International Journal of Applied Economics, Finance and Accounting
ISSN 2577-767X
Vol. 16, No. 1, pp. 43-55.
2023
DOI: 10.33094/ijaefa.v16i1.888

The impact of exchange rate changes on the trade balance: Evidence from Saudi Arabia vs her major trading partners

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Keywords:
ARDL model
Bilateral trade balance
J-curve
Real exchange rate.

JEL Classification:
F31; F14.

Received: *4 January 2023*
Revised: *23 February 2023*
Accepted: *15 March 2023*
Published: *28 March 2023*

Abstract

This study aims to analyse the short- and long-term effects of real exchange rate changes on the bilateral trade balance between Saudi Arabia and its major trading partners. The study used the aggregated and disaggregated panel data for the analysis. The autoregressive distributed lag (ARDL) model in error correction is used to analyse the short and long-term relationship between exchange rate and trade balance. It was discovered that the real exchange rate (RER) had no appreciable impact on the trade balance over the long run using the panel data linear ARDL model. The first leg of RER is determined to have a very negative short-term impact on the trade balance. However, the non-linear ARDL model, which took into account non-linear trade balance adjustments in reaction to exchange rate fluctuations, demonstrated a significant and adverse long-term link between the two variables. It shows that depreciation leads to the deterioration of the trade balance. Finally, the study extends the analysis to disaggregated data country-wise. The results of the linear ARDL model revealed that 3 out of 13 cases have significantly short-term relationships. Still, it is observed that no specific short-term patterns are in line with the J-curve hypothesis. The investigation discovered evidence for the J-Curve and the new definition of the J-curve using the non-linear ARDL model in three of the 13 cases. The study concluded that Saudi Arabia must not rely on devaluation as a policy instrument to improve its trade balance. It should maintain its fixed exchange rate for extended periods.

Funding: This study received no specific financial support.
Competing Interests: The author declares that there are no conflicts of interests regarding the publication of this paper.

1. Introduction

Saudi Arabia mainly depends on oil for trading; therefore, it is necessary to check the other determinants to increase the growth of exports and to reach a balanced trade to gain the advantage of high economic growth rates. Saudi economy adopts a policy of maintaining a high exchange rate by using foreign currency reserves, which would create a problem for the sustainability of the balance of payments in the future. Therefore, exports should be extended, and imports should be reduced to maintain the exchange rate. Moreover, sharp fluctuations in the price of oil have created problems in collecting sufficient foreign reserves to keep the trade balance. For the stable growth rate, the impact of the devaluation policy on the trade balance should be checked.

According to economists, devaluation can improve the trade balance of any nation and they might take benefit from a fixed or managed exchange rate regime by making imports expensive and exports cheaper. Therefore, they have been interested to know the dynamic relationship between exchange rate and trade balance. Two factual reasons led to this interest; firstly, the exchange rate dynamics determine the improvement of trading position with the trading partners. Secondly, the country's trading position in relation to its trading partners reflects whether it gains from the trade or owes its partners money. In context with this, two theories have guided the research activities: the first theory by Marshall-Learner states that the devaluation of the currency will improve the trade balance only, when the elasticity sum of demand for import and export is more than 1. The second theory is suggested by Magee (1973), known as the J-Curve phenomenon, which states that the devaluation of currency will decrease the trade balance before improving it. Theoretically, the devaluation of the currency has two effects on the trade balance: volume and price effect. Considering the volume effect, any country that devalue its currency will likely be experiencing an increase in its exports by increasing the revenue accrued to the government. If a country's currency is devalued for the price effect, the cost of imports is likely to increase, which will decrease the amount of imports from its trade partners.

Considering the proposition of the above two theories, the research trajectory takes place in 3 ways. The first way is to test the short-term relationship between exchange rate and trade balance to either support or reject the J-Curve theory. The second method centres on the development of econometric techniques to account for the impact of both long-term and short-term currency devaluation on the trade balance. One common feature in the first and second ways is that there might be a symmetric relationship between the exchange rate and trade balance. This relationship would show that currency devaluation will have a similar effect on the trade balance, yielding biased results. According to Bussiere (2013) the support for a non-linear evaluation of the influence of devaluation of currency on the trade balance is based on the fact that the price of imports and exports react non-linearly towards movement in the exchange rate. Bahmani-Oskooee and Baek (2016) argue that traders' expectations of future exchange rate movements are non-linear during the appreciation and depreciation periods.

Only a few empirical studies in Saudi Arabia have discussed the relationship between exchange rate and trade balance with its partner could be found. Most of the trading partners in Saudi Arabia belong to Gulf-Cooperation Council (GCC) countries. In addition, nations outside the GCC are actively engaged in trade for a variety of reasons; it is important to assess if Saudi Arabia's fixed exchange rate policy will help to balance trade or will have a detrimental impact. In the GCC countries, particularly in Saudi Arabia, studies have been conducted to determine the impact of exchange rate movement on the trade balance. In context with Saudi Arabia, some studies investigating the influence of exchange rate movements on trade balance have yielded conflicting findings. For instance, Mahmood, Khateeb, and Ahmad (2017) used a non-linear ARDL model to study the asymmetric impact of the exchange rate on the Saudi service sector in the case of all sectors in the short and long term. The results revealed that devaluation confirmed the existence of the J-Curve after some lag, and the appreciation of Saudi currency may have an adverse effect on the trade balance in all sectors except travel, tourism and construction. Similarly, the present study investigates the impact of exchange rate changes on the bilateral trade balance between Saudi Arabia and its major trading partners.

