pre-tests for unit roots given that it deals with variables that are integrated of different orders i.e I(0), I(1), or a combination of both, and is robust when there is a single long-run relationship of the underlying variables in a small sample size (Nkoro and Uko, 2016). However, this technique explodes in the presence of an integrated stochastic trend of I (2). To prevent this futile effort, we test for unit root to obtain the orders of integration, though not a necessary condition.

Following Bahmani-Oskooee and Gelan (2019), we begin our specification with a reduced form trade balance equation specified as follows:

$$lnTB_{Rw,t} = \alpha + \beta \ln wgdp_{,t} + \vartheta \ln rgdp_{,t} + \sigma \ln reer_t + \varepsilon_t \text{ ....} (1)$$

Where TB_{Rw} is Rwanda's trade balance, defined as exports divided by imports. $wgdp$ is the world gross domestic product or foreign income, used as a proxy for external demand of Rwanda's exports. $rgdp$ is real domestic income and $reer$ is a real effective exchange rate and ε_t is a stochastic error term.

In terms of expected signs, the coefficient associated with foreign income is expected to be positive, implying that an increase in external demand boosts exports and improves the trade balance. The parameter estimate of real domestic income is expected to be negative given that economic growth induces more imports, thereby depressing the trade balance. The coefficient associated with real exchange rate depreciation[7]is expected to be positive as currency depreciation improves the trade balance.

The parameter estimates discussed above mirror the long-run effects of exogenous variables since equation (1) is a long-run model. To assess the short-run effects, to verify the J-curve effect, we convert to an error correction specification and to estimate both the short-run and the long-run effects in a single step, we follow the ARDL approach, similar to Pesaran et al. (2001) specifies as follows:

[7] Real exchange rate is defined in a manner that an increase signifies a depreciation of Rwandan franc

$$\Delta \ln TB_{Rw,t} = \phi + \sum_{j=1}^{n} \delta_j \Delta \ln TB_{Rw,t-j} + \sum_{j=0}^{n} \gamma_j \Delta \ln wgdp_{,t-j} + \sum_{j=0}^{n} \theta_j \Delta \ln rgdp_{,t-j} + \sum_{j=0}^{n} \eta_j \Delta \ln reer_{,t-j}$$
$$+\lambda_0 \ln TB_{Rw,t-1} + \lambda_1 \ln wgdp_{,t-1} + \lambda_2 \ln rgdp_{,t-1} + \lambda_3 \ln reer_{,t-1} + \mu_t ....(2)$$

From the above specification, the short-run effects are obtained from the first-differenced variables; the long-run effects are reflected in the estimates $\lambda_1 - \lambda_3$ normalized λ_0. In addition, two tests are implemented to avoid spurious regressions, the F-test to establish the joint significance of lagged level variables, signifying the presence of cointegration, and the T-test to establish the significance of λ_0, which must be negative. For both tests, Pesaran et al. (2001) tabulate new critical values that consider the degree of integration of variables. As they show, the upper bound critical values could be used even if some variables in the model are I (1) and some I (0). The interpretation is that if the estimated F-value is greater than a critical value of the upper bound, the null hypothesis of no cointegration is rejected.

Shin et al. (2014) adjust the model specified in (2) to capture the asymmetric effects of the real exchange rate. The modification amounts to disaggregating real exchange rates into depreciation and appreciation to estimate their effects separately. In this case, we first take the positive variable for the partial sum of positive changes in the exchange rates.

Similarly, a negative variable for the partial sum of negative changes in the real exchange rates is created, where positive, where positive and negative changes in the real exchange rates signify depreciation and appreciation of the real exchange rates respectively. The two variables are defined as:

$$reerdep_{,t} = \sum_{j}^{t} i\Delta reer_j^+ = \sum_{j=1}^{t} \max(\Delta reer_{j,} 0) \quad , \quad reerap = \sum_{j=1}^{t} \Delta reer_j^- = \sum_{j=1}^{t} \min(\Delta reer_j, 0) \quad .... (3)$$

Following Shin et al. (2014), the non-linear ARDL model can be expressed as:

$$TB_{Rw,t}^{+} = \theta^{+} lreer_t^{+} + \theta^{-} lreer_t^{-} + \mu_t ....(4)$$

