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Nonlinear Asymmetric Effects of Devaluation on Trade Balance: A Case Study of Iran and South Korea

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The present paper analyzes the existence of a long-run relationship between the trade balance and exchange rate of Iran and South Korea by a new approach. It proposes an asymmetric co-integrating NARDL model by two positive and negative partial sum decompositions which can use mixed I (0) and I (1) variables by bounds testing approach. The proposed tests are based on calculated F –statistics and Error Correction Model (ECM) used to test the importance of the lagged levels of variables in an equilibrium correction model. Non-Linear ARDL approach has employed to study the reaction of the trade balance to currency devaluation. The bounds test of the NARDL model implies the presence of cointegration among the variables. Our empirical findings demonstrate that currency devaluation has asymmetric effects on the trade balance of Iran and South Korea by non-linear modeling. Furthermore, the J-curve phenomenon is not supported in this case.

Keywords: Non-linear Modeling, Bilateral Trade Balance, Devaluation Currency
JEL Classification*:* *F*31, C12

1 Introduction

Progress in econometric methodology has caused economists to review existing theories. For the first time, Magee (1973) defined that the reaction of the trade balance to currency devaluation or depreciation is like “J” letter. In other words, currency depreciation affects the trade balance over time because of adjustment lags. These lags are recognition lag, production lag, delivery

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lag, etc. He demonstrated that when currency devaluation occurred, the trade balance will deteriorate until the lags come off. After some years, Rose and Yellen (1989) tested this phenomenon within new techniques. They applied cointegration and error-correction modeling. In their research, the bilateral trade relationship has analyzed instead of aggregate one for the U.S. trade flows by its trading partners. While the J curve was not supported again.

Many researchers and economists have studied this phenomenon in the world by different approaches. Some of them support the existence of J-curve, and the other ones reject it. But they couldn't achieve operational results.

Bahmani-Oskooee and Ratha (2004); Bahmani-Oskooee and Hegerty (2010) provided a general summary of the studies have done in this field. These two review articles reveal that every country has its literature and our country of concern, Iran, must be no exception.

Recently, Bahmani-Oskooee and Fariditavana (2015) have argued about the utilization of bilateral data by application of a non-linear approach. They use a non-linear approach to ascertain whether short-run and long-run effects are symmetric or asymmetric. The results of their research show that using non-linear approaches have more reliable results.

Thus, following Shin et al. (2013) $NARDL$ model is also employed. This model utilizes both positive and negative partial sum decompositions, allowing for the detection of asymmetric effects both in the long- and the short-run (Katrakilidis and Trachanas, 2012). According to Granger and Yoon (2002), two time series have hidden cointegration if their positive and negative components are cointegrated with each other. Nusair (2016) indicates that the $NARDL$ model has greater flexibility as it yields valid results regardless of whether the variables are $I(0)$, $I(1)$ or both of them.

In this paper, we attempt to examine whether the J curve phenomenon is supported in trading relation between Iran and South Korea, or not. Furthermore, the asymmetric effect of exchange rate on the trade balance is tested by using NARDL model. It means that the effects of positive and negative fluctuations are reviewed.

The remainder of this paper is organized as follows: In section 2, the employed methodology will be described, linear, and non-linear. After that, in section 3, the main feature of the database includes trade balance, real exchange rate, Iran and South Korea' income are discussed. And then the empirical result will be reported. The last section presents the conclusions and policy recommendation.

2 Econometric Methodology

2.1 Linear and Non-Linear Modeling

In this part, we introduce the autoregressive distributed lag ($ARDL$) and bounds test approach followed by Pesaran et al. (2001). By this way, it is possible to examine the existence of short-run and long-run relationship between dependent and explanatory variables. In this way the vector autoregressive (VAR) of order p is:

$$Z_t = \mu + \sum_{i=1}^{p} \beta_i Z_{t-i} \qquad (1)$$

Which Z_t includes the vector y_t and x_t, which y_t is the dependent variable and x_t is the vector of explanatory variables. In this study, the dependent variable is Iran's trade balance, and the explanatory variables include Iran's GDP, South Korea's GDP and real exchange rate. μ is the constant term related to both y and x variables ($\mu = [\mu_y . \mu_x]$), β_i is the vector autoregressive of lagged parameters and t show the time trend of each variable.