2. Literature Review

Previously, a significant relationship between exchange rate and trade balance has been reported. Previous studies have found no J-curve effects in the cases of India, Turkey and Brazil (Akbostanci, 2004; Moura & Da Silva, 2005; Singh, 2004). However, similar studies conducted by Rehman and Afzal (2003); Reis Gomes and Senne Paz (2005); Rahman and Islam (2006) and Duasa (2007) found evidence of the J-curve effect on Pakistan, Malaysia, Brazil and Bangladesh, respectively. Due to the availability of additional data and the remarkable advancement in the econometric methodology, empirical results varied depending on the effect of exchange rate devaluation on the trade balance in the short and long run. According to Mohsen and Brooks (1999) and Dash (2013) studies using aggregated trade data suffer from the problem of aggregation bias. Therefore, it is recommended to use bilateral data. The studies conducted by Bahmani-Oskooee, Economidou, and Goswami (2006); Halicioglu (2007); Bahmani-Oskooee, Goswami, and Talukdar (2008); Bahmani-Oskooee and Harvey (2009) and Bahmani-Oskooee and Cheema (2009) used bilateral data; however, mixed findings were established. Consequently, the lack of consensus on this issue led to new studies that simultaneously depend on bilateral and aggregated data to examine the relationship between exchange rate changes and trade balance. One of the most prominent works in this field was conducted by Bahmani-Oskooee and Wang (2008). However, the results also remained mixed. Recently, Bahmani-Oskooee, Bose, and Zhang (2018) and Bahmani-Oskooee and Nasir (2020) used the model of trade balance model in a non-linear ARDL framework to examine asymmetric effects of depreciations and appreciations on the trade balance. Most of these studies demonstrated the superiority of the non-linear ARDL over its linear counterpart to highlight the impact of the J-Curve.

3. Methodology

In this study, the trade balance between Saudi Arabia and its top 13 major trading partners, including China, United States, United Arab Emirates, India, Japan, South Korea, Egypt, Turkey, Bahrain, Australia, Kuwait, Oman and Vietnam has been examined bilaterally. The major trading partners and their trade balance reflecting the relative importance of each partner are listed in Table 1. The selection of the above countries is based on the share of the total foreign trade turnover of Saudi Arabia and data availability over the study period.

Table 1. Saudi Arabia's external trade in 2020 in USD (Million).

Trading partners	Exports	Imports	Trade balance
China	8180	26510	-18330
United States	1850	14100	-12250
United Arab Emirates	8920	8980	-60
India	3100	6370	-3270
Japan	665.09	5660	-4994.91
South Korea	844.88	3820	-2975.12
Egypt	1780	2630	-850
Turkey	1830	1990	-160
Bahrain	1850	1800	50
Oman	957.72	1650	-692.28
Vietnam	641.97	1200	-558.03
Australia	365	721	-356
Kuwait	1623	518	1105

The study followed the approach adopted by Lal and Lowinger (2002); Onafowora (2003) and Bahmani-Oskooee and Kutan (2009) to specify the trade balance model at the bilateral level. The following specification was adopted:

$$lnTB_{i,t} = \alpha + \varphi lnY_{SAU,t} + \beta lnY_{it} + \gamma lnRER_{i,t} + \varepsilon_t \qquad (1)$$

Where;

TB_i is a measure of the trade balance between Saudi Arabia and its trading partner *i* defined as the ratio of Saudi Arabia' export to country i over her imports from country *i*;

Y_{SAU} is Saudi Arabia's real income set in index form to make it unit free;

Yi is the index of real income of trading partner *i*;

RERi is the real bilateral exchange rate between Saudi Arabia and its trading partner *i* defined such that an increase signifies depreciation of the Saudi Riyal against the currency of its trading partner *i*.

Considering the economic theory, the increase in Saudi exports and decrease in imports is determined based on the depreciation of the Saudi Riyal. This clarifies that an improvement in the trade balance is determined by an expected positive sign of the estimated coefficient γ. At the same time, the Estimate of φ could be positive or negative. Usually, an increase in real domestic income leads to higher imports, which means a positive estimate for φ. However, the increase in real domestic income is due to increase production of imported substitute goods. In that case, imports could decrease, which means a negative sign of φ. According to this, the estimated coefficient of β could also be positive or negative. The adoption of the log-functional form is justified by the fact that the coefficients will be interpreted as elasticities (Amusa & Fadiran, 2019). Equation 1 only estimates the long-term coefficients (Bahmani-Oskooee & Baek, 2016). However, the J-curve is a short-term phenomenon. Therefore, short-term dynamic adjustment mechanisms should be incorporated into Equation 1. Common practice is to specify it as the error correction model, which is done by following the error correction ARDL (Autoregressive Distributed Lag) approach of Pesaran, Shin, and Smith (2001) as done in Equation 2 below:

$$\Delta lnTB_{i,t} = \alpha + \sum_{j=1}^{p} \varphi_i \Delta lnTB_{i,t-j} + \sum_{j=1}^{q1} \delta_i \Delta lnY_{SAU,t-j} + \sum_{j=1}^{q2} \beta_i \Delta lnY_{i,t-j} + \sum_{j=1}^{q3} \gamma_i \Delta lnRER_{i,t-j} + \mathrm{w}_1 lnTB_{it-1} + \mathrm{w}_2 lnY_{SAU,t-1} + \mathrm{w}_3 lnY_{it-1} + \mathrm{w}_4 lnRER_{it-1} + \mu_i + \varepsilon_{i,t} \qquad (2)$$

Where;

p: is the lag length;

Δ: is the first-difference operator.

In this setup, the short-term effects of each variable are assessed by the estimates of coefficients assigned to the first-differenced variables. Specifically, the J-curve effect is established if estimates of γ are negative at lower and positive at higher lags. The long-term effects are detected by the estimates w2, w3 and w4 normalised on w1. However, for the long-term coefficient estimates to be relevant, one must first establish the joint significance of lagged level variables using the conventional F test with the critical values that take into account integrating properties of each variable.

In the empirical literature review, the J-curve effect could be examined based on the aggregate data or a single-equation country-by-country estimate. Therefore, in this study, panel data approaches were first applied to take advantage of valuable data and effectively handle non-stationary heterogeneous dynamic panels. Then, the study uses a country-by-country analysis of bilateral trade commerce.