θ^+ and θ^- are the asymmetric long-run equilibrium parameters associated with positive and negative changes in the real exchange rate. After generating these variables, we replace $\ln reer$ them with the two partial sum variables to obtain equation (5).

$$\Delta \ln TB_{Rw} = \alpha' + \beta_j' \Delta \ln TB_{Rw,t-j} + \sum_{j=1}^{n} \sigma_j' \Delta \ln wgdp_{,t-j} + \vartheta_j' \Delta \ln rgdp_{,t-j} + \phi_j' \Delta \ln reerdep_{,t-j} + \gamma_j' \Delta \ln reerap_{,t-j}$$
$$+\pi_0 \ln TB_{Rw,t-1} + \pi_1 \ln wgdp_{,t-1} + \pi_2 \ln rgdp_{,t-1} + \pi_3 \ln reerdep_{,t-i} + \pi_4 \ln reerap_{,t-1} + \xi_t ....(5)$$

Where $\theta^+ = \frac{\phi}{\beta'}$ and $\theta^- = \frac{\gamma}{\beta'}$ if the two partial sums carry the same coefficient in terms of sign and size, the effects are symmetric. Otherwise, they are asymmetric. While the specification in equation (2) is referred to as the linear ARDL model, equation (5) is known as the non-linear ARDL model or asymmetric ARDL model. Shin et al. (2014) indicate that the non-linear ARDL model is subject to similar diagnostic tests and the same estimation procedure as the linear ARDL model.

The non-linear ARDL model specified in equation 5 is used to derive the two dynamic multipliers computed as:

$$m_h^+ = \sum_{j=0}^{h} \frac{\partial TB_{Rw,t+j}^+}{\partial lreer_t^+}, \quad m_h^- = \sum_{j=0}^{h} \frac{\partial TB_{Rw,t+j}^-}{\partial lreer_t^-} ....(6)$$

Where $h \to \infty$ then $m_h^+ \to lreer^+$ and $m_h^- \to lreer^-$

4.2. Data description and sources

The series presented in models (1), (2), (3), (4) and are constructed as follows. The real exchange rate is the relative inflation-adjusted exchange rate and trade-weighted, computed by multiplying the nominal effective exchange rate by the ratio of consumer price index $REER = \sum_{t=1}^{k} (Neer_{it}) \left(\frac{p_{it}^*}{p_{it}} \right)$, where $NEER_{it}$ is the nominal effective exchange rate for Rwanda for the trading partner i, p_{it}^* is the price in partner trading country i representing the price of tradable, and p_{it} is the CPI of the home country as a proxy for the price of non-tradable ($NEER = \sum_{t=1}^{k} w_{it} * E_{it}$).

Real gross domestic product (GDP) is the nominal gross domestic product adjusted for inflation. World gross domestic product is foreign income, obtained by aggregating real gross domestic product for all the world economies. Exchange rate depreciation and appreciation are generated through partial sums. Finally, the trade balance is defined as the ratio of exports to imports. This measure of trade balance allows someone to perform nominal and real trade balance analysis without additional data manipulation and it also neatly solves the problem of using the log-form of a trade deficit. Our data series are transformed into natural logarithms and data is sourced from the National Bank of Rwanda (NBR), National Institute of Statistics of Rwanda (NISR), and World Bank's world development indicators (WDI). The empirical analysis builds on quarterly data spanning the period 2000Q1-2019Q4.

5. EMPIRICAL RESULTS

5.1. Unit root test

We start the analysis with the pre-test of the order of integration of variables even though the ADL bound test does not require the pre-test for stationarity, its technique explodes in the presence of integrated stochastic trend of I (2). To avoid this futile effort, we test for unit root to obtain the orders of integration. The test of the presence of unit roots is applied to all selected variables using the Augmented Dickey-Fuller (ADF) test and the results are reported in Table 1. The trade balance and domestic real GDP are stationary at levels, implying that they are integrated of order zero (0) while real effective exchange rate and foreign income proxies by U.S real GDP become stationary after differencing once i.e. I(1).

