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# REAL EXCHANGE RATES AND INDIA'S EXPORTS TO UNITED STATES: AN APPLICATION OF ARDL APPROACH

[1]*Swami Prasad Saxena*

[2]*Vasudha Gupta*

[1]*Professor (Macroeconomics and Finance), Department of Applied Business Economics, Dayalbagh Educational Institute, Dayalbagh, Agra, Uttar Pradesh 282005, IN*

[2]*Research Scholar, Department of Applied Business Economics, Dayalbagh Educational Institute, Dayalbagh, Agra, Uttar Pradesh 282005, IN*

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***Abstract***

*This paper examines both the long-run and short-run impact of real exchange rates and its volatility on India's exports to United States by using autoregressive distributed lag (ARDL) bound test on quarterly data spanning from 1991Q1-2018Q4. The results of sensitivity analysis conducted by using ARDL bound testing approach confirm that India's aggregate real exports are relatively more sensitive to the real exchange rates in the long-run but less responsive in the short-run. The empirical results failed to reject the null hypothesis of no short-run causality. The error correction term (ECT) is found to be negatively and statistically significant, which indicates the correctness of short-run shocks towards long-run equilibrium at the speed of 24 percent within a quarter.*

***Keywords:*** Real exchange rate, Volatility, Export, Error correction term, ARDL model.

***JEL Codes****:* F11, F31, F32

## 1.0 Introduction

Due to the unequal distribution and imperfect substitutability of some of the factors, no country is in position to produce all of its needs; consequently, international trade is indispensable for every nation of the world. The nations try to produce those goods in which they have comparative advantage and exchange the specialised products and services among others. Today, almost all the countries have opened their economies for trade and investment; and hence they maintain annual record of international transactions with rest of the world, commonly called as statement of balance of payments (BoP) for reference and future decisions. BoP shows the international financial position of a country and is considered as an economic barometer of the nation.

Trade, one of the major components of BoP is influenced by exchange rate fluctuations. Exchange rate, the rate at which one country's currency can be converted into another, plays a vital role in international trade of goods and services. As regards to exchange rate determination, a number of economists have propounded several methodologies. Some of the prominent theories of exchange rate determination include Purchasing Power Parity theory (Cassel, 1918) and Productivity Differential theory (Balassa and Samuelson, 1964). After the collapse of the fixed exchange rate system in 1971, some other economists put forth their view. The main among them are Flexible Price Monetary model (Frenkel, 1976), Sticky Price Monetary approach (Dornbush, 1976), Real Interest Rate Differential model (Frankel, 1979) and Sticky Price-Assets Monetary model (Hooper and Morton, 1982).

Since independence India, being a member of IMF, followed the par value system where external par value of Indian rupee was fixed with gold and UK pound sterling. India pegged its currency to the pound sterling (from December 1971 to September 1975) and to US dollar (from August 1971 to December 1991). After breakdown of Bretton-Woods system, the value of pound collapsed, and India witnessed misalignment of the rupee. To surmount the stress, India pegged its currency to the basket of 14 currencies, where exchange rate was officially determined by the RBI (Pattnaik et al., 2003).

The period after BoP crisis of 1991 witnessed two-step downward adjustment of 18-19 per cent in the exchange rate of the Indian rupee; adoption of liberalised exchange rate management system (LERMS) since 1992-93 whereby 40 per cent of foreign exchange earnings were to be surrendered at the official exchange rate while the remaining 60 per cent were to be converted at a market determined rate; and finally, in August 1994, government allowed 100 percent conversion of forex earnings on current account at market based rate (Ranadive and Burange, 2011). Now, exchange rate in India is determined by demand or supply position of foreign currencies, thus, affected by BoP situation of the country. A deficit in BoP account results into depreciation in the rate of exchange while a surplus in the BoP appreciates the exchange rate and strengthens the foreign exchange reserves.

