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SENSITIVITY OF TRADE BALANCE TO EXCHANGE RATE DEPRECIATION: EVIDENCE FROM INDO-U.S. BILATERAL TRADE

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ABSTRACT

The fundamental economic theories presume a relationship between exchange rate and trade balance that depreciation in the exchange rate would affect trade balance. Magee (1973) formulated a hypothesis that for a given currency devaluation or depreciation, the trade balance reacts differently in short run and long run. It has been argued that with the depreciation of domestic currency the trade balance deteriorates in the short run and improves in the long run leading to J-shaped pattern of response. Since then some studies have empirically investigated the J-curve hypothesis with mixed results. The theory is hardly tested to Indian scenario. The present study, hence, examines the nature of response of India's trade balance to exchange rate shocks. The study specially focuses on the response of India's bilateral trade with U.S for continuous depreciation of Indian rupee against U.S dollar. The study uses monthly data for the period from 2009 to 2017. Using the VAR methodology, the Impulse Response Function has been fitted and the results do not have evidence for J-curve pattern of trade balance rather it appears to be 'inverted J-curve'.

Contribution/ Originality: This study contributes to the existing literature as it disproves the theoretical perception at least in Indian scenario that currency depreciation/devaluation would accelerate exports in the long run. The result has policy significant implications. The paper contributes immensely to the policy makers towards perusing appropriate exchange rate and export policies.

1. INTRODUCTION

Subsequent to the collapse of Bretton Woods Accord in 1973 many countries have gravitated towards floating exchange rate regime (Krugman and Baldwin, 1987) which triggered evolution of economic theories advocating that devaluation or depreciation of domestic currency vis-à-vis foreign currencies would generate improved trade balance. Theories argue that upon exchange rate depreciation, the trade balance deteriorates initially and sometime along the way it starts to improve, until it reaches its long run equilibrium. According to Bahmani-Oskooee and Scott (2010) the impact of currency depreciation varies in short and long run because of time lags involved in adjusting contracts, however, the quantity of exports or imports is temporarily fixed. The currency depreciation has price effect on imported and exported items. It has been believed by the literature that the price effect of exchange rate depreciation in the short run causes no impact on domestic and foreign demand as demand is inelastic in the short run. This deteriorates trade balance in the short run following to the depreciation. Whereas, in the long run the demand is more elastic to the changed prices. This accelerates exports of domestic products which are now cheaper and reduces import demand for goods from other countries as they are costlier after depreciation. This improves the trade balance in the long run. The time path through which the trade balance follows generates a J-curve (Junz and Rhomberg, 1973). The J-curve effect was first advocated by Magee (1973).

The series of economic reforms introduced since 1991 in India have radically changed the course of Indian economy. They led to higher growth, accelerated investment and intensified trade flows. The effects of these reforms in India have been profound on India's trade with U.S. With the transition from socialistic oriented growth approach to market oriented growth approach, India also moved from pegged exchange rate regime to floating exchange rate system with trade liberalisation. It is during this reforms period the Indian rupee depreciated by 196 percent from Rs.22.7 to Rs. 67.2 against U.S. dollar (Refer Annexure-1. for trends in exchange rate of Indian rupee against U.S. dollar). This generates a questions as to whether India's trade balance with U.S. has evolved responses for such massive rupee depreciation as predicted by Magee (1973). The present study, thus, is an attempt to examine whether such free fall of Indian rupee against U.S. dollar has created J-curve pattern of response of trade balance.

1.1. Overview of Indo-U.S. Trade

The rapid demographical transition in India attracts the global marketing giants. High growth of population, very large proportion of youth and speedy growth of middle and high income classes make India a potentially large market for global goods and services. The U.S continues to be the biggest trade partner of India for several years. According to the data from the U.S Census Bureau, India's exports to U.S increased by 51.6 percent annually during 1991-2016 from U.S $ 3,192.40 million to U.S $ 46,032.40 million. India's imports from U.S rose annually at 37.8 percent during the same period from U.S. $1,999.40 million to U.S. $ 21,652.30 million. Annexure-1 presents dynamics of trends in Indo-U.S. trade.