Table 1: Unit roots test for non-stationarity (Sample: 2000Q1–2019Q4)

	Level		First Difference		Order of Integration
	Intercept	Trend	Intercept	Trend	
Tb	-4.49***	-5.59***	-10.54***	-10.47***	I(0)
Lnreer	-2.27	-2.89	-7.46***	-7.63***	I(1)
Lnrgdp	-0.99	-3.88**	-9.01*	-8.99*	I(0)
Lnwgdp	-0.19	-1.23	-6.42*	-6.39*	I(1)
Note: *, **, ***: denote rejection of null hypothesis at 10%, 5% and 1% significance level respectively.					

Source: Author's calculations

5.2. Bounds testing to cointegration

After testing for stationarity of the variables as presented in table 1, we proceed to test for cointegration between the dependent and the explanatory variables in the linear and the nonlinear specifications. The results of the linear and nonlinear ARDL bounds test for cointegration are presented in table (2). First, the test for the existence of long-run cointegration between variables for the linear model is conducted using the linear ARDL bounds test. The results show that the estimated value of the F-test is greater than the upper bound critical value, suggesting that the null hypothesis of no cointegration is rejected, confirming the presence of cointegration between dependent and independent variables. Secondly, also presented in table (2) are the results of the nonlinear ARDL bound test, which is using two tests. The first is theF_{PSS}proposed by Pesaran et al. (2001), which tests the significance of the variables that enter into the nonlinear or asymmetric model equation (4) in level and the second is T_{BDM} developed by Banerjee et al. (1998), which tests the significance of the feedback coefficient. The results from both tests show that the test statistics are greater than their corresponding upper bound critical values, suggesting that the null hypothesis of no cointegration is rejected, hence, the existence of a long-run cointegrating relationship between the selected variables.

Table 2: Cointegration test in the linear and the nonlinear specifications[8]

Model		F-Statistics	95% Lower bound	95% upper bound	Result
Linear ARDL		5.058	3.23	4.35	Cointegration
Non-linear ARDL	F_{PSS}	5.130	2.86	4.01	Cointegration
	T_{BDM}	-4.907	-2.86	-3.99	
Note: F_{PSS} and T_{BDM} denote the F-statistics proposed by Peseran et al. (2001) and the t-statistics proposed by Banerjee et al. (1998).					

Source: Authors' calculation

5.3. Presentation of model results

Table 3 and Table 4 report the results of the linear and nonlinear ARDL models respectively. The linear model shows short-run and long-run dynamics of the trade balance to the changes in the regressors. The nonlinear ARDL estimation presents both the long and short-run estimated coefficients for the different partial sums of real exchange rates. Each model was estimated by imposing a maximum of three lags for both the dependent and independent variable and the selection criteria is based on Akaike Information Criterion (AIC) to select an optimum model. The presence of an asymmetric impact in the long and short run is examined by the Wald test, which tests the null hypothesis of symmetric against the alternative of asymmetric.

5.3.1. Linear ARDL model results

The results from the linear model show that the short-run impact of real exchange rate on trade balance provides positive and negative but not statistically significant effects whereas the long-run coefficient revealed positive and statistically significant effects on Rwanda's trade balance, suggesting that the real exchange rate depreciation favors trade balance. This result does not seem to

[8] The testing procedure uses two critical bounds: upper and lower. If the values of the test statistic exceed the upper bound, the null hypothesis is rejected. If they lie below the lower critical bound, the null cannot be rejected, and if they lie between the critical bounds, the test is inconclusive.

support the traditional definition of the J-curve phenomenon that was tested empirically (Bahmani-Oskooee, 1985), which requires statistically significant negative coefficients (i.e. deterioration of trade balance) in the short-run and positively significant ones (i.e. improvement of trade balance) in the long-run. This implies that if Rwanda is experiencing trade deterioration, a depreciation or devaluation policy will not help in the short run given that the trade balance takes some time to adjust but eventually improves the trade balance in the long run. On the other hand, the long-run estimates are meaningful as cointegration is supported by either the F-stat or the t-test as previously reported in table 2. In addition, the normalized estimated error correction term, ECM= -0.63, is negative and statistically significant, supporting fast adjustment towards the long-run, further supporting the existence of cointegration.

Table 3 also reports few additional diagnostic statistics. We used the Lagrange Multiplier (LM) test to check for serial correlation. The result of the LM statistic is distributed as chi-squared with 2 degrees of freedom. As can be seen, it is insignificant, implying the lack of autocorrelation of residuals. We also tested the stability of the model using the cumulative sum of recursive residuals (CUSUM) and the cumulative sum of squares of recursive residuals (CUSUMSQ) tests. The result showed that the model is structurally stable. In addition, adjusted R^2 is reported judging the goodness of the fit. Lastly, the Jarque-Bera statistic suggests normal distribution.