One of the benefits of this model as mentioned is the regressors can be I (0), I (1) or both of them by developing the vector error correction model ($VECM$) we can write:

$$\Delta Z_t = \mu + \alpha t + \lambda Z_{t-1} + \sum_{i=1}^{p-1} \gamma_i \Delta y_{t-i} + \sum_{i=0}^{p-1} \gamma_i \Delta x_{t-i} + \varepsilon_t \qquad (2)$$

In error correction models, Δ means the first difference operator and λ Shows the long-run multipliers that are distributed:

$$\lambda = \begin{bmatrix} \lambda_{yy} & \lambda_{yx} \\ \lambda_{xy} & \lambda_{xx} \end{bmatrix} \qquad (3)$$

The Vector autoregressive model ($VECM$) for testing the cointegration of y and the regressors, is applicable.

Following the literature we decompose the movement of the LnREX variable into $LNREX_t^+$ and $LNREX_t^-$ which are the partial sum process of positive and negative changes in $LnREX$:

$$\mathrm{POS} = \mathrm{LNREX}_t^+ = \sum_{j=1}^{t} \Delta\mathrm{LNREX}_j^+ = \sum_{j=1}^{t} \max(\Delta\mathrm{LNREX}_j . 0)$$

$$NEG = LNREX_t^- = \sum_{j=1}^{t} \Delta LNREX_j^- = \sum_{j=1}^{t} \min(\Delta LNREX_j.0)$$

Following Pesaran et al. (2001), the error correction model is:

$$\Delta Ln\ TB_{i.t} = \alpha + \sum_{k=1}^{n} \beta_k \Delta\ LnTB_{i.t-k} + \sum_{k=0}^{n} \gamma_k \Delta\ Ln\ Y_k^{IR} + \sum_{k=0}^{n} \delta_k\ \Delta Ln\ Y_{t-k}^{SK} + \sum_{k=0}^{n} \sigma_k\ \Delta LnREX_{i.t-k} + \mu_1 LnTB_{i.t-1} + \mu_2 LnY_{t-1}^{IR} + \mu_3 LnY_{t-1}^{SK} + \mu_4 LnREX_{i.t-1} + \omega_t \quad (4)$$

In this model all of the variables are presented in natural logarithm form, Δ is the first-difference operator and ω_t is a disturbance term. This equation is $ARDL$ model, which expresses that trade balance tends to be influenced and explained by its past values. Therefore, it includes the effects of previous shocks.

By using the non-linear approach of Shin et al. (2013), this phenomenon would be supported like asymmetric effects of exchange rate changes on the trade balance.

Separating currency appreciations from depreciation and using non- linear models in recent literature have improved discovering the significant link between the trade balance as the dependent and the exchange rate as the exogenous variable.

Bahmani-Oskooe et al. (2014) and Bahmani-Oskoee and Fariditavana (2015) have argued that the disapproval of J-curve in previous studies may be due to the asymmetric effects of the exchange rate. So they adjusted the model proposed by Shin et al. (2013) to consider asymmetric effects of exchange rate changes. In this way, the effects of depreciation and appreciation on the trade balance tested separately.

Now in equation (5) asymmetric adjustment of the exchange rate has introduced by decomposing the changes in the exchange rate. We determine the partial sum of positive changes by POS and partial sum of negative ones by NEG.

$$\Delta Ln\ TB_{i.t} = \alpha + \sum_{k=1}^{n_1} \beta_k\ \Delta Ln\ TB_{i.t-k} + \sum_{k=0}^{n_2} \gamma_k\ \Delta Ln\ Y_{t-k}^{IR} + \sum_{k=0}^{n_3} \delta_k\ \Delta LnY_{t-k}^{SK} + \sum_{k=0}^{n_4} \sigma_k\ \Delta POS_{t-k} + \sum_{k=0}^{n_5} \rho_k\ \Delta NEG_{t-k} + \varphi_0\ LnTB_{i.t-1} + \varphi_1\ LnY_{t-1}^{IR} + \varphi_2\ LnY_{t-1}^{SK} + \varphi_3\ POS_{t-1} + \varphi_4 NEG_{t-1} + \varepsilon_t \quad (5)$$