The 1991 reform touched upon almost every aspect for the betterment of the Indian economy, particularly targeting the foreign exchange market (deregulation) and international trade (liberalization). India’s overall share of total world trade increased from 0.52 percent in 1991 to 2.12 percent in 2011 and 2.13 percent in 2018 (IMF, DoTs database). However, exchange rate and international trade are interconnected but it is complicated to predict the impact of exchange rate volatility on trade flow (imports and exports). In general, it is prescribed that weaker domestic currency stimulates exports and makes imports more expensive; but starting from 2002 onwards, the expected relationship seems to have been reversed. Veeramani (2008) observed that high export growth occurred despite REER appreciation in India over the period from 2002 to 2007. But, it does not imply that an appreciation in REER had no adverse impact on exports. The growth rate of exports might have been higher without REER appreciation.

The remainder of the paper is structured as; section two reviews the literature on exchange rate and international trade, the third section describes the data collection and methodology, the empirical results of export model are discussed in the section fourth and section fifth concludes the observations.

## 2.0 Review of Literature

The expected impact of exchange rate volatility on international trade activities can be positive or negative depending on the assumptions made on issues like the presence or absence of forward markets and other hedging instruments, the modelling of trader's risk preferences, the structure of production such as the prevalence of small firms, and the degree of economic integration (Auboin and Ruta, 2013 and Bahmani-Oskooee and Hegerty, 2007). A number of studies, however, support the view that a rise in exchange rate volatility results into a decrease in international trade volumes. If economic agents are risk averse, increased volatility in exchange rate increases uncertainty in the market and raises the cost of conducting international trade. Ethier (1973) mentioned that when firms know that their revenues depend on the future exchange rate, the exchange rate uncertainty will not affect the volume of trade.

Some researchers observed an indirect effect of exchange rate volatility on international trade. Viaene and Vries (1992) mentioned that the effects of increasing exchange rate volatility on importers and exporters might be different since they are located on different sides of the forward contract. According to this, if the trade balance and any forward risk premium are positive, exporters will lose and importers will benefit. Baak (2008) in a study on impact of the exchange rate volatility on trade between China and US observed negative impact of exchange rate volatility on China's exports to US, but, no effect on US exports.

Baak et al. (2007) in another study on impact of exchange rate volatility on exports in four East Asian countries (Hong Kong, South Korea, Singapore, and Thailand) found negative effect of exchange rate volatility on exports of selected countries. Panda and Mohanty (2015) by using Johansen cointegration examined long run effect of real exchange rate volatility on India's exports over the period from 1970-71 to 2011-12 and found negative effect of real exchange rate volatility on India's export. Broll and Eckwert (1999), Doyle (2001) and Ha (2019) claimed that exchange rate volatility and international trade are positively associated. Kang and Dagli (2018) in the context of the global financial crisis used gravity model to examine the impact of real exchange rates on exports of 72 economies over a period 2001–2015 and confirmed that real exchange rate has positive and significant effect on exports. Pham and Tran (2018) used ARDL model on aggregated and disaggregated trade data to assess the impact of VND/ CNY exchange rate on trade flows between Vietnam and China. They mentioned that volatility of exchange rate is more sensitive on export commodities than import commodities.