The dynamic panel data analysis was similar to Comunale and Hessel (2014). Three approaches were adopted based on the ARDL panel framework, including; the pooled mean group estimate (PMG), the mean group estimate (MG) and the dynamic fixed effects estimate (DFE). These techniques differ only in their treatment of the coefficients. The DFE restricts the coefficients and makes them homogeneous across cross-sectional units. At the same time, the MG approach allows the coefficients to vary across cross-sectional units in the short and long term. The PMG incorporates the features of MG and DFE approaches by equalising long-term elasticity for all cross-sections and allowing short-term elasticity to vary with each cross-section unit. Therefore, Equation 2 is rewritten into a panel error correction ARDL (p; q_1 q_2, q_3) dynamic formulation as follows;

$$\Delta lnTB_{i,t} = \alpha + \sum_{j=1}^{p} \varphi_{ij} \Delta lnTB_{i,t-j} + \sum_{j=1}^{q1} \delta_{ij} \Delta lnY_{SAU,t-j} + \sum_{j=1}^{q2} \beta_{ij} \Delta lnY_{i,t-j} + \sum_{j=1}^{q3} \gamma_{ij} \Delta lnRER_{i,t-j} + w_1 lnTB_{it-1} + w_2 lnY_{SAU,t-1} + w_3 lnY_{it-1} + w_4 lnRER_{it-1} + \mu_i + \varepsilon_{i,t} \quad (3)$$

In Equation 3, the symmetric relationship between exchange rate (RER) movements and trade balance (TB) is assumed. If depreciation results in an improvement of trade balance, appreciation should deteriorate it by the same magnitude. However, this assumption was challenged by Bahmani-Oskooee and Fariditavana (2016). It showed that a linear ARDL specification could not model non-linear trade balance adjustments in response to exchange rate changes. This leads to the use of non-linear ARDL modelling by the decomposition of the effects of appreciation and depreciation of the RER using the partial sum process. This specification is given in Equation 4:

$$\Delta lnTB_{i,t} = \alpha + \sum_{j=1}^{p} \varphi_{ij} \Delta lnTB_{i,t-j} + \sum_{j=1}^{q1} \delta_{ij} \Delta lnY_{SAU,t-j} + \sum_{j=1}^{q2} \beta_{ij} \Delta lnY_{i,t-j} + \sum_{j=1}^{q3} \gamma_{ij}^{1} \Delta lnRERP_{i,t-j} + \sum_{j=1}^{q4} \gamma_{ij}^{2} \Delta lnRERN_{i,t-j} + w_1 \left(lnTB_{it-1} - \theta_1 lnY_{SAU,t-1} - \theta_2 lnY_{it-1} - \theta_3 lnRERP_{it-1} - \theta_4 lnRERN_{it-1} \right) + \mu_i + \varepsilon_{i,t} \quad (4)$$

Where $\Delta lnRERP_j = \sum_{j=1}^{t} Max(\Delta lnRER_j, 0)$, $\Delta lnRERN_j = \sum_{j=1}^{t} Min(\Delta lnRER_j, 0)$ are the partial sum variables of the positive values representing real bilateral exchange rate depreciations and the negative values that are the real bilateral exchange rate appreciations, respectively.

4. Empirical Findings

As mentioned above, the original series is transformed into natural logarithms form, which interprets the coefficients more intuitive. The coefficients are elasticity to measure the change in the trade balance for a 1% change in the real exchange rate and the other control variables in the model. Table 2 presents the statistical characteristics of the underlying variables as described above. LTB_i is a natural logarithm of measure of trade balance between Saudi Arabia and trading partners *i*. It has an average value of 0.932. $LRGDP_{SAU}$ is a natural logarithm of Saudi Arabia's real income set in index form to make it unit free and has an average value of 22.619. LRGDP is a natural logarithm of the index of real income of trading partner *i*, which has an average value of 23.124. At the same time, LRER is a natural logarithm of real bilateral exchange rate between Saudi Arabia and its trading partners *i*, defined in a way that an increase would imply a depreciation of the Riyal against the currency of its trading partner *i* with an average value of 0.914.

Table 2. Descriptive statistics.

Variable		Mean	Std. dev	Min	Max	Observations
LTB	Overall	0.932	1.214	-2.606	4.810	N = 403
	Between		0.928	-1.082	1.953	n = 13
	Within		0.823	-1.755	3.790	T = 31
LRGDP	Overall	23.124	1.849	19.540	29.216	N = 403
	Between		1.603	20.651	25.894	n = 13
	Within		1.019	20.319	28.480	T = 31
LRER	Overall	0.914	3.181	-2.654	8.726	N = 403
	Between		3.303	-2.484	8.552	n = 13
	Within		0.136	0.491	1.431	T = 31
$LRGDP_{SAU}$	Overall	22.619	0.647	21.746	23.534	N = 403
	Between		0.000	22.619	22.619	n = 13
	Within		0.647	21.746	23.534	T = 31

Note: Gross domestic product (GDP) and price index data are sourced from the World Bank' World Development Indicators database. Data on the real exchange rate are obtained from the OANDA website (https://www.oanda.com/fx-for-business/historical-rates), while the data on bilateral imports and exports are from the International Monetary Fund (IMF), Direction of Trade Statistics (DOTS).

Table 3 shows the correlation between the underlying variables. According to the theory, there is a positive correlation between trade balance and the real exchange rate.

Table 3. Correlations.

Variable	LTB	LRGDP	LRER	$LRGDP_{SAU}$
LTB	1.000			
LRGDP	-0.221	1.000		
LRER	0.013	-0.017	1.000	
$LRGDP_{SAU}$	-0.149	0.482	0.041	1.000

4.1. Preliminary Data Analysis

Findings of empirical studies state that there are two generations of unit root tests in panel data. In the first generation, the main limit is the assumption of the cross-sectional independence hypothesis across units, and the second generation of tests rejects the cross-sectional independence hypothesis. Considering this, the study will be started with the test of Pesaran (2004) and the cross-section dependence statistic (*CD)* was computed. Table 4 shows that the null hypothesis of cross-section independence is rejected for all the variables. Based on this finding, the study carried out a second-generation panel unit root test. Thus two different tests are used, Moon and Perron (2004) and Pesaran (2007) Cross-sectional Augmented Dickey-Fuller (PCADF) unit root tests. The results of these tests are shown in Table 5. According to the panel unit root test results in Table 5 some variables are stationary in levels; others are non-stationary in levels while becoming stationary in first differences. Therefore, the variables are *I* (0) and *I* (1). This evidence gives a reason for using the ARDL/NARDL model.