Where, as it is mentioned in part 2.2:

$TB_{i.t}$ means the bilateral trade balance of Iran and its trading partner, South Korea. Y^{IR} and Y^{SK} are the GDP of these two countries, respectively. NEG and POS show the decomposition of the real exchange rate and t index expresses the time of them.

According to the literature and the number of available data, the optimum lags are determined by Swartz-Bayesian criterion. The long-run elasticities are the coefficient of the one lagged explanatory variable which has multiplied by a negative sign, divided by the coefficient of the one lagged dependent variable (Bardsen, 1989). In other words, these are normalized coefficients. The short-run effects are obtained by the coefficients of the first difference variables in the above equation.

The null and alternative hypotheses are:

$H_0: \varphi_0 = \varphi_1 = \varphi_2 = \varphi_3 = \varphi_4 = 0$ (No long-run relationship)
$H_A: \varphi_0 \neq \varphi_1 \neq \theta_2 \neq \varphi_3 \neq \varphi_4 \neq 0$ (Existing long-run relationship)

The calculated value of F-statistic compares to the critical values which are brought in the table CI (iii) of Pesaran et al. (2001). The lower bound values indicate that the explanatory variables are $I(0)$ which means that they are integrated of order 0, while the upper bound values suppose that they are $I(1)$ or integrated of order 1. If the calculated value of F is less than the lower bound value, H_0 Cannot be rejected so there is no long-run relationship between trade balance and its determinants and if it is greater than the upper bound value, they have a long-run relationship. While the computed F between these two values (lower and upper bound), the result is inconclusive. Finally, if we establish that the normalized estimated coefficient attached to the POS variable is significantly different from the normalized estimated coefficient attached to the NEG variable, there will be long-run asymmetric effects.

2.2 Data

In this study, there are four variables involved. Iran's trade balance is the dependent variable defined as the Iran imports from South Korea over its export to this partner. Iran's GDP, South Korea's GDP and real exchange rate[1] are explanatory ones. GDP of two countries have obtained from IMF[2], trade balance (import and export) from the Islamic Republic of Iran Customs and

[1] It should be noted that the exchange rate has two definitions. In this article it is the number of units of the Iran currency in terms of South Korea currency.
[2] International Monetary Funds

the exchange rate from the Central Bank of Islamic Republic of Iran. All of them are quarterly data from 1992 to 2016. It should be noted that all of these series are transformed to logarithm form because it leads to a reduction of the heteroscedasticity problem due to the compress the scale in which the variables are measured, so reducing a tenfold difference between two values to a twofold difference. (Gujarati, 1995)

As an application of this model, the trade balance of Iran to South Korea, which has been one of the major trade partners of Iran in this period, has been considered. The following shape represents the trend of trade balance of Iran against of this partner.

[1]

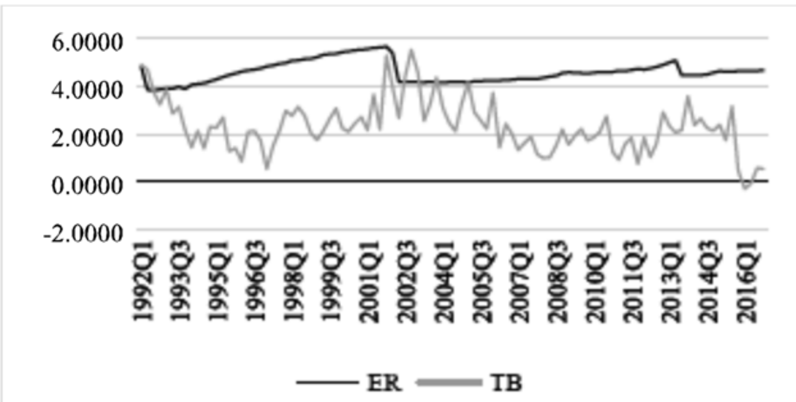

Figure 1. The Trend of Trade Balance of Iran against of South Korea Source: Research Findings

