Testing J-Curve Phenomenon in Vietnam: An Autoregressive Distributed Lag (ARDL) Approach

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Abstract. The assessment of factors having impacts on trade balance, especially exchange rate, is very important for effective implementation of macroeconomic policy. This paper investigates the existence of the short-run and long-run impacts of real exchange rate on trade balance in Vietnam by employing an Autoregressive Distributed Lag (ARDL) approach using quarterly data ranging from 2000Q1 to 2015Q4. Our results present the evidence of both short-term and long-term effects. In the short-run, Error Correction Model (ECM) based on ARDL approach indicates that real exchange rate has negative impact on trade balance. Also, impulse response functions based on ECM exhibit J-curve pattern of trade balance. In the long-run, real exchange rate has positive impact on trade balance. The stability of the long-run trade balance equations is also checked through CUSUM and CUSUMSQ stability tests.

1 Introduction and Literature Review

Devaluation is normally considered to have negative effect on trade balance in the short-run as well as positive one in the long-run, which refers to the term "J-curve" that has been widely studied since its first introduction in 1973; see, e.g., [24]. J-curve effect can be explained by the lagged adjustment of quantities to the changes in prices right after the devaluation occurred, which worsens trade balance in the short-run due to the increasing import value and the decreasing export value; see, e.g., [21,24]. In the long-run, however, the quantities can be appropriately adjusted to the prices, which fosters trade balance. Consequently, policy makers try to exploit the long-run favorable impact of devaluation to improve trade balance. The well-known Marshall-Lerner condition states that the absolute sum of long-run export and import elasticities of demand should be greater than one so as to make such devaluation effective.

Many researchers have tested the J-curve phenomenon in various countries. Although they apply different econometric methods, their studies can be

L. H. Anh et al. (eds.), *Econometrics for Financial Applications*, Studies in Computational Intelligence 760, https://doi.org/10.1007/978-3-319-73150-6_39

classified into two categories based on the types of data: aggregate and disaggregated ones. Studies with aggregate data normally tried to test the existence of J-curve in a country by treating all her main trading partners as a whole and building aggregate variables which can represent incomes and exchange rates of all her trading partners. Studies with disaggregated data, on the other hand, tried to find the occurrence of J-curve in the relationship between a country with each of her main trading partners.

Regarding studies employing aggregate data, the findings are mixed. An intensive research by Bahmani-Oskooee and Alse testing J-curve phenomenon in 41 countries found the evidence of J-curve in Costa Rica, Ireland, Netherlands and Turkey; see, e.g., [3]. Also, Halicioglu showed that J-curve existed in Turkey; see, e.g., [19]. Bahmani-Oskooee and Kutan, however, did not detect J-curve in Turkey as well as 7 East European countries (Cyprus, Czech Republic, Hungary, Poland, Romania, Slovakia, and Ukraine); see, e.g., [10]. Rather, they concluded that Croatia, Bulgaria and Russia witnessed J-curve effect, which supported the result of Stučka in terms of the evidence of J-curve in Croatia; see, e.g., [10,34]. Anju and Uma found the proof of J-curve in Japan; see, e.g., [1]. Nevertheless, using Johansens cointegration technique and impulse response function when examining 7 countries including Indonesia, Japan, Korea, Malaysia, Philippines, Singapore and Thailand, Lal and Lowinger reported J-curve phenomenon in all countries except for Japan; see, e.g., [23]. Trinh indicated that J-curve effect happened in Vietnam; see, e.g., [35]. Similarly, Kyophilavong, Shahbaz and Uddin confirmed the occurrence of J-curve in Laos; see, e.g., [22]. Besides, Felmingham found no sign of J-curve in Australia; see, e.g., [16]. Bahmani-Oskooee and Gelan detected no trace of J-curve in 9 African countries including Burundi, Egypt, Kenya, Mauritius, Morocco, Nigeria, Sierra Leone, South Africa and Tanzania, which went in line with the findings of Ziramba and Chifamba about the case of South Africa; see, e.g., [6,38].