Table 4. Tests of cross-sectional dependence.

Variables	CD statistic
(LTB)	16.286*** (0.000)
(LRGDP)	39.237*** (0.000)
(LRER)	10.435*** (0.000)
($LRGDP_{SAU}$)	49.173*** (0.000)

Note: ***indicate the statistical significant at 10 % confidence level, respectively. P-values are in parentheses.

Table 5. Panel unit root test results.

	LLC test		PCADF test		Order of integration
	Level	First difference	Level	First difference	
	[t − bar]	[t − bar]	[t − bar]	[t − bar]	
(LTB)	-1.976* (0.052)	-6.064*** (0.000)	-2.569*** (0.001)	-3.749*** (0.000)	I (0)
(LRGDP)	-0.846 (0.998)	-4.990*** (0.000)	-1.122 (0.994)	-3.679*** (0.000)	I (1)
(LRER)	-1.369 (0.737)	-4.957*** (0.000)	-1.277 (0.971)	-3.694*** (0.000)	I (1)
	ADF test		KPSS test		
	Level	First difference	Level	First difference	
($LRGDP_{SAU}$)	-0.555 (0.866)	-4.965*** (0.000)	0.581 (0.739)	(0.247) (0.739)	I (1)

Note: ***, * indicate the statistically significant at 1%, and 10 % confidence level, respectively. P-values are in parentheses. The test has the null hypothesis of the presence of a unit root. To test for stationary $LRGDP_{SAU}$, the Augmented Dickey-Fuller (ADF) and the Kwiatkowski, Phillips, Schmidt, and Shin (KPSS) tests are used.

Moreover, the study used the Granger non-causality test of Dumitrescu and Hurlin (2012) to determine the causality between trade balance and real exchange rate. As known, this is one of the tests used in the presence of cross-section dependence. According to the Granger non-causality test results presented, the outcome of the test led to the rejection of the null hypothesis.[1] Table 6, which depicts bidirectional causality between trade balance and real exchange rate.

Table 6. Granger non-causality test results.

	LTB-LRER
(Z − bar)	2.635 (0.008)
(Z − bar tilde)	2.117 (0.034)
H0: LRER does not granger-cause LTB.	
H1: LRER does granger-cause LTB for at least one panelvar (Country).	

Source: Dumitrescu and Hurlin (2012).

[1] For (Z-bar) and (Zbar tilde) statistics, p-values are provided based on the standard normal distribution.

4.2. Co-Integration Test

The present study found the variables of interest, I (0) and I (1), besides a bidirectional causality relationship. Co-integration tests are performed to look for a long-term relationship among the variables. Table 7 shows the results of the Westerland test (Westerlund, 2007). In both the linear and non-linear specifications, the Westerlund (2007) co-integration test fails to reject the null hypothesis of no co-integration between the variables for at least two statistics, Gt and Pt. Therefore, it is concluded that the real exchange rate and the trade balance are moving together, implying a long-term relationship.

Table 7. Westerlund (2007) panel co-integration test.

	Linear model statistics	Non-linear model statistics
Gt	-2.221*** (0.002)	-3.264*** (0.000)
Ga	-6.319 (0.372)	-4.159 (0.983)
Pt	-7.703*** (0.001)	-10.182*** (0.000)
Pa	-5.435** (0.015)	-4.254 (0.504)

Note: ***, ** indicate the statistical significant at 5%, and 10 % confidence level, respectively. P-values are in parentheses. H0: no co-integration; Gt and Ga test the co-integration for each country individually, Pt and Pa test the co-integration of the panel as a whole.

4.3. Estimation Results

The ARDL/NARDL model was used to detect the J-curve phenomenon. Four lags of the real exchange rate change (LRER) were included in Equation 4. The coefficients of the first lags of the real exchange rate are expected to be negative and then turn positive.

4.3.1. Panel ARDL Results

The next step is to estimate the relationship between trade balance and real exchange rate using the mean group (MG), the pooled mean group (PMG) and the dynamic fixed-effect (DFE) methods after confirming the existence of the co-integration relationship between them. Using the error correction ARDL (4 4 4 4) structures[2], estimation results and the outcome of the Hausman tests are reported in Table 8. The Hausman test failed to reject the null hypothesis to decide between the MG and PMG techniques (p-value = 0.872), which suggested PMG as the best estimator.

Part (A) of Table 8 presents the long-term results. The error correction coefficient was significantly negative, pointing to a long-term co-integrating relationship between trade balance, real exchange rate, and the rest of the control variables. Under the PMG estimation, the long-term coefficient of LRER was statistically insignificant, which shows that the real exchange rate depreciation has no impact on the trade balance in the long term. On the other hand, the coefficient of $LRGDP_{SAU}$ is (-0.533) and statistically significant. This estimation shows that the trade balance will decrease by 0.533% for an increase of 1% in Saudi income. However, LRGDP doesn't affect the trade balance since its coefficient is not significant in the long term.

The short-term impact of the real exchange rate and other explanatory variables on the trade balance is in part (B) of Table 8. The short-term coefficient of the real exchange rate (LRER) at the first lag is negative and statistically significant (-1.014) at 5% significance, which shows that the real exchange rate depreciation deteriorates the trade balance. The second lag coefficient is positive but non-significant; however, this is consistent with the literature. This implies that the depreciation of the Saudi Riyal will not be able to improve the trade balance of Saudi Arabia. Therefore neither the J-curve nor the new definition of the J-curve holds (Rose & Yellen, 1989).

To distinguish between the effect of positive (depreciation) and negative (appreciation) variation of the real exchange rate on the trade balance, the NARDL approach of Shin (2014) is used.