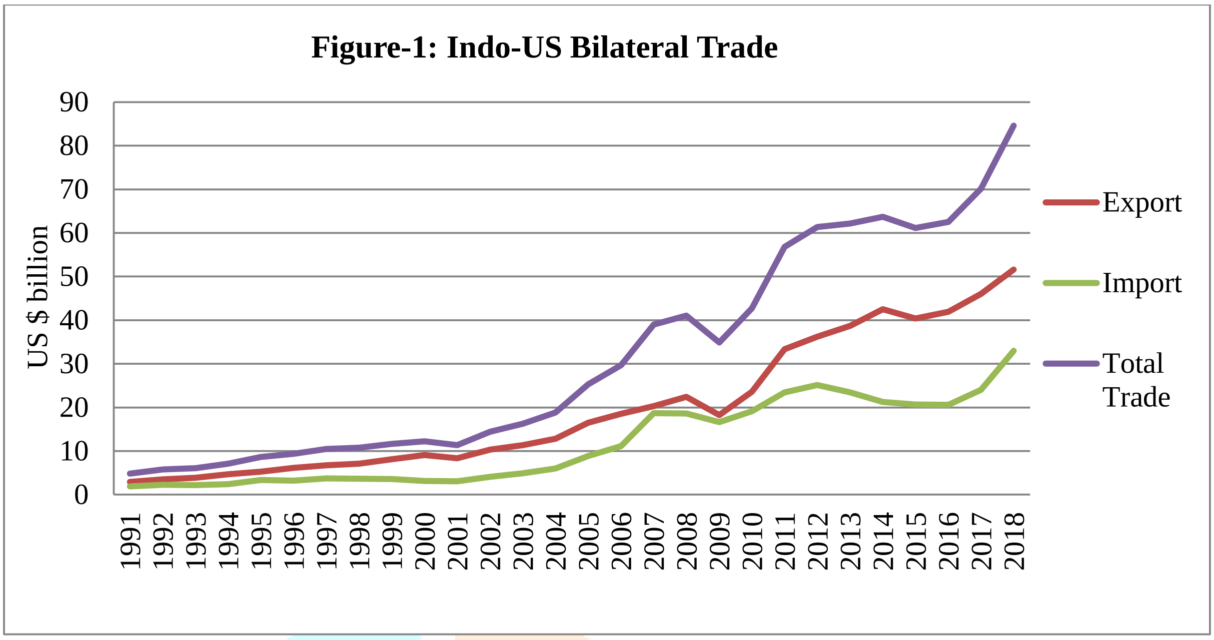
Ozturkand Kalyoncu (2009) by using Engle-Granger cointegration studied the impact of exchange rate volatility on the trade flows of six countries over the period from 1980–2005. The researchers observed long-run negative impact of exchange rate volatility on real exports for Pakistan, Poland, South Africa and South Korea, and a positive impact for Turkey and Hungary. They also observed exchange rate volatility to be more effective in short run for the sample countries except South Korea and Turkey. Alam (2010) estimated the effect of exchange rate volatility on Pakistan's aggregate export by employing ARDL model on the quarterly data from 1979 to 2005. The results revealed that real effective exchange volatility had significant negative impact of exchange rate volatility on Pakistan's exports in long-run and insignificant impact in short run. Chaudhary et al. (2016) in a study on the relationship between exchange rate volatility and foreign trade of major South-Asian and South-East Asian economies also observed long-run significant relationship between exchange rate volatility and exports in more than half of the sample countries. Alam et al. (2017) investigated the presence of long-run and short-run association of exchange rate volatility on Pakistan's bilateral aggregate exports with its major six trading partner countries viz. Germany, Japan, Saudi Arabia, UAE, UK and US. Due to difference in export elasticities they observed mixed results.

Baek (2012) employed ARDL approach to study the short-run and long-run effects of exchange rate fluctuations on disaggregated industry data of bilateral trade between Korea and Japan. The result indicated that Korea's exports and imports are relatively sensitive to the exchange rate in the short-run, but less responsive in the long-run. Bahmani-Oskooee et al. (2012) examined impact of exchange rate volatility on trade of 96 exporting and 29 importing industries of US with South Korea. They observed significant short-run effects of exchange rate volatility on most of the exporting and importing industries. In long run, however, only 16 export and 7 import industries were found to be affected by exchange rate volatility. Bahmani-Oskooee et al. (2016) in another study examined the impact of exchange rate volatility on trade of Pakistan's 44 export and 60 import industries with Japan and found that many industries were not affected by exchange rate volatility either in long-run or in the short-run. Bahmani-Oskooee and Aftab (2017) assessed the asymmetric effects of exchange rate volatility on 54 Malaysian export and 63 import industries involved in trade with the US. The result based on nonlinear ARDL model suggested that almost one third industries were affected by exchange rate volatility in asymmetric manner.