Regarding studies employing disaggregated data, the results also varied. As researchers faced bias with the application of aggregate data, they have utilized disaggregated data at 2 levels: bilateral and industry ones. Firstly, at bilateral level, Rose and Yellen found no evidence of J-curve for the case of USA from 1960 to 1985; see, e.g., [32]. Bahmani-Oskooee and Brooks did not find J-curve proof in USA, either; see, e.g., [4]. Bahmani-Oskooee and Kantipong analyzed the trade between Thailand and her 5 main partners (alphabetically listed as Germany, Japan, Singapore, UK and USA), reporting that J-curve appeared only in the trade with USA and Japan; see, e.g., [9]. Wilson examined bilateral data of Korea, Malaysia and Singapore in trading with Japan and USA and noticed J-curve in the pair Korea-USA only; see, e.g., [37]. For China, Bahmani-Oskooee and Wang discovered no J-curve; see, e.g., [11]. Halicioglu reported no indication of J-curve in Turkey; see, e.g., [18]. Bahmani-Oskooee and Harvey studied data between Singapore and her 13 largest partners (alphabetically listed as Australia, Canada, China, Hong Kong, India, Japan, Korea, Malaysia, Philippines, Saudi Arabia, Thailand, UK and USA) and witnessed J-curve effect in the trade between Singapore and Canada, Philippines, Saudi Arabia and USA; see, e.g., [8]. Dash researched the trade between India and her 4 major partners (alphabetically listed as Germany, Japan, UK and USA) and demonstrated J-curve effect in India-Germany and India-Japan cases; see, e.g., [14]. Secondly, at industry level, Baek tested J-curve hypothesis of 5 forest products (softwood lumber, hardwood lumber, panel/plywood product, logs and chips, and other wood product) in the trade between USA and Canada, and little evidence was found; see, e.g., [2]. Bahmani-Oskooee and Mitra detected J-curve phenomenon in 8 out of 38 industries in India-USA trade; see, e.g., [5]. Bahmani-Oskooee and Hajilee observed the proof of J-curve in 23 out of 87 industries in the trade between Sweden and USA; see, e.g., [7]. Šimáková and Stavárek, analyzed 10 product groups in Czech Republic's trade relations with Germany, Slovakia, Poland, France, Italy and Austria and reported no sign of J-curve; see, e.g., [33]. Vural employed disaggregated data at industry level for the case of Turkey (in relationship with her major trading partner Germany) and revealed J-curve appearance in 20 out of 96 industries; see, e.g., [36].

2 Theoretical Framework

We start by reviewing the standard "two-country" model of trade which was used by Rose and Yellen and Stučka; see, e.g., [32,34]. The requirement of this model is that imported and exported goods cannot totally substitute for domestic goods. Hence, the majority of traded goods' demand and supply elasticities can be estimated; see, e.g., [34]. The volume of imports demanded domestically and the volume of imports demanded by the rest of the world are displayed in Eqs. (1) and (2) respectively:

$$D_m = D_m(Y, p_m), \frac{\partial D_m}{\partial Y} > 0, \frac{\partial D_m}{\partial p_m} < 0. \tag{1}$$

$$D_m^* = D_m^*(Y^*, p_m^*), \frac{\partial D_m^*}{\partial Y^*} > 0, \frac{\partial D_m^*}{\partial p_m^*} < 0. \tag{2}$$

where $D_m(D_m^*)$ is the quantity of goods imported by home country (the rest of the world); $Y(Y^*)$ is the real income of home country (the rest of the world); p_m is the relative price of imported goods of home country, calculated as the ratio between the price of imported goods (measured in home currency) and the overall price level of home country; p_m^* is the relative price of imported goods of the rest of the world, calculated as the ratio between the price of imported goods (measured in the rest of the world currency) and the overall price level of the rest of the world. The real incomes have positive correlations with the volumes of goods imported while the relative prices have negative ones.