4.3.2. Panel NARDL Results

The Westerlund (2007) test results in Table 5 provide non-linear co-integration between the interest variables for all the statistics. Therefore, the study followed the same steps as the linear ARDL model. The next step entailed testing for the short and long-term asymmetry by performing a standard Wald test Shin (2014). This test checks the null hypothesis of symmetry against the alternative of asymmetry after estimating a non-linear ARDL model. Thus, based on equation (5), the long-term asymmetry is performed by testing the null hypothesis ($H_0: \theta_3 = \theta_4$). At the same time, the null hypothesis took the following form to test for short-

[2] The optimal lag structure was selected using the AIC criterion following the recommendations of Liew (2004).

term asymmetry: ($H_0: \gamma^1 = \gamma^2$). Estimation results of the error correction NARDL specification are presented in Table 9. Table 9 shows that the error-correction coefficient estimates are significant and negative, indicating the existing of the long-term relationship between trade balance and real exchange rate. Moreover, the Hausman test of long-term homogeneity restriction is not rejected, proving that the PMG estimator is more suitable for the analysis than MG and DFE. Therefore, the remainder of the study focuses on the PMG approach.

Table 8. Panel ARDL estimation results.

Variables	**Linear panel ARDL**		
	PMG coefficient	**MG coefficient**	**DFE coefficient**
Part A: Long-term estimates			
$(LRER)$	-0.104 (0.455)	8.460 (0.330)	0.096 (0.673)
$(LRGDP)$	-0.011 (0.836)	-24.739 (0.353)	-0.163 (0.345)
$(\mathrm{LRGDP}_{\mathrm{SAU}})$	-0.533*** (0.003)	14.023 (0.407)	-0.517* (0.056)
Part B: Short-term estimates			
Error correction term	-0.227*** (0.000)	-0.467*** (0.000)	-0.245*** (0.000)
$(\Delta LRER)$	-1.014** (0.032)	-1.106* (0.061)	-0.031 (0.735)
$(\Delta LRER)_{t-1}$	0.042 (0.855)	0.850 (0.100)	-0.010 (0.818)
$(\Delta LRER)_{t-2}$			
$(\Delta LRER)_{t-3}$			
$(\Delta LRER)_{t-4}$			
Constant	0.031** (0.049)	9.686 (0.523)	3.969 (0.000)
Hausman test	1.23 (0.872)		

Note: *, **, and *** Indicate significance at 10 %, 5 % and 1% respectively. P-values are in parentheses. The best model selected through the AIC criterion is ARDL (1 2 2 2).

The empirical results of the Wald test for long-term asymmetries show that the real exchange rate has an asymmetric impact on the trade balance, while the response is symmetric in the short term. In the long-term, the results of the non-linear ARDL model Table 9 after decomposing the real exchange rate variable (LRER) show that the integration of the asymmetry assumption indicates the asymmetric response of trade balance to the depreciation and the appreciation of the real exchange rate variable. Indeed, the long-term coefficients of the negative and positive changes in the real exchange rate are significantly negative but differ in size. Such results corroborate the existence of an asymmetric effect where, unlike the linear ARDL model, appreciation and depreciation of the real exchange rate always exert a symmetric impact on the trade balance. In the short term, the estimated real exchange rate coefficients using the non-linear ARDL model remain insignificant for all lags, which indicates the absence of the real exchange rate impact on the trade balance in the short term.

In the long-term, the $\mathrm{GDP}_{\mathrm{SAU}}$ worsen the trade balance, which can be explained by an increase in imports since its coefficient is statistically significant and negative Table 9. This can be explained by the fact that the improvement in economic growth in Saudi Arabia has an unfavourable effect on the trade balance in the long term.

4.3.3. Disaggregated Bilateral Analysis

The study extends the analysis to estimate the ARDL/NARDL model between Saudi Arabia and its 13 most significant trading partners. Therefore, evaluating 13 linear models (ARDL) is necessary, in which the symmetry assumption is relevant. Moving towards asymmetry analysis requires non-linear models (NARDL), and 13 non-linear models were estimated. Akaike' Information Criterion (AIC) is used to select optimum models and presented in Table 10 and Table 11.

The J-Curve hypothesis is verified if positive ones follow negative coefficients. It indicated the trade balance deterioration initially, followed by an improvement due to currency depreciation. Using the error correction ARDL model Table 10, the J-curve hypothesis does not hold for any of the 13 countries. Indeed, it is observed that no specific short-term patterns are in line with such hypothesis. However, some short-term coefficients are significant (at the 10% level) in the relationship between the United States, Japan, Egypt, Australia, Saudi Arabia, and Kuwait. They indicated a significant short-term effect.

In the long-term, it is found that the real exchange rate carries a positive and significant coefficient (at the 10% level) only in the case of Egypt and Britain, which implies that a depreciation of the Saudi Riyal against the British Pound and Egyptian Pound will improve its trade balance. Thus, a short-term deterioration (that is if the new definition of the J-curve of Rose and Yellen (1989) is followed) by a long-term improvement in the balance of trade, the concept receives empirical support in Saudi Arabia's trade balance with Egypt and Britain. In the short term, the study found a negative sign for the coefficient of the variable, $\mathrm{LRER}_{\mathrm{POS}}$ (depreciation), followed by a positive sign for its lags, only in the case of Saudi Arabia's trade balance with China, the USA, and Korea. This is in line with the J-curve hypothesis.

In the long-term, 12 out of 13 cases of Saudi Arabia's trading partners show a significant effect of the depreciation of the Saudi Riyal on the trade balance. However, this effect is positive only in the case of Turkey, Britain and Australia, which is in line with the new definition of the J-curve by Rose and Yellen (1989). For the rest of the countries, there is a deterioration in the trade balance.

Table 9. Panel NARDL estimation results.