In India studies show both the presence and absence of link between exchange rates volatility and exports. Dholakia and Saradhi (2000) found significant relationship between exchange rate and export quantity but exchange rate volatility has no significant impact on the exports. Srinivasan and Kalaivani (2013) found a negative and significant relationship between the exchange rate volatility and real exports both in the short-run and long-run, implying that higher exchange rate fluctuation tends to reduce real exports in India. Bhattacharya and Mukherjee (2014) claimed that exports in India are mostly caused by other factors, not by the real exchange rate. Similarly, Haider and Adil (2017) indicated that real exchange rate has insignificant impact on exports. Several other researchers such as, Jayachandran (2013), Gondaliya and Dave (2015) and Panda and Mohanty (2015) made attempts in different ways to examine the impact of exchange rates volatility on the India's trade performance, none focused on the effect of real exchange rate volatility on India-US exports. Present study tries to fill this vacuum. It attempts to investigate the long-run and short-run impact of real exchange rate volatility on India's exports to US by employing bound test and error correction model.

Among the major trading partner countries, United States is India's largest trading partner. India enjoys a favourable balance of trade with United States at an increasing pace. The export grew at a compound annual growth rate (CAGR) of 11.22 percent while import grew by 11.17 percent from 1991 to 2018. India's bilateral trade with US has witnessed a significant jump from US$ 4.8 billion in 1991-92 to USD 84.62 billion in 2018-19 (about 10.17 percent of India's total trade). India's total exports to the US has increased at a rapid pace in recent years and stood at USD 51.61 billion in 2018-19 (approximately 15.97 percent of India's total exports) as against USD 46.07 billion during the year 2017-18. Likewise, United States is India's second largest import partner (after China) with 6.48

percent share in India's total imports during 2018-19. In 2018-19, India imports from United States stood at USD 33.00 billion as against USD 24.06 billion in 2017-18 (see Figure-1).




Source: Direction of Trade Statistics (complied), IMF Database

## 3.0 Data Collection and Methodology

### *3.1 Data Collection*

The paper considers quarterly data for the period from 1991-Q1 to 2018-Q4. All the variables such as India's exports to US, economic activity in US and exchange rate are collected from IMF - International Financial Statistics (IMF-IFS) and Direction of Trade Statistics (IMF-DOTS) database. For maintaining uniformity in analysis, all the data are taken in US Dollars.

For transforming nominal to real data (inflation adjustment), of variables under consideration the nominal data are deflated by their relevant price index. The description of variables is as follows:

*3.1.1 Real Export:* Most of the studies have used export price/ unit value index as the deflator for real export. However, there is no separate export price index and unit value (data available from 2004-Q4) for export in India. Therefore, for extracting real data on India's exports, the nominal data is deflated by consumer price indices (CPI) of India (see Alam, 2010 and Bhattacharyya and Rit, 2018).

$$X_t = ln\left(\frac{NX}{CPIi}\right)$$

Here, $X_t$ stand for India's real export to US, NX is India's nominal export to US and $CPI_i$ means Consumer price Index of India.

*3.1.2 Foreign Economic Activity:* Industrial production index (IPI) of United States is used as a proxy for foreign economic activity. It is expected that an increase in economic activity in industrial trading partner country should promote trade. In other words, industrial production growth in the US leads to an increase in India's exports to US. The same measure used as a proxy for economic activity in many recent studied such as, Doyle (2001), Oztuok (2009), Alam (2010), Bahamani-Oskoee (2017).