Under perfect competition assumption, the volume of goods exported by home country and the volume of goods exported by the rest of the world are given in Eqs. (3) and (4) respectively:

$$S_x = S_x(p_x), \frac{\partial S_x}{\partial p_x} > 0. \tag{3}$$

$$S_x^* = S_x^*(p_x^*), \frac{\partial S_x^*}{\partial p_x^*} > 0. \tag{4}$$

where $S_x(S_x^*)$ is the quantity of goods exported by home country (the rest of the world); p_x is the relative price of exported goods of home country, calculated as the ratio between the price of exported goods (measured in home currency) and the overall price level of home country; p_x^* is the relative price of exported goods of the rest of the world, calculated as the ratio between the price of exported goods (measured in the rest of the world currency) and the overall price level of the rest of the world. The relative prices have positive correlations with the quantities of goods exported.

Call E the nominal exchange rate between home country currency and the rest of the world currency (1 unit of the rest of the world currency = E units of home country currency). Call e the real exchange rate between home country currency and the rest of the world currency. Call P_m the price of imported goods of home country (measured in home currency). Call P_x^* the price of exported goods of the rest of the world (measured in the rest of the world currency). Call P the overall price level of home country. Call P^* the overall price level of the rest of the world. The relationship between p_m and p_x^* is demonstrated as:

$$p_m = \frac{P_m}{P} = \frac{E \cdot P_x^*}{P} = \frac{E \cdot P^*}{P} \cdot \frac{P_x^*}{P^*} = e \cdot p_x^*. \tag{5}$$

Similarly, the relationship between p_m^* and p_x is as follows:

$$p_m^* = \frac{p_x}{e}. \tag{6}$$

In equilibrium, the volume of goods imported by home country equals the volume of goods exported by the rest of the world and the volume of goods imported by the rest of the world equals the volume of goods exported by home country:

$$D_m = S_x^*. \tag{7}$$

$$D_m^* = S_x. \tag{8}$$

Call B the real value of trade balance of home country, defined as the real value of export minus the real value of import:

$$B = p_x \cdot S_x - p_m \cdot D_m = p_x \cdot D_m^* - e \cdot p_x^* \cdot D_m. \tag{9}$$

Equations from (1) to (8) can be solved for D_m, D_m^*, p_x, p_x^* as functions of e, Y and Y^*. Consequently, B can be expressed as a "partial reduced form":

$$B = B(e, Y, Y^*), \frac{\partial B}{\partial e} > 0, \frac{\partial B}{\partial Y} < 0, \frac{\partial B}{\partial Y^*} > 0. \tag{10}$$

In Eq. (10), real exchange rate (e) and real income of the rest of the world (Y^*) have positive correlations with trade balance (B) while real income of home country (Y) has negative one.

The trade balance as the difference between export value and import value faces a weakness which is sensitive to the unit of measurement; see, e.g., [4]. Accordingly, we apply the definition provided by Ziramba and Chifamba which defines trade balance as the ratio between export value and import value; see, e.g., [38]. The natural logarithm form of trade balance is as follows:

$$\ln B_t = \pi \cdot \ln e_t + \delta \cdot \ln Y_t + \alpha \cdot \ln Y_t^*. \quad (11)$$

From Eq. (11), π is expected to be positive, and if so, the Marshall-Lerner condition is satisfied; see, e.g., [38]. δ is expected to be negative and α is expected to be positive.