Variables	**Non-linear panel ARDL**		
	PMG coefficient	**MG coefficient**	**DFE coefficient**
Long-term estimates			
(LRER_pos)	-0.353* (0.022)	-14.607 (0.167)	0.121 (0.610)
(LRER_neg)	-0.519*** (0.000)	-6.605 (0.216)	0.136 (0.586)
(LRGDP)	-0.057 (0.459)	9.208 (0.230)	-0.167 (0.339)
($LRGDP_{SAU}$)	-0.567*** (0.001)	-6.930* (0.061)	-0.501* (0.090)
Short-term estimates			
Error correction term	-0.172*** (0.000)	-0.565*** (0.000)	-0.244*** (0.000)
(ΔLRER_pos)	-14.839 (0.243)	6.410 (0.341)	0.001 (0.989)
$(\Delta LRER\_pos)_{t-1}$	3.575 (0.360)	-2.304 (0.309)	-0.017 (0.757)
$(\Delta LRER\_pos)_{t-2}$			
$(\Delta LRER\_pos)_{t-3}$			
$(\Delta LRER\_pos)_{t-4}$			
(ΔLRER_neg)	1.071 (0.551)	-1.636*** (0.002)	-0.046 (0.729)
$(\Delta LRER\_neg)_{t-1}$	-1.219 (0.154)	1.272*** (0.005)	-0.018 (0.854)
$(\Delta LRER\_neg)_{t-2}$			
$(\Delta LRER\_neg)_{t-3}$			
$(\Delta LRER\_neg)_{t-4}$			
Constant	2.778*** (0.000)	14.245 (0.493)	3.902*** (0.001)
Hausman test	1.52 (0.911)		
WSR	1.10 (0.294)		
WLR	5.04 (0.046)		

Note: * Indicate significance at 10 %, and *** at 1 %. P-values are in parentheses. WLR, WSR denote Wald tests for the null hypothesis of the long run and short run symmetry, respectively.

Figure 1 depicts the dynamic asymmetric multiplier of the NARDL model and reveals a short-term asymmetric effect of the real exchange rate changes on the trade balance for China, Japan, Turkey and Australia and the long-term asymmetric impact for Australia, India and Egypt. The effect is symmetric for the rest of the cases. This finding is in line with the results of the asymmetric effects test presented in Part (C) of Table 11. For more consistency in the results, some diagnostic statistics are shown at the bottom of Tables 10 and 11. First, a negative and significant error correction coefficient is observed, which indicates evidence of an adjustment of the variables toward their long-term equilibrium values.

Moreover, the models are checked for misspecification using Ramsey' RESET test. The results show that the statistic is insignificant for all the cases except Oman and Kuwait, indicating the absence of unspecified models. The study also tested the stability of each model using CUSUM and CUSUMSQ tests. All specifications are found stable. Thus, these results indicate the econometric sufficiency of the study's estimated model and the reliability of the estimates.

Table 10. Coefficient estimates of optimum linear ARDL models and diagnostics.

Model	China	USA	ARE	IND	JPN	KOR	EGY	TUR	GB	AUS	KWT	OMN	VNM
Panel A: Short-term estimates													
dlRER													
t-1	-1.313	-6.995	-0.847	-0.102	-0.068	-0.042	-1.988	0.104		-3.049	-4.728	0.504	0.534
	(0.420)	(0.082)	(0.101)	(0.369)	(0.622)	(0.503)	(0.004)	(0.406)		(0.028)	(0.015)	(0.316)	(0.155)
t-2		-0.085	3.224		-0.082		-3.262				0.761	0.382	0.682
		(0.983)	(0.037)		(0499)		(0.001)				(0.689)	(0.342)	(0.194)
t-3		-3.852			-0.169		-4.267					0.324	0.201
		(0.250)			(0.076)		(0.001)					(0.364)	(0.295)
t-4					-0.198		-5.704					-0.201	0.034
					(0.006)		(0.002)					(0.477)	(0.622)
Panel B: Long-term estimates													
LRER	3.120	37.581	2.376	1.879	0.052	0.147	2.746	-0.052	-0.466	-81.210	-0.435	-0.194	-0.092
	(0.768)	(0.736)	(0.198)	(0.828)	(0.942)	(0.186)	(0.080)	(0.754)	(0.084)	(0.960)	(0.809)	(0.386)	(0.781)
LRGDP	-5.477	-10.038	-9.273	4.306	3.055	2.796	3.488	0.089	4.550	-140.925	2.254	-2.107	0.984
	(0.263)	(0.662)	(0.010)	(0.652)	(0.653)	(0.000)	(0.018)	(0.183)	(0.000)	(0.955)	(0.030)	(0.097)	(0.216)
$LRGDP_{SAU}$	8.086	18.867	8.616	-10.374	-0.224	-2.560	-8.526	-0.958	-1.709	76.801	-2.382		-4.050
	(0.317)	(0.684)	0.044)	(0.726)	(0.686)	(0.000)	(0.025)	(0.007)	(0.001)	(0.955)	(0.022)		(0.102)
Panel C: Diagnostics													
F	1.294	1.097	9.353	1.868	1.406	9.263	26.561	6.932	7.728	1.157	4.856	3.548	25.497
ECM(-1)	-0.292	-0.129	-0.935	-0.082	-0.255	-0.992	-0.487	-1.060	-1.840	0.012	-0.522	-1.412	-1.723
	(0.207)	(0.673)	(0.000)	(0.778)	(0.231)	(0.000)	(0.016)	(0.000)	(0.001)	(0.960)	(0.002)	(0.232)	(0.207)
RESET	1.860	7.046	0.748	1.726	3.140	2.150	0.008	0.860	1.220	4.581	0.139	0.411	0.012
	(0.188)	(0.019)	(0.435)	(0.203)	(0.106)	(0.170)	(0.927)	(0.364)	(0.295)	(0.048)	(0.712)	(0.545)	(0.911)
CUSUM	Stable	Stable	Stable	Stable	Stable	Stable	Stable	Stable	Stable	Stable	Stable	Stable	Stable
CUSUMSQ	Not stable	Stable	Stable	Not stable	Stable	Stable	Stable	Not stable	Stable	Stable	Stable	Stable	Stable
Lags	(1,1,1,1)	(1,3,4,1)	(1,1,1,1)	(3,1,0,0)	(3,4,1,1)	(2,1,2,1)	(4,4,4,3)	(2,1,0,1)	(4,0,4,1)	(3,1,4,4)	(1,2,0,1)	(4,4,4,0)	(4,4,4,4)

Note: RESET: Ramsey's test for function form. It is distributed as $\chi 2$ with one degree of freedom.
CUSUM: Cumulative sum of recursive residuals, CUSUMSQ: Cumulative sum of squares of recursive residuals.
The number inside the parenthesis under the coefficient is the p-value. ECM denotes the error-correction term.

Table 11. Coefficient estimates of optimum non-linear ARDL models and diagnostics.