Table 3: Results from linear ARDL model

Dependent variable: tb			
Variable	**Coefficient**	**T-stat**	**P-value**
Short-term			
Constant	-12.05** (3.82)	-3.16	0.003
Δtb_{t-1}	0.06 (0.13)	0.44	0.660
$\Delta lnreer$	0.32 (0.25)	1.25	0.216
$\Delta lnreer_{t-1}$	-0.27 (0.23)	-1.15	0.255
$\Delta lnrgdp$	-1.07** (0.35)	-3.00	0.004
$\Delta lnrgdp_{t-1}$	-1.03*** (0.28)	-3.73	0.000
$\Delta lnrgdp_{t-2}$	-0.56 (0.34)	-1.65	0.105
$\Delta lnwrgdp_{t-1}$	-2.39 (1.61)	1.48	0.145
$\Delta lnwrgdp_{t-2}$	-2.72* (1.49)	-1.83	0.073
Long-term			
ECM	-0.63*** (0.15)	-4.20	0.000
$lnreer_{t-1}$	0.23* (0.12)	1.84	**0.070**
$lnrgdp_{t-1}$	-0.27** (0.10)	-2.64	**0.011**
$lnwrgdp_{t-1}$	1.37*** (0.45)	2.86	**0.006**
Diagnostics tests	$Adjusted\ R^2 = 0.712; F-statistics = 13.526$; $\chi^2_{LM} = 0.898$; $\chi^2_{HET} = 19.47$; $Jarque-Bera(p-value) = 0.542$; CUSUM: Stable; CUSUMSQ = Stable; RESET = 1.146		

Notes: Standard errors are in parentheses. *, **, *** denote 10%, 5% and 1% significance level. χ^2_{LM} is the Lagrange Multiplier test of residual serial correlation distributed as χ^2 with 2 degrees of freedom; χ^2_{HET} is the Breusch-Pagan-Godfrey test of residual homoskedastic distributed as χ^2 with 15 degrees of freedom. RESET is Ramsey's test for misspecification.

Source: Authors' calculation

5.3.2. Non-Linear ARDL model results

Several studies have argued and empirically proven that the non-existence of the J-curve concept could be due to the fact that they assume an asymmetric relationship between the real exchange rate and trade balance whereas in fact, it is an asymmetric one. Therefore, it is possible that the relationship between the real exchange rate and the trade balance is nonlinear, and thus the assumption that they are linearly associated discounts some important information. Thus, we proceeded to estimate the nonlinear ARDL model to verify whether the relationship is asymmetric. Table 4 below reports the nonlinear ARDL estimates.

The nonlinear model is based on separating depreciations ($lreer^{+}$) from appreciations ($lreer^{-}$). The results of the nonlinear ARDLmodel suggest that depreciation of the real exchange rate has both short and long-run effects on the trade balance. In the short run, real depreciation appears to have a negative effect on the trade balance at lag one, while in the long run, the impact is reversed. These results are consistent with the J-curve phenomenon as defined by Bahmani-Oskooeeand Fariditavana (2015 and 2016), which implies that the deterioration of trade balance in the short-run but eventually reversed to improve the trade balance in the long run based on the partial sum concepts and $lreer^{+}$ and $lreer^{-}$ variables).In contrast, real appreciation did not affect the trade balance both in the short and long run during the study period. In addition, as clearly shown in Table 4, at a given lag, the short-run coefficient associated with$lreer^{+}$ is different from the one associated with$lreer^{-}$, supporting short-run asymmetric effects of real exchange rate on the trade balance. However, as suggested by Bahmani-Oskooee et al. (2016) this conclusion should be confirmed by a formal test. The study applied the Wald test to examine if the partial sums of the short-run coefficients associated with$\Delta lnreer^{+}$ and $\Delta lnreer^{-}$ variables are significantly different. Short-run asymmetry is obtained if the Wald Statistic appears significant.