India's current exports to U.S are composed primarily by precious stones and metals mostly worked diamond and gold jewellery, woven and knit apparel, other textile articles, textile floor coverings, fish and sea food, iron and steel products, organic chemicals, machinery such as taps, valves, transmission shafts, gears, pistons, etc. Imports from U.S to India include sophisticated machineries in the areas of computers and their components, gas turbines and telecom, electrical machineries relating to recording/sound media, medical and surgical equipment, mini aircraft, spacecraft, diamond stones and jewellery, plastic, cotton, cotton waste and wood pulp.

2. REVIEW OF LITERATURE

The J-curve hypothesis has attracted abundant empirical research but the results are mixed and largely fragmented. The empirical investigation on the underlying subject has evolved over the period of time since the collapse of Bretton Woods Accord paving way for floating exchange rate in 1973 and revelation of Magee (1973) with new theory on floating exchange rate-trade balance relationship. The evolution of the empirical studies passed through three major phases. The initial studies were on aggregate trade data, while the later studies focused on bilateral trade and the latest studies are made on impact of exchange rate depreciation on sector–wise trade. One of the earliest noteworthy studies investigated the impact of exchange rate fluctuations on trade balance was by Haynes and Stone (1982). They studied on USA data and find no evidences to J-curve. Bahmani-Oskooee (1985) investigated for the J–curve pattern of response of trade balance for exchange rate depreciation in four countries but finds evidence to J-curve only in Thailand. Later, Krugman and Baldwin (1987) studied on the same subject for USA data and conclude that for a given dollar depreciation trade balance is affected negatively in the short run but recovers and improves in as the time progresses and hence, find evidence to support J-curve. The studies of

Rosensweig and Koch (1988) and Wassink and Carbaugh (1989) also found evidences to support J-curve hypothesis for USA, but in these cases the results draw up delayed J-curve. Subsequent to a unit shock of devaluation, the trade balance takes very longer duration to recover and improve. Rose and Yellen (1989) contradicted these results. Their study rejected J-curve hypothesis and found support to argue that exchange rate does not have any significant impact on trade balance either in developed or developing economies. Yet another study on USA data by Bahmani-Oskooee and Brooks (1999) using ARDL approach also provided similar results.

The intensifying rigour in testing the J-curve phenomena has evolved new methodologies in late 1990's. Demirden and Pastine (1995) suggested for application of impulse response function from the VAR model developed by Sims (1980) to ascertain the accurate trends in trade balance for the given depreciation in the exchange rate. Koop *et al.* (1996) and Pesaran and Shin (1998) improved further the methodological part of measuring J-curve by introducing general impulse response function which is an improvised version of the impulse response function. The generalised impulse response function controls for intermediate effects and is insensitive to the ordering of the variables (Bahmani-Oskooee and Scott, 2010) which lacks in erstwhile impulse response function. Koray and McMillin (1999) used VAR model with the application of impulse response function to examine the pattern of response of trade balance for exchange rate depreciation and find evidence to support J-curve pattern.

Wilson and Tat (2001) studied Singapore's trade relations with USA and found very little evidence to support J-curve hypothesis. Bahmani-Oskooee and Tatchawan (2001) studied the relationship between trade balance and exchange rate in emerging economies using ARDL approach and the results have evidences for J-curve hypothesis only in the case of Thailand's bilateral trade with U.S and Japan. Narayan (2004) used cointegration method to examine the response of trade balance to currency depreciation in New Zealand and found that the trade balance worsened for the first three years and improved thereafter, indicating the J-curve pattern. However, Singh (2004) did not find similar result for India. He estimated the balance of trade model to test the J-curve hypothesis and analysed the effect of exchange rate volatility on the balance of trade in India for quarterly data from 1975 to 1996. Using the ARCH and GARCH models the study found that exchange rate volatility does not significantly affect the balance of trade in India.