Model	China	USA	ARE	IND	JPN	KOR	EGY	TUR	GB	AUS	KWT	OMN	VNM
Panel A: Short-term estimates													
dlRERPOS	-6.871 (0.055)	-0.803 (0.625)	-23.233 (0.041)	-0.558 (0.202)	-1.986 (0.011)	-1.435 (0.058)	-0.508 (0.300)	-0.536 (0.120)	-2.459 (0.311)	-3.870 (0.002)	-14.362 (0.006)	-0.160 (0.179)	-5.398 (0.018)
t-1	14.300 (0.003)	14.590 (0.035)		-0.166 (0.401)	-0.240 (0.673)	0.185 (0.018)	-3.453 (0.028)	-0.778 (0.031)	-13.170 (0.041)		-3.206 (0.494)	0.205 (0.106)	0.901 (0.229)
t-2		4.344 (0.340)		-0.207 (0.397)	-0.878 (0.048)	0.094 (0.121)			-7.502 (0.104)				
t-3									-3.477 (0.114)				
t-4													
dlRERNEG		-5.998 (0.121)		0.330 (0.086)	0.083 (0.401)	0.069 (0.395)	-1.466 (0.031)		7.673 (0.063)		23.327 (0.092)		-0.134 (0.019)
t-1		-2.709 (0.232)		0.953 (0.067)	-2.336 (0.004)	-0.479 (0.417)	834.7 (0.033)		8.518 (0.111)		-21.129 (0.002)		-0.856 (0.515)
t-2		-6.879 (0.025)		0.161 (0.486)	-0.405 (0.467)		833.4 (0.033)		3.411 (0.327)		-0.731 (0.181)		1.000 (0.212)
t-3		1.625 (0.287)			-1.030 (0.025)				4.377 (0.396)		-0.774 (0.130)		
t-4													
Panel B: Long-term estimates													
lRERPOS	-29.202 (0.000)	-18.704 (0.035)	-7.681 (0.170)	-1.038 (0.042)	0.320 (0.654)	-1.016 (0.331)	0.232 (0.699)	0.437 (0.069)	7.224 (0.062)	1.437 (0.051)	-0.399 (0.773)	-0.281 (0.099)	-4.637 (0.000)
LRERNEG	-9.790 (0.002)	-14.014 (0.033)	0.398 (0.792)	-0.787 (0.151)	0.256 (0.728)	-0.859 (0.390)	-834.9 (0.033)	0.487 (0.143)	12.041 (0.078)	0.373 (0.693)	31.386 (0.011)	-0.088 (0.644)	-4.823 (0.000)
LRGDP	3.622 (0.000)	22.531 (0.012)	-5.134 (0.045)	3.451 (0.023)	-0.204 (0.901)	6.007 (0.022)	1.390 (0.008)	0.181 (0.040)	19.912 (0.009)	-1.330 (0.370)	2.606 (0.051)	-1.543 (0.583)	4.064 (0.000)
$LRGDP_{SAU}$	-2.533 (0.023)	-9.695 (0.008)	1.869 (0.285)	-3.641 (0.046)	-0.047 (0.898)	-3.789 (0.021)	-4.227 (0.010)	-1.701 (0.002)	-6.639 (0.014)		0.386 (0.820)	0.974 (0.741)	-7.195 (0.000)
Panel C: Diagnostics													
F	7.737	8.086	9.784	3.612	6.804	9.939	3.949	3.985	6.589	3.319	7.202	3.574	83.445
ECM(-1)	-1.128 (0.000)	-0.326 (0.000)	-0.905 (0.000)	-0.255 (0.001)	-0.638 (0.000)	-1.201 (0.000)	-0.097 (0.000)	-0.696 (0.000)	-1.990 (0.002)	-0.040 (0.000)	-1.563 (0.000)	-0.688 (0.001)	-0.946 (0.000)
RESET	2.831 (0.116)	0.003 (0.954)	0.008 (0.932)	1.515 (0.285)	2.170 (0.214)	0.004 (0.949)	0.073 (0.794)	2.651 (0.127)	0.478 (0.560)	1.822 (0.194)	0.202 (0.668)	0.874 (0.402)	17.839 (0.013)
CUSUM	Stable	Stable	Stable	Stable	Stable	Stable	Stable	Stable	Stable	Stable	Stable	Stable	Stable
CUSUMSQ	Stable	Stable	Stable	Stable	Stable	Stable	Stable	Not stable	Stable	Stable	Stable	Stable	Stable
WSR	3.535 (0.033)	3.581 (0.095)	0.018 (0.979)	1.165 (0.341)	12.91 (0.007)	3.379 (0.140)	0.796 (0.423)	3.733 (0.058)	0.593 (0.466)	3.017 (0.092)	1.091 (0.331)	0.822 (0.431)	1.748 (0.317)
WLR	0.422 (0.551)	2.840 (0.130)	0.088 (0.785)	3.358 (0.082)	38.290 (0.000)	0.275 (0.628)	3.395 (0.064)	0.046 (0.840)	0.073 (0.794)	3.361 (0.080)	0.033 (0.859)	0.021 (0.929)	3.729 (0.193)
Optimal lags	(1 2 0 2 0)	(1 3 4 4 4)	(1 1 0 1 0)	(1 3 3 3 3)	(1 3 4 4 4)	(3 3 2 1 3)	(1 2 3 1 3)	(1 2 0 0 2)	(1 4 4 4 4)	(1 1 0 0 0)	(1 2 3 4 4)	(1 2 0 2 2)	(1 2 3 3 2)

Note: WLR, WSR: Wald test for the null hypothesis of the long run and short run symmetry, respectively.
RESET: Ramsey's test for function form. It is distributed as $\chi 2$ with one degree of freedom.
CUSUM: Cumulative Sum of Recursive Residuals, CUSUMSQ: Cumulative Sum of squares of recursive residuals.
The number inside the parenthesis under the coefficient is the p-value. ECM is the error-correction term.