The result from Table 4 reveals the Wald statistic denoted by $W_{SR,lnreer}$is 1.11, which is insignificant, hence, failing to reject the null of the short-run symmetry, suggesting that there is no short-run asymmetry of the real exchange rates on the trade balance. Furthermore, the long-run asymmetry is tested using the Wald test by verifying if $\pi_3 = \pi_4$which are coefficients associated with depreciation and appreciations respectively in the nonlinear specifications. The Wald statistics $W_{LR,lnreer}$is equal to 8.77 and is statistically significant, confirming the presence of the long-term asymmetry. The long-run coefficient of $lreer^{+}$is 0.93 and statistically significant while the long-run coefficient of $lreer^{-}$is 0.002but is not significant. This implies that 1 percent depreciation improves the trade balance by

0.93 percent while real appreciation does not affect the trade balance in the long run.

Furthermore, the F-statistics well as the estimated error correction term, $ECM_{t-1} = -0.86$, which is negative and statistically significant, indicates the presence of cointegration of variables in the nonlinear model. The results of long-run estimates of the nonlinear model appear to be more meaningful when supported by the diagnostic statistics as represented in Table 4.

Table 4: Results from nonlinear ARDL model

Dependent variable: tb			
Variable	**Coefficient**	**T-stat**	**P-value**
Short-term			
Constant	-11.28 (2.16)	-5.23	0.000
Δtb_{t-1}	0.19 (0.14)	1.32	0.192
$\Delta lnreer^{+}$	0.32 (0.35)	0.91	0.367
$\Delta lnreer^{+}_{t-1}$	-0.78* (0.42)	-1.89	0.064
$\Delta lnreer^{-}$	0.36 (0.48)	0.76	0.448
$\Delta lnreer^{-}_{t-1}$	-0.09 (0.47)	-0.20	0.845
$\Delta lnrgdp$	-1.24*** (0.36)	-3.45	0.001
$\Delta lnrgdp_{t-1}$	-0.65** (0.312)	-2.069	0.043
$\Delta lnwrgdp$	-0.47 (1.73)	-0.27	0.789
$\Delta lnrgdp_{t-1}$	1.73 (1.75)	0.99	0.327
Long term			
Dependent variable: tb			
Variable	**Coefficient**	**T-stat**	**P-value**
$lnreer^{+}_{t-1}$	0.93 (0.30)	3.10	0.003
$lnreer^{-}_{t-1}$	0.02 (0.18)	0.13	0.901
$lnrgdp_{t-1}$	-0.97 (0.32)	-3.02	0.004
$lnwrgdp_{t-1}$	1.88*** (0.54)	3.49	0.001
Long-run asymmetric coefficients	$LR^{+}_{lreer} = 1.08^{***} LR^{-}_{lreer} = 0.03$		
Long run asymmetric coefficients test	$W_{LR,lnreer} = 8.77^{***} W_{SR,lnreer} = 1.11$		
Diagnostics tests	$Adjusted\ R^2 = 0.701; F-statistics = 10.251$;$X^2_{LM} = 2.688$; $X^2_{HET} = 20.516$;$Jarque-Bera(p-value) = 0.4498(0.7985)$; CUSUM: Stable; CUSUMSQ = Stable; RESET = 0.038		

Notes: $W_{LR,lnreer}$ refer to the Wald test for the null of long-run symmetry while $W_{SR,lnreer}$ refer to the Wald test for the null of the additive short-run symmetry condition. Standard errors are in parentheses. ***, **, * denote 1%, 5% and 10% significance level. χ^2_{LM} is the Lagrange Multiplier test of residual serial correlation distributed as $\chi^2$with 2 degrees of freedom; $\chi^2_{HET}$is the Breusch-Pagan-Godfrey test of residual homoskedacity distributed as $\chi^2$with 15 degrees of freedom. RESET is Ramsey's test for misspecification.