*3.1.3 Real Exchange Rate:* The real exchange rate (RER) is calculated by considering nominal exchange rate (NER) of INR-USD; consumer price indices of India (CPI*ind*) and the consumer price indices in US (CPI*us*) – (Base 2010=100) see for instance; Baak (2008),Srinivasan and Kalaivani (2013), Bahmani-Oskooee and Aftab (2017). The real exchange rate (RER) is calculated by using formula:

$$RER = ln\left(NER \times \frac{CPIus}{CPIind}\right)$$

*3.1.4 Real Exchange Rate Volatility:* Following, Baak et al. (2007), Baak (2008), Ozturk and Kalyoncu (2009) and Panda and Mohanty (2015) the exchange rate volatility is estimated by using moving average standard deviation. It is expressed as:

$$V_{ijt} = \sqrt{\frac{1}{\mathrm{m}} \sum_{k=tm}^{tn} \left(LnRER_{ijt+i-1} - \overline{LnRER_{ij}}\right)^2}$$

Here, $V_{ij}$ stands for India-US bilateral exchange rate volatility; t denotes for time (i.e., quarter); m represents number of periods (i.e., 2 period moving average); $LnRER_{ijt}$ is the natural log of real exchange rate; $\overline{LnRER}_{ij}$ is the mean of $LnRER_{ij}$ from k = tm (last quarter) to k = tn (first quarter).

Finally, all the variables are transformed into natural logarithms.

***3.2 Methodology***

Before applying the cointegration test, it is important to check the order of integration of all variables in time series analysis. If variables of interest are stationary at first difference i.e., I(1), then either Johansen or ARDL cointegration tests can be used. If variables are mixed order of integration or some are stationary at I(0) and others are stationary at I(1) then the ARDL method is most appropriated (Shrestha and Bhatta, 2018). One more advantage of ARDL model is that it is suitable for determining the cointegration in small size samples (Ghatak and Siddiki 2001). Based on the result of unit root test (see table-1), we employed ARDL approach.

The autoregressive distributed lag (ARDL) approach to cointegration and error correction model is used to investigate the long-run and short-run relationship among variables under consideration. Before implementing ARDL model, it is necessary to determine the optimum lag. It is also important to check whether data at selected lag length do not have problem of serial correlation. Once the orders of the lags in the ARDL model have been appropriately selected, then we can estimate the cointegration relationship using a simple Ordinary Least Square (OLS) method.

To examine the impact of exchange rate volatility on India’s exports to US, the model is specified as:

$$lnX_t^{ind} = a_0 + a_1\, lnRER_t + a_2 lnIP_t^{us} + a_3\, lnV_t + \varepsilon_t \quad \text{......} \quad (1)$$

In above equation (1) $lnX_t^{ind}$ represents natural log of India’s real exports to US, $lnRER_t$ stands for real effective exchange rate i.e., per dollar against Indian rupees, $InIP_t^{us}$ is industrial production indices of United States, ln $V_t$ refers to bilateral exchange rate volatility, t is for time, and $\varepsilon_t$ is the stochastic error term.

The equations ARDL model in the present study is specified as:

$$D\left(lnX_t^{ind}\right) = ά_0 + \sum_{i=1}^{p} ά_1 D(lnX_{t-i}) + \sum_{i=1}^{q} ά_2 D(lnRER_{t-i}) + \sum_{i=1}^{q} ά_3 D(lnIP_t^{us}{}_{t-i}) + \sum_{t=1}^{q} ά_4 D(lnV_{t-i}) + α_1\, lnX_{t-1} + α_2 lnRER_{t-1} + α_3 lnIP_{t-1}^{us} + α_4 lnV_{t-1} + ε_t \text{.............................}(2)$$

In equation 2, D represents first difference, p and q are the lag orders, Σ signs show summation coefficients of the short run effect of bilateral real exchange rate, industrial production in partner country and real exchange rate volatility on India's exports to US, and α estimates the long run relationship.

Here, null hypothesis ($H_0$) is that there is non-existence of the long run relationship ($α_1 = α_2 = α_3 = α_4 = 0$) and the alternative hypothesis ($H_1$) is that there exists long run relationship among variables under consideration, i.e., $α_1 \neq α_2 \neq α_3 \neq α_4 \neq 0$.