3 Estimation Methodology, Sample, Data and Results

Estimation Methodology. Our theoretical framework follows the work of Rose and Yellen and Stučka, while our empirical methodology follows that of Ziramba and Chifamba; see, e.g., [32,34,38]. The empirical equation is modeled as following:

$$TB_t = \alpha + \beta_1 \cdot REER_t + \beta_2 \cdot GDP_t + \beta_3 \cdot GDP_t^* + \varepsilon_t. \quad (12)$$

where TB, $REER$, GDP, GDP^* represent trade balance, real effective exchange rate, domestic output and foreign output respectively. We use $REER$ to represent real exchange rate since it can measure the value of VND in relation to the currencies of major trading partners of Vietnam.

Many methods could be used for analyzing the cointegration of the trade balance's function. Among them, there are 2 common methods including the residual-based one introduced by Engle and Granger and the maximum likelihood-based one introduced by Johansen and Juselius. Both of these methods require that the variables have the same order of integration; see, e.g., [15,20]. In case this requirement is not met, Autoregressive Distributed Lag (ARDL) is an optimal alternative as it does not need the classification of I(0) and I(1) variables; see, e.g., [30,31]. Thus, unit root test is not necessary when employing ARDL approach for cointegration test. Besides, ARDL approach has several more advantages. First, in terms of the required sample size, ARDL approach needs a smaller size than the Johansen cointegration technique; see, e.g., [17]. Second, if some regressors in the model are endogenous, the ARDL approach can provide unbiased long-run estimates associated with valid t statistics; see, e.g., [25,26]. Third, it can measure the short-term and long-term effects of independent variables on the dependent variable in only one equation without the need of solving a set of equations; see, e.g., [13].

Due to the above advantages, we apply ARDL approach, which is widely used in empirical study, in this paper to analyze the trade balanceof Vietnam.

The specified trade balance function of Eq. (12) can be written as unrestricted error correction version of ARDL model as the following:

$$\begin{aligned}\Delta TB_t = \alpha + \sum_{i=1}^{p_1}(\beta_{1,i} \cdot \Delta TB_{t-i}) + \sum_{j=0}^{p_2}(\beta_{2,j} \cdot \Delta REER_{t-j}) \\ + \sum_{k=0}^{p_3}(\beta_{3,k} \cdot \Delta GDP_{t-k}) + \sum_{l=0}^{p_4}(\beta_{4,l} \cdot \Delta GDP^*_{t-l}) \\ +\lambda_1 \cdot TB_{t-1} + \lambda_2 \cdot REER_{t-1} + \lambda_3 \cdot GDP_{t-1} + \lambda_4 \cdot GDP^*_{t-1} + \varepsilon_t. \quad (13)\end{aligned}$$

The ARDL procedure begins by doing the check for existence of the long-run relation among the variables in the function by utilizing "bound tests". The null hypothesis of no cointegration (or no long-run relationship) is shown by H0: $\lambda_1 = \lambda_2 = \lambda_3 = \lambda_4 = 0$. The alternative hypothesis is H1: $\lambda_1 \neq \lambda_2 \neq \lambda_3 \neq \lambda_4 \neq 0$. These hypotheses are tested by computing the F-statistics and compare it with the two sets of critical values (one set is calculated under I(0) variable assumption and the other is calculated under I(1) assumption) of the F-statistics; see, e.g., [29,31]. If the F-statistics is higher than the upper bound of the critical value, we reject H0. In contrast, if the F-statistics is below the lower bound, we cannot reject H0. In case the F-statistics is between the lower and upper bounds, the result is inconclusive.

The next step is that, after checking the occurrence of cointegration among variables, we choose the optimal lag orders of the variables using Schwarz Bayesian Criteria (SBC); see, e.g., [29]. The appropriate selection of the lag orders of variables is very important because it can help identify the true dynamics of the models. In order to verify the performance of the model, we conduct the diagnostic tests to check some issues including the serial correlation, functional form, normality, and heteroscedasticity; see, e.g., [28]. Furthermore, we also apply Cumulative Sum (CUSUM) and cumulative sum of squares (CUSUMSQ) of recursive residuals tests to assess the stability of the model; see, e.g., [12]. In addition, we use the impulse response function based on obtained ECM to examine the response of the trade balance to the real exchange rate.