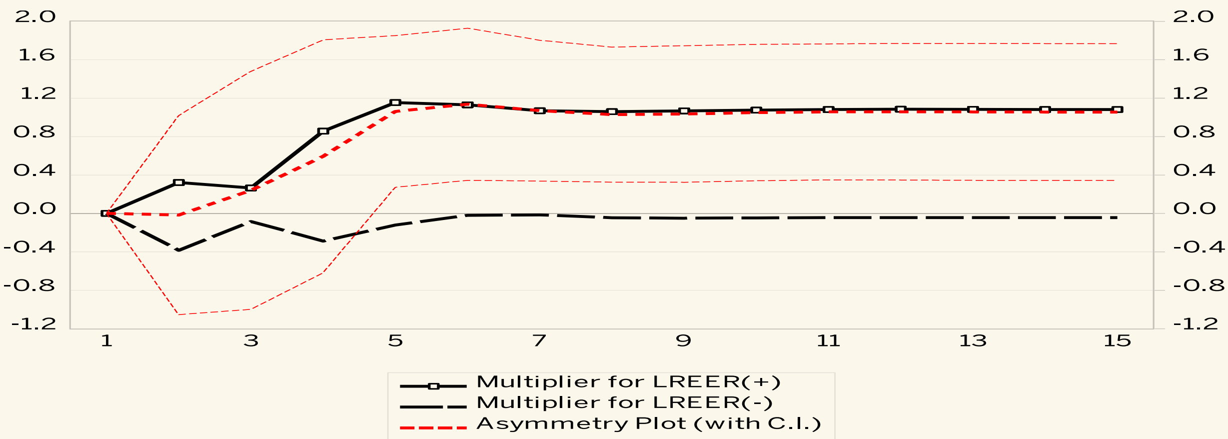
Source: Authors' calculation

Given that no studies have analyzed the asymmetric effects of exchange rate changes on the trade balance in the case of Rwanda, we are unable to make a direct comparison. However, the results from this study are in line with many other previous studies conducted in other countries (Bahmani-Oskooee and Durmaz, 2016; Bahmani-Oskooee et al., 2016; Iyke and Ho, 2017; Bahmani-Oskooee and Gelan, 2019) among others. These studies found that nonlinear models yield a significant asymmetric link between the trade balance and the real exchange rate changes.

5.3.2.1. Dynamic multipliers

Given that we have rejected the null hypothesis of symmetry in the long run, we proceed to obtain the asymmetric dynamic multipliers of the positive and negative charges of the explanatory variables. The asymmetric cumulative dynamic multipliers show the pattern of adjustment of the dependent variable, trade balance, to its new long-run equilibrium following a positive or negative unitary shock of its regressors. In this study, our interest is the asymmetric dynamic multiplier of the real exchange rate to capture the impact of appreciation and depreciation on the trade balance. Figure 2 shows the dynamic effects of real exchange rate where real trade balance responds more rapidly to an increase in the REER (depreciation) than its decrease (appreciations) as the asymmetry line moves away so distantly from the zero lines in the upper bound. In addition, the graph confirms the results from the Wald test of the nonexistence of short-run asymmetry as presented earlier.

Figure 3: Long-run and short-run NARDL dynamic multiplier



Source: Authors' calculation

6. CONCLUSION AND RECOMMENDATIONS

The impact of the exchange rate on trade balance has been studied extensively given the role it plays in determining a country's competitiveness. Theoretical literature stipulates that the economies that suffer from trade balance should devalue their currency or put in place policies that promote real depreciations. Several studies have then tried to establish this relationship. It has been suggested that following a country's currency depreciation or devaluation, the trade balance will deteriorate in the short-run before reversing in the long run, a feature commonly known in the literature as the J-curve effect. These studies have assumed a linear relationship between exchange rate changes and trade balance. However, several studies have recently suggested and tested nonlinear impacts of exchange rate movements on trade balances using the nonlinear Autoregressive Distributed Lags (ARDL) models. The nonlinear ARDL approach allows us to decompose the impact of the exchange rate changes in terms of appreciations and depreciations. The presence of asymmetric impacts in the long and short run is detected from the Wald test based on the null hypothesis of the presence of symmetric against the alternative of asymmetric effects.