In ARDL model the bound testing is used to test the null hypothesis of no cointegration; and the value of F-statistics calculated by using Wald coefficient restrictions tests whether there exists long run relationship. If calculated value of F-statistics exceeds the upper critical value (given by Pesaran et al., 2001), it supports the rejection of null hypothesis and indicates that there exists long run relationship among variables under consideration. On the contrary, if calculated F- statistic value falls below a lower critical tabulated value, it supports the non- rejection (acceptance) of null hypothesis, meaning that there is no long run relationship exists. The F-statistics value falling between upper and lower bound indicates that result is inconclusive.

The short run model describing relationship between real exchange rate, US industrial production, and bilateral exchange rate volatility with India's exports to United States using error correction term is determined as:

$$D\left(lnX_t^{ind}\right) = ά_0 + \sum_{i=1}^{p} ά_1 D(lnX_{t-i}) + \sum_{i=1}^{q} ά_2 D(lnRER_{t-i}) + \sum_{i=1}^{q} ά_3 D(lnIP^{us}{}_{t-i}) + \sum_{t=1}^{q} ά_4 D(lnV_{t-i}) + \lambda ECT + ε_t \text{ .................................................................................. } (3)$$

In the above equation, all variables are previously defined. Where, symbol λ shows the speed of adjustment to the long run equilibrium after having a disturbance in the short run. Parameters $ά_1$, $ά_2$, $ά_3$, and $ά_4$ indicate short run dynamics.

## 4.0 Results and Discussion

This section contains the results of unit root test, ARDL model diagnostic test and stability test, long run and short run estimations of the variables used in the study.

### *4.1 Unit Root Test*

The unit root test is employed to verify the order of integration of the variables. A time series variables are said to be stationary or non-unit root if the statistical properties such as mean, variance and covariance, etc. all are constant overtime. The Augmented Dickey Fuller (ADF) Unit Root is used to check the stationarity of time series data of concerned variables.

**Table - 1: ADF Unit Root Test**

| Variables | t-statistic* | Critical value at 5% | P-value | Order of integration |
|---|---|---|---|---|
| LnX | -5.56 | -2.88** | 0.00 | I(1) |
| LnRER | -3.59 | -3.45*** | 0.03 | I(0) |
| $LnIP^{us}$ | -4.71 | -2.88** | 0.00 | I(1) |
| LnV | -7.74 | -2.88** | 0.00 | I(0) |
| * All tests are performed by using Schwarz Info criterion, ** denotes model with intercept, *** model with intercept and linear trend. | | | | |

Table - 1 makes it clear that all the variables are stationary either at I(0) or I(1); none of them are found to be stationary at I(2). Hence, ARDL model developed by Persaran et al. (2001) can be used for further analysis.

### *4.2 ARDL Model*

The results of most popular Schwarz information criterion (SIC) applied through VAR lag order selection criteria suggest lag 1 as most appropriate lag length for the model. To ascertain the goodness of fit of the model, the stability test i.e., cumulative sum of recursive residuals (CUSUM) test is applied (see fig 2and 3). For testing the null hypothesis 'there is no serial correlation in the model' Breusch-Godfrey Serial Correlation LM Test is used. It is accepted at 5 percent level of significance because the Chi-Square P value in our model (equation - 2) is 0.0708 (see table-2).

**Table - 2: LM Test**

| | | | |
|---|---|---|---|
| F-statistic | 3.05933 | Prob. F(1,98) | 0.0833 |
| Obs*R-squared | 3.26537 | Prob. Chi-Square(1) | 0.0708 |

#### *4.2.1 Bound F-test for Cointegration*

The Wald test is applied to check whether there exists cointegration. The test results presented in table-3 indicate that the value of F-statistics is greater than the upper bound value at 10 percent as well as 5 percent level of significance (Persaran et al., 2001); hence the null hypothesis of no cointegration is rejected. Thus, it is confirmed that there exists long run cointegration among the variables under consideration.