Estimation Sample and Data. We use quarterly data from International Financial Statistics (IFS) and Direction of Trade Statistics (DOTS) of IMF in this paper. The time range is from 2000(1) to 2015(4). The trade balance (TB) is defined as the ratio of Vietnam's export value to import value. GDP is Vietnam's real GDP index. GDP^* is the foreign real GDP index and it is the sum total of real GDP indices of 22 trading partners after each of the index is multiplied by their respective percentage of export and import volume in trading with Vietnam. $REER$ is the real effective exchange rate. REER is the geometric mean of real exchange rates between VND and 22 trading partners' currencies associated with the respective percentage of export and import volume of each partner in trading with Vietnam. These 22 partners occupy approximately 90% of trade volume of Vietnam. All variables are in index forms with base period 2000(1) = 100 and converted into natural logarithms.

The empirical results. In order for F-test is valid for cointegration "bounds test", we need to use unit root test to confirm that the variables are not integrated at I(2); see, e.g. [27].

We apply the Augmented Dickey-Fuller (ADF) test and the Phillips-Perron (PP) test for our study. Table 1 reports the test results for the four variables.

All variables are in natural logarithms, D is the first difference operator.

From Table 1, we can see that TB, GDP, and GDP^* are stationary at their level forms, meaning that the order of integration is I(0). $REER$ is non-stationary at its level form, but stationary in first-difference, meaning that the order of integration of REER is I(1).

Table 1. ADF and PP tests results for non-stationarity of variables.

Variable	ADF test statistic	PP test statistic
TB	–6.003339***	–5.904744***
$REER$	–1.982632	–2.270239
GDP	–8.307229***	–8.315656***
GDP^*	–7.549758***	–7.680978***
$D(TB)$	–17.52242***	–28.91540***
$D(REER)$	–5.395644***	–5.364851***
$D(GDP)$	–15.70245***	–26.84714***
$D(GDP^*)$	–14.11703***	–24.50858***

Note: ***, ** and * are respectively the 1%, 5% and 10% significance level.

We display the F-statistics results according to various lag orders (shown in Table 2) to check the existence of the cointegration among variables in the model.

Table 2. F-statistics of bound tests, 10% CV [2.711, 3.800], 5% CV [3.219, 4.378], 1% CV [4.385, 5.615].

Lag order	1	2	3	4	5	6
F-statistic	4.285*	2.709	5.080**	1.768	1.295	1.587

Note: ** and * are respectively the 5% and 10% significance level.

The results of Table 2 show that some of the values of F-statistics are above the upper bounds of the critical values (CV) of standard signicance levels; see, e.g., [29]. Hence, we reject the hypothesis H0, showing that there is cointegration or long-run relationship between trade balance and its determinants in case of Vietnam.

Next, we estimate Eq. (13) and use Schwartz Bayesian Criterion (SBC) to select the optimal lag length. The maximum lag order is 6, which allows saving the degree of freedom. From Table 3, ARDL(1,2,2,0) is obtained based on SBC.

Our model can account for about 60% of trade balance performance, meaning that real exchange rate, domestic income and world income can explain for 60%

Table 3. Autoregressive Distributed Lag Estimation Results (Autoregressive Distributed Lag Estimates ARDL(1,2,2,0) selected based on Schwarz Bayesian Criterion).