3 Empirical Results

We used augmented Dickey-Fuller (ADF), a common unit root test to check the order of the variable's integration. The tests performed to make sure that there is no I (2) variable, which is the requirement of $ARDL$ and $NARDL$ approach. The results show that all of the variables are $I\ (0)$ or $I\ (1)$. It is clear that in this situation, using the bound test approach or $ARDL$ model is the best method. The optimum lags are determined by Schwartz-Bayesian criteria. It represents that the optimum model is $ARDL(1.0.0.0.0)$.

[1] The numbers of Trade Balance are in million dollars.

3.1 Short-run and long-run relationship

The result of the estimation of equation (5) is shown in table (1). The coefficients and their p-value are reported in the table (1):

Table 1

Estimated Model for Trade balance between Iran and South Korea

Variable	Coefficient	t-Statistic	p-value
TB_{t-1}	-0.53	-5.68	0.00
$GDP_{IR.t-1}$	-4.29	-2.38	0.01
$GDP_{SK.t-1}$	2.56	1.91	0.05
NEG_{t-1}	0.10	0.58	0.56
POS_{t-1}	-5.83	-1.79	0.07
α'	8.94	3.24	0.00
$\Delta GDP_{IR.t}$	-4.29	-2.38	0.01
$\Delta GDP_{SK.t}$	2.56	1.91	0.05
ΔNEG_t	0.10	0.58	0.56
ΔPOS_t	-5.83	-1.79	0.07

Source: Research Findings[1]

The diagnostic tests indicate that the results of the model are suitable for a valid explanation. Therefore, the specification of the model is verified.

Table 2

Bound Test for Co-integration Analysis

Critical Value	F-Statistic	Lower Bound Value	Upper Bound Value
5%	7.07	3.00	4.22
10%	7.07	2.53	3.66

Source: Research Findings

The results of the bound co-integration test are reported in the table (2). It demonstrates that the null hypothesis against its alternative is rejected. The value of computed F-statistics is more than the upper critical bound value, so there is a long-run relationship between the defined variables.

The value of $ecm(-1)$ coefficient (-0.53) indicates that the short-run relationship will tend to a long-run relationship after about two years. To

[1] It should be noted that the model has estimated by Microfit and Eviews software. Although the results are the same but some parts of estimation process are not reported in Microfit, so the results and statistics reported in table (1) are obtained from the both software.

obtain a long-run relationship, the coefficients of lagged-level dependent and independent variables should be normalized by dividing them by (-0.53)[1] . These normalized coefficients are reported in the table (3):

Table 3
Long-run Estimated Coefficient

Variable	**Coefficient**
α'	16.82
GDP_{IR}	-8.08
GDP_{SK}	4.82
NEG	0.19
POS	-10.96

Source: Research Findings

The estimated long-run coefficients are all significant except NEG. We can write:

$$TB = 16.82 - 80.8GDP_{IR} + 4.82GDP_{SK} + 0.19NEG - 10.96POS \quad (6)$$

Equation (6) demonstrates the long-run relationship. It should be noted that due to our definition of the exchange rate, in the short-run, its coefficient should be positive and significant or positive and insignificant (deteriorate the trade balance), also significant and negative in the long-run (improve the trade balance), to support the J curve. Because according to our definition of the exchange rate, the increase in the exchange rate is equivalent to devaluation. So by the above definition, the increase of the exchange rate leads to a reduction of import and trade balance, its coefficient should be positive in short-run and negative in the long-run.[2] In our case, J-curve is not supported because this condition is not true.

As expected, the coefficient of Iran's GDP is negative and significant. It means the trade balance will improve by increasing Iran's GDP. And Korea's GDP is in the opposite direction.