**Table - 3: Calculated F-statistics and Critical Value**

| Dependent variables | F-statistic | P-value | Outcome |
|---|---|---|---|
| $LNX^{ind}$ (LnX/LnRER, $LnIP^{US}$, LnV) | 6.628515 | 0.0001 | Cointegration |
| Level of significance | | 10 Percent | 5 Percent |
| Lower bound value, I(0) | | 4.04 | 4.94 |
| Upper bound value, I(1) | | 4.78 | 5.73 |

### *4.2.2 Long-run Estimations of Export Demand Function*

The results of long-term relationship of real exchange rate (LnRER), US industrial production ($LnIP^{us}$), and bilateral exchange rate volatility (LnV) with India's exports to US ($LnX^{ind}$) are shown in table-4. It shows negative (-0.996156) and statistically significant coefficient for real exchange rate (LnRER) meaning that one percent increase in real exchange rate will decrease the India's aggregate exports to US by 0.996 percent. In contrast, the coefficient of US industrial production ($LnIP^{us}$) is positive (1.528615) and statistically significant. It indicates that one percent increase in US industrial production will result into 1.529 percent increase the India's aggregate export demand in US. The impact of real exchange rate volatility (LnV) is not found to be statistically significant with India's exports to US.

**Table - 4: Long-run Export Model Analysis**

| Dependent variable | Independent variables | | |
|---|---|---|---|
| | LnRER | $LnIP^{us}$ | LnV |
| $LnX^{ind}$ | -0.996156 | 1.528615 | -0.133351 |
| t-statistics | -11.89470 | 19.16244 | -1.152595 |
| Prob. | 0.0000 | 0.0000 | 0.2516 |

### *4.2.3 Short-run Model and Error Correction Model Specification*

The short run relationships among the relevant variables shown in table 5 show that indicate that P-value of LM test Chi-Square is 0.7157; which means the null hypothesis is accepted at 5 percent level and there is no serial correlation in the model.

**Table - 5: Error Correction Representation of ARDL Model**

| Dependent variable d($LnX^{ind}$) | | | | Wald test |
|---|---|---|---|---|
| Independent variables | Coefficient | t-statistic | Prob. | |
| C | 0.011129 | 1.251109 | 0.2137 | |
| D(LnX(-1)) | -0.329365 | -3.441355 | 0.0008 | |
| D(LnRER(-1)) | -0.460220 | -1.571145 | 0.1192 | 0.1161 |
| D($LnIP^{us}$(-1)) | 0.20986 | 0.325274 | 0.7456 | 0.7450 |
| D(LnV(-1)) | 0.096881 | 1.044906 | 0.2985 | 0.2961 |
| ECT(-1) | -0.239939 | -2.909002 | 0.0044 | |
| Serial Correlation LM test Chi-Sq.= 0.7157 | | | | |

The result of Wald test explicates that the null hypothesis of no short run causality among the variables are accepted. It means, in short run, real exchange rate, economic activity in US and exchange rate volatility does not caused India's export demands in United States. The coefficient of error correction term (ECT) indicates the speed of adjustment towards long run equilibrium should be negative and statistically significant. The negative coefficient tells us the correction of the previous year's errors in the subsequent period. The result of our model reveals that the estimated coefficient of the ECT is negative and statistically significant at 5 percent level of significance. This indicates that 24 percent is the speed of adjustment of short run shocks to the long run equilibrium within a quarter.

### *4.3 Stability Test Parameter*

In this paper, to ascertain the goodness of fit of the model, the stability test i.e., cumulative sum of recursive residuals (CUSUM) test is applied. Figure 2 and 3 figures show that CUSUM value of both, the long run as well as short run model lies within the range (between the critical bounds) at 5 percent level of significance; hence it can be concluded that the models are structurally stable.