Dependent variable: TB		
Variable	Coefficient	t-statistic
TB_{t-1}	0.33421***	3.4368
$REER_t$	0.35542	0.61417
$REER_{t-1}$	–1.3553	–1.5345
$REER_{t-2}$	1.5016***	2.7032
GDP_t	–0.36290***	–4.9789
GDP_{t-1}	–0.036870	–0.45102
GDP_{t-2}	–0.44896***	–6.1911
GDP_t^*	–0.15673**	–2.1285
$constant$	5.5894***	3.7369
$Adj - R^2 = 0.60054$		
$DW - statistics = 1.8766$		
$SE\ of\ Regression = 0.080581$		
Diagnostic tests	A: Serial Correlation	$F(1,52) = 0.32779$ [0.569]
	B: Functional Form	$F(1,52) = 0.33912$ [0.563]
	C: Normality	$ChiSQ(2) = 3.8046$ [0.149]
	D: Heteroscedasticity	$F(1,60) = 0.51002$ [0.478]

Note: ***, ** and * are respectively the 1%, 5% and 10% significance level.
A: Lagrange multiplier test of residual serial correlation
B: Ramsey's RESET test using the square of the fitted values
C: Based on a test of skewness and kurtosis of residuals
D: Based on the regression of squared residuals on squared fitted values.

of Vietnam's trade balance, which is higher than that of the prior study in Vietnam; see, e.g., [35]. The reason is that our study includes the independent variable GDP^* (an important variable affecting trade balance); see, e.g., [32,38]. Also, we employ longer range time series. Besides, the real effective exchange rate used in our study represents the exchange rates between VND and the currencies of 22 countries occupying nearly 90% the trade volume of Vietnam, which is better than the prior study and reinforces the existence of J-curve in Vietnam; see, e.g., [35].

The diagnostic tests are also provided in Table 3, which suggests that there is no issue with this model. Thus, short-run and long-run impacts derived from the model are reliable.

The estimation of short-run coefficients of the ARDL model is shown in Table 4. In short-run, our results indicate that Vietnam's real income lagged 1 quarter has a positive and significant impact on trade balance at the current quarter. Vietnam's real income, foreign income and real exchange rate lagged

Table 4. The Error Correction Representation for the Selected ARDL model (Error Correction Representation for the Selected ARDL Model ARDL(1,2,2,0) selected based on Schwarz Bayesian Criterion).

Dependent variable: ΔTB		
Variable	Coefficient	t-statistic
$\Delta REER_t$	0.35542	0.61417
$\Delta REER_{t-1}$	–1.5016***	–2.7032
ΔGDP_t	–0.36290***	–4.9789
ΔGDP_{t-1}	0.44896***	6.1911
ΔGDP_t^*	–0.15673**	–2.1285
constant	5.5894***	3.7369
EC_{t-1}	–0.66579***	–6.8465
$Adj - R^2 = 0.73222$		

Note: ***, ** and * are respectively the 1%, 5% and 10% significance level.

1 quarter have negative and significant impacts on trade balance in the case of Vietnam. This indicates the negative impact of devaluation on trade balance in the short-run.

$$EC_{t-1} = TB_{t-1} - 0.75364 \cdot REER_{t-1} + 1.2748 \cdot GDP_{t-1} + 0.23541 \cdot GDP^*_{t-1} - 8.3951 \cdot constant. \quad (14)$$

From the table, it is obvious that the error correction term (EC_{t-1}) has negative sign and is statistically significant. This result once again provides the evidence of cointegration among variables in the model. This shows the speed of adjustment from short-run towards long-run. Specifically, the estimated value of EC_{t-1} is –0.66579 (about 66%) which indicates the speed of adjustment to equilibrium following short-run shocks.

The impulse response function based on obtained ECM allows us to examine the evolution of the trade balance over time subsequent to a real devaluation of VND. The results reported in Fig. 1 shows that the trade balance declines and hits bottom in the third quarter. After that, the trade balance

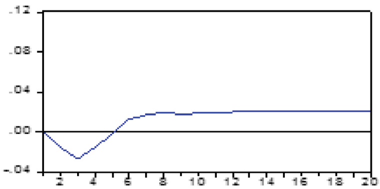

Fig. 1. Evolution of trade balance following real depreciation. Source: Authors' calculation based on response of TB to Cholesky One S.D. REER Innovation.