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[1] The coefficient of lagged dependent variable.

[2] In most studies such as Bahmani-Oskooee (2016) to validate the presence of J-curve, the exchange rate defined as U.S. Dollar per the trading partner's currency value while in our case we use its inverse. So we must interpret the coefficients with opposite sign, that is raising our exchange rate means devaluation.

3.2 Stability Test

The cumulative sum test ($CUSUM$) is used to test the randomness of a sequence of zeroes and ones (Data plot will cover a data set with exactly two distinct values to a sequence of zeroes and ones). For this test, the zeros are converted to negative ones. This test is based on the maximum distance from zero of a random walk defined by the cumulative sum of the sequence. Figure (1) and (2) represent these results:

Figure 2. The Result of the CUSUM Test.

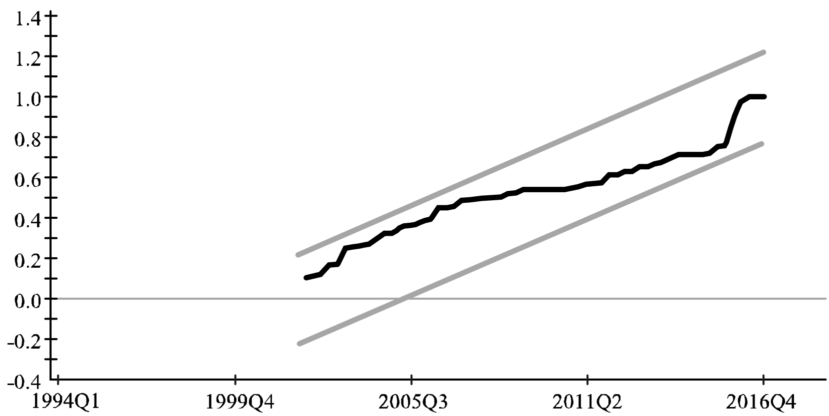

Figure 3. The Result of the CUSUMSQ Test.

We applied $CUSUM$ and $CUSUMSQ$ tests to the residuals of the optimum model. Figure (1) and (2) represent the results. The straight lines represent critical bounds at 5% significance level, so it's obvious that the coefficients are stable at 95% confidence level. The LM statistic which is distributed by χ^2 with four degrees of freedom, is 8.17 and Ramsey's RESET statistic is 0.43. The comparison of them to the critical values demonstrates that the model's residuals are autocorrelation free and have no misspecification. So these diagnostic tests confirm that the model is reliable in the 5% significance level.

4 Conclusion

After introducing the J curve phenomenon which reflects the reaction of the trade balance to currency devaluation by Magee (1973), other researchers tried to check the validity of the phenomenon for different countries and different data sets. Rose and Yellen (1989) proposed using bilateral trade balance instead of aggregate one. Some others, like Bahmni-Oskooee (2016) expressed that it should be studied as an asymmetric relationship followed by Shin et al. (2013). They believe that non-linear modeling can gain more accurate and more reliable results in applied researches.

The findings of our study using Non-linear ARDL explores that the calculated F- statistic is more than the value of the upper bound, so there is a long-run relationship between the model's variables. Also, the ECM (-1) illustrates that over time, it will be adjusted to the long-run relationship between the bilateral trade balance and real exchange rate.[1] Our estimated non-linear model by decomposing positive and negative fluctuations of the exchange rate shows that there is no evidence of J- curve between Iran and South Korea because the coefficient of POS is negative and significant and it is positive and insignificant for NEG in both short-run and long-run. In fact, in this model, devaluation will improve the trade balance from the beginning, and there isn't any delay. It can be due to the lack of manufacturing infrastructures in Iran and the exporting of raw material to South Korea.

Furthermore, the coefficients of POS and NEG decomposition imply that these effects in short-run and long-run are both asymmetric. It should be noted that this result is because of ascending the exchange rate in this period. So it can guide the policymakers to amend the foreign business due to the results.

[1] Due to the coefficient of it (-0.53), it lasts about 2 years.

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