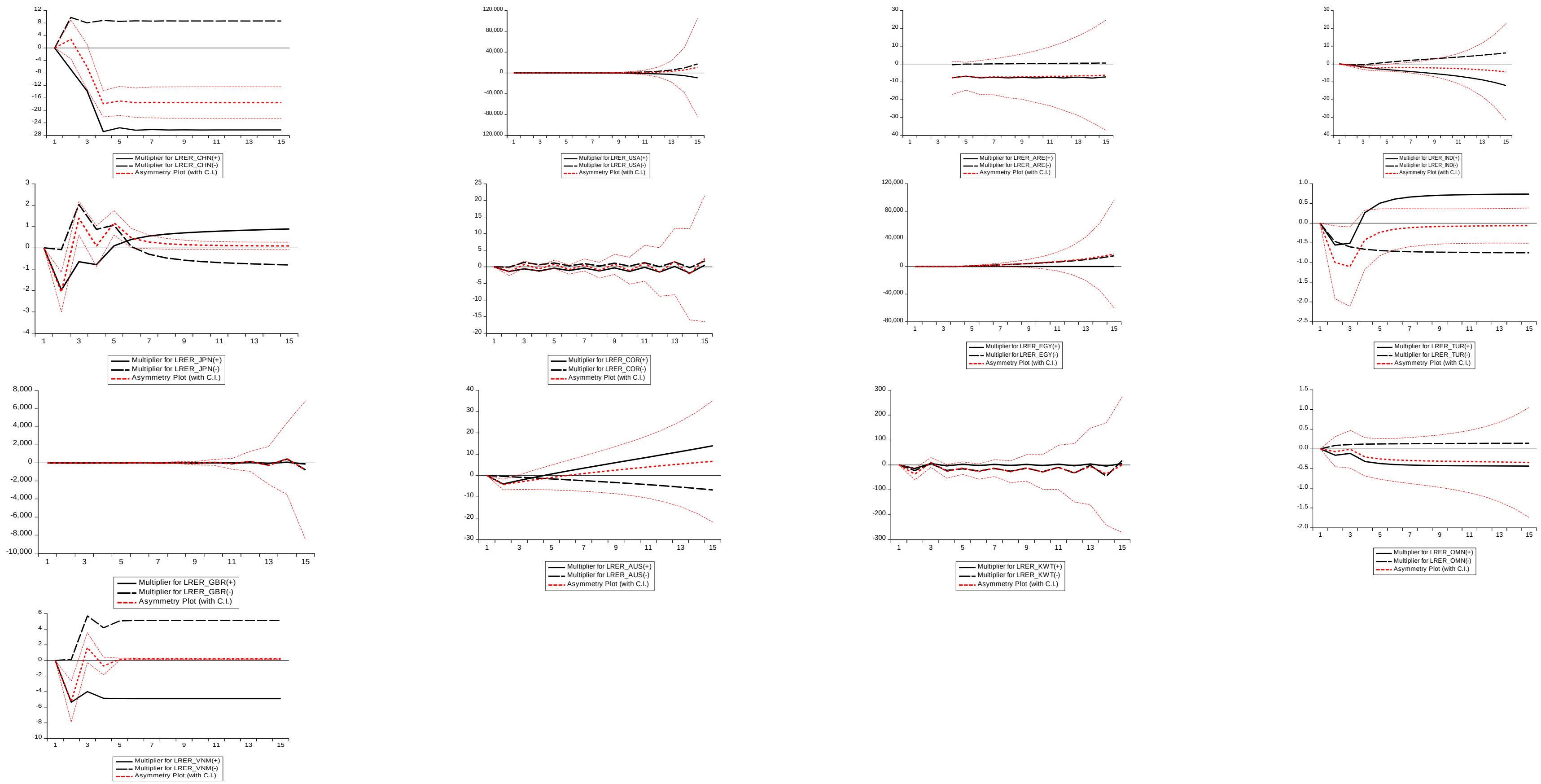

Figure 1. NARDL dynamic asymmetric multiplier.

5. Conclusion

The study has estimated the short and long-term impact of the real exchange rate on the trade balance in Saudi Arabia from 1990 to 2020 by using aggregate trade balance and bilateral trade balance approaches. First, the study considered aggregate data on the trade balance between Saudi Arabia and its major trading partners based on the analysis with a panel ARDL model. The estimation results allow the study to suggest that currency devaluation does not affect the trade balance, neither in the short-term nor in the long-term, specifically in Saudi Arabia. However, the aggregate trade balance approach could have provided a misleading result if the trade balance response to real exchange rate movements differs from one trading partner. Therefore, an extension of the study was subsequently conducted, using disaggregated data on the bilateral trade balance between Saudi Arabia and its major trading partners.

The study used the non-linear ARDL model of Shin (2014) to isolate currency depreciation from appreciations, either in aggregated or disaggregated data analysis, to uncover the real exchange rate changes that they have symmetric or asymmetric effects on the trade balance. The study concluded that the trade balance responds asymmetrically to the depreciation and appreciation of the Saudi Riyal for China, Japan, Turkey and Australia in the short term and Australia, India and Egypt in the long term.. The policy conclusion is that Saudi Arabia should keep its stable exchange rate for a lengthy period of time because it cannot normally rely on the depreciation of the Saudi Riyal as a policy weapon to improve its trade balance.

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Appendix

Data Definitions and Sources

A. Data

Annual data over the period 1990-2020 come from the following sources:

- Data on nominal exchange rate are obtained from the OANDA website.
- GDP and price index data are sourced from the World Bank' World Development Indicators database.
- The IMF Direction of Trade Statistics (DOTS) provides data on bilateral imports and exports.

B. Variables

- TB_j = Saudi Arabia' trade balance with trading partner j defined as the ratio of Saudi Arabia' exports to country j over her imports from country j.
- $RGDP_{SAU}$ = Index of Saudi Arabia' real GDP.
- $RGDP_J$ = Index of Real GDP of partner j.
- RER_j = Bilateral real exchange rate between riyal and partner j' currency. It is defined as $(CPI_j xNER_j)/CPI_{SAU}$, where CPI_{SAU} is Saudi' consumer price index, CPI_j is the trading partner' consumer price index, and NER_j is the nominal bilateral exchange rate defined as the number of Riyal per unit of partner j' currency. Thus, an increase in RER reflects the real depreciation of the Riyal.