Table 5. Long-run estimation results (Estimated Long-Run Coefficients using the ARDL Approach ARDL(1,2,2,0) selected based on Schwarz Bayesian Criterion).

Dependent variable: TB		
Variable	Coefficient	t-statistic
$REER_t$	0.75364**	1.7973
GDP_t	–1.2748***	–4.9127
GDP_t^*	–0.23541**	–2.1733
$constant$	8.3951***	4.4704

Note: ***, ** and * are respectively the 1%, 5% and 10% significance level.

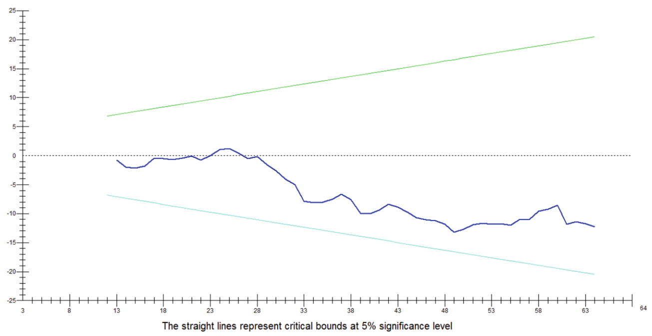

Fig. 2. Plot of cumulative sum of recursive residuals (CUSUM).

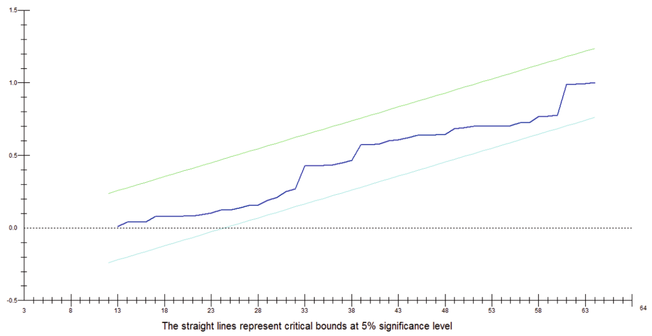

Fig. 3. Plot of cumulative sum of squares of recursive residuals (CUSUMSQ).

starts to improve. 6 quarters after devaluation, the new equilibrium is stable. Thus, impulse response result shows the occurrence of J-curve phenomenon in the relationship between real exchange rate and trade balance of Vietnam.

The results of long-run impacts are presented in Table 5. They indicate that the signs of the estimated coefficients of GDP and GDP^* are negative. The positive sign of real exchange rate's estimated coefficient implies that the devaluation of VND makes Vietnam's trade balance improve in the long-run.

To verify the stability of the estimated model, the tests of CUSUM and CUSUMSQ are employed in this study. Figures 2 and 3 respectively provide the graphs of CUSUM and CUSUMSQ statistics staying within the critical bounds indicating the stability of trade balance equation.

4 Conclusion

In this paper, by using aggregate data and employing ARDL approach, we find that the real effective exchange rate (between VND and a basket of 22 main trading partners' currencies) has statistically significant impacts on Vietnam's trade balance in both short-run and long-run.

Both results from analyzing ARDL model and impulse response function indicate the occurrence of J-curve phenomenon in Vietnam.

In short-run, a devaluation of real exchange rate causes considerably negative impact on Vietnam's trade balance. Nevertheless, this negative effect of real exchange rate on trade balance only lasts for 5 quarters. Trade balance will be improved from the fifth quarter after the devaluation. In the long-run, the increase of real exchange rate helps improve the trade balance.

Our study employs aggregate data to test the overall existence of J-curve in Vietnam by treating main trading partners of Vietnam as a whole. Consequently, we cannot examine the J-curve phenomenon in the trade between Vietnam and each of her major trading partners. Future researches could use disaggregated data at bilateral level between Vietnam and her largest trading countries or even at industry level for more detailed examination.

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