**Figure-2: CUSUM Test for Long-run Model**

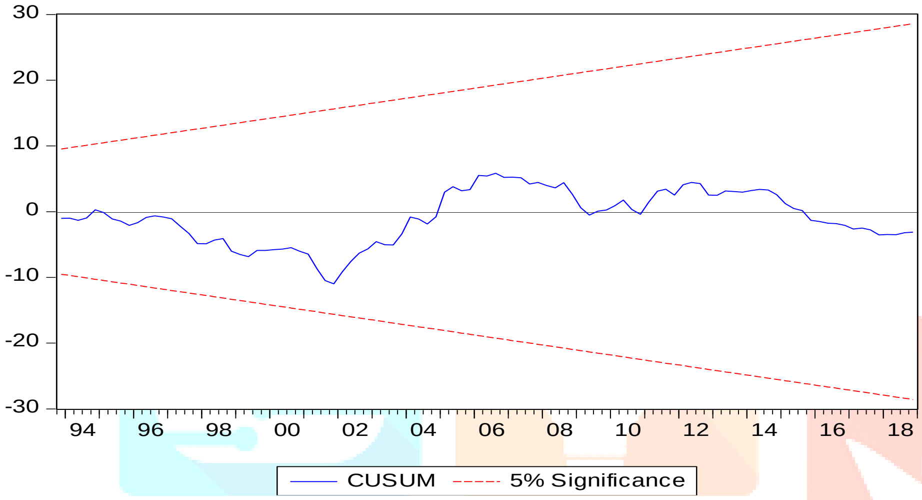
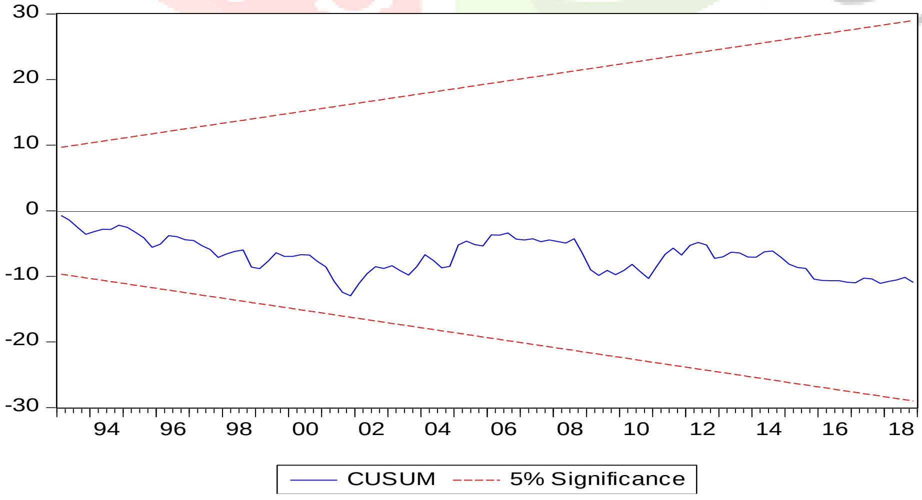



**Figure-3: CUSUM Test for Short-run Model**



## 5.0 Conclusion

This paper examines the impact of the real exchange rate and its volatility on India's aggregate exports to United States by using ARDL approach. The empirical results based on cointegration analysis reveal that in long-run, real exchange rates has significantly negative and US industrial production growth has significantly positive relation with India's exports to US. The real exchange rate volatility is found to have no significant relation with India's exports to US. The study, however did not observe dynamic short-run causality among the variables. The coefficient of error correction term is found to be negative and statistically significant; which explicated the adjustment of short run shocks towards long run equilibrium at the speed of 24 percent within a quarter. This study is limited to aggregated Indo-US trade data because of non-availability of the industry-wise/ commodity-wise quarterly data for the period under consideration. Future studies may examine the impact of exchange rate volatility on disaggregated trade data to document more comprehensive results.

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