Given the limited literature in the case of Rwanda, this study examined the effects of exchange rate on the trade balance in Rwanda by using both the linear ARDL and nonlinear ARDL approach. Using quarterly data spanning the period 2000Q1 to 2019Q4, the results from the linear ARDL model did not support the J-curve phenomenon. Only a long-run relationship between trade balance and the real exchange rate was identified and emerged as statistically significant. The long-run coefficient suggested that a 1 percent depreciation improves Rwanda's trade balance by 0.23 percent. In addition, the error correction term appears negative and highly significant, further supporting the long-run relationship. In contrast, there was evidence of short-run and long-run effects of exchange rate changes on the trade balance in the nonlinear specification. While the short-run asymmetry was refuted by the Wald test, the result from the nonlinear ARDL showed that in the short run, real depreciation appears to have a negative and statistically significant effect on the trade balance at lag one, while in the long run, the impact is reversed, hence, supporting the J-curve phenomenon. However, real appreciations do not have any significant effect on trade balance both in the short-run and long run. This evidence suggests that policymakers should be aware of the consequences of asymmetric impacts of Rwandan francs' appreciation and depreciation in the development of trade policies so that international competitiveness is not adversely affected. In addition, from the results obtained, the improvement of the trade balance after depreciation is very limited, hence, policymakers should weigh the benefits of the improvement in trade balance with potential unfavorable effects of a permanent depreciation. This study also suggests further research to better understand the effect of exchange rates on the trade balance. Previous studies suggested that using a country's trade data with the rest of the world might suffer from aggregation bias. To address this issue, future research should consider modeling Rwanda's trade data with its main trading partners. Alternatively, other studies could utilize the aggregate data according to standard international trade classification to assess the response of trade balance on exchange rate changes by industry.

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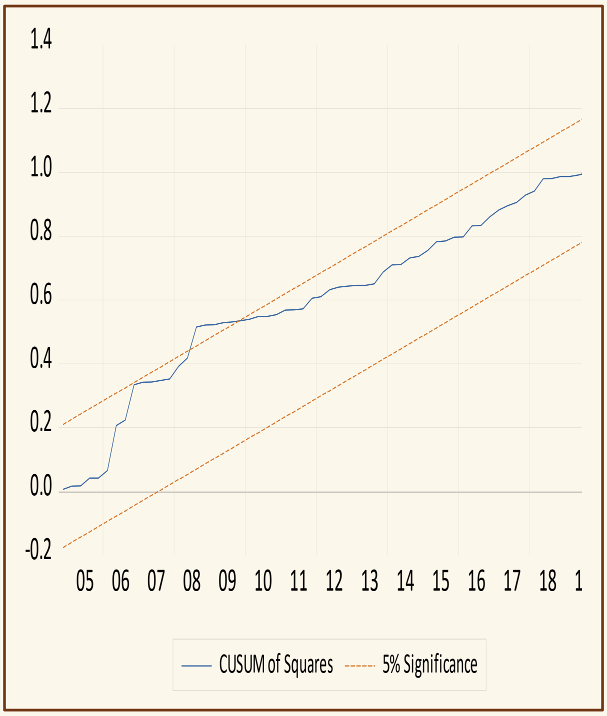
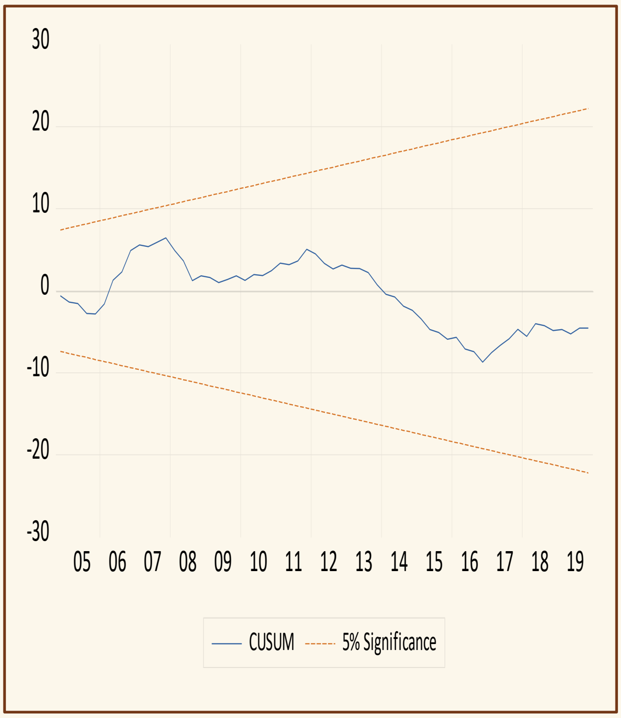
Appendices

Stability Diagnostics test for Linear ARDL Model





Stability diagnostics test for Nonlinear ARDL Model