Narayan and Narayan (2004) studied to investigate whether J-curve adjustment behaviour exists in the aftermath of a devaluation of domestic currency in Fiji using ARDL approach and fully modified OLS approach. The results have the evidences of J-curve pattern of trade balance as response for shocks in currency devaluation. Another study of Narayan (2006) did not find support for J-curve in Chana. He investigated the nexus between China's trade balance and the real exchange rate vis-à-vis the USA. Using the bounds testing approach to cointegration, it was found that the study variables were cointergrated. The autoregressive distributed lag model showed no evidence for J-curve pattern. It was found that devaluation of the Chinese RMB improves the trade balance both in the short run as and long run.

Bahmani-Oskooee and Ali (2011) conducted a study for the data on 11 emerging European economies by applying ARDL and cointegration approach. They found J-curve pattern of trade balance as response for currency depreciation only in three countries -Bulgaria, Croatia and Russia. Duasa (2007) examined the short run and long run relationships between trade balance, real exchange rates, income and money supply in the case of Malaysia using ARDL bound testing approach to cointegration and error correction models. Variance decomposition and impulse response function are also used for further inferences. The results did not find evidences of short run and long run impact of exchange rate depreciation on trade balance in Malaysia. Similarly, Nasir *et al.* (2009) could not extract evidences for J-curve in Bangladesh. They studied bilateral trade balances of Bangladesh with five of her largest trade partners namely the United States, the United Kingdom, France, Italy and Germany. The study analysed quarterly data using ARDL approach to cointegration. Results were unable detect presence of persistent J-curve pattern in the trade balances for exchange rate depreciation.

However, a study by Petrovic and Grigoric (2010) exhibits the J-curve pattern of trade balance in Serbia for exchange rate depreciation. This study estimated VAR model. Adeniyi *et al.* (2011) ARDL methodology investigated the J-curve phenomena for four West African countries viz. Gambia, Nigeria, Ghana and Sierra Leone. The results are in conformity with theoretical J-curve pattern of relationship between currency depreciation and trade balance except for Nigeria. Guechari (2012) also arrived at similar conclusion. He estimated the effects of real effective exchange rate on Algeria's trade balance using cointegration techniques, error correction model (ECM) and impulse response function for quarterly data from 1981 to 2009. The results showed that exchange rate affects significantly and negatively in the short run while positively in the long run on the Algeria's bilateral trade balance with respect to US and France, thus supporting J-curve hypothesis.

Some of the most recent studies examined the J-curve effect of currency depreciation sector-wise. Umoru and Eboreime (2013) studied the Nigerian oil sector using bounds approach. They found that the J-curve was inverted. The response of trade balance to the exchange rate shocks was inverse to the J-curve path. Grigoryan (2015) studied the J-curve effect on trade balance in USA using VECM approach and found evidence for J-curve pattern. The depreciation of currency was causing the deterioration in trade balance initially, but the same improves in the longer time path.

From the review of prominent empirical literature, it is traced that despite abundant research works gone into testing the applicability of the J-curve phenomena for the case of several countries, hardly the same is tested for Indian case. The review of exiting literature also facilitates to supply appropriate research methodology and empirical techniques. As argued in the literature, the impulse response function with VAR methodology is the best available technique to study J-curve and is borrowed for the present study. The USA has been the largest trade partner of India for long and U.S dollar is the dominant currency in India's external trade. This necessitates an exclusive study on the behaviour of trade balance with respect to India's bilateral trade with U.S in relation to continuous depreciation Indian rupee against U.S dollar. This paper is an attempt to fill this vacuum.

3. RESEARCH METHODOLOGY

3.1. Variables and Data Description

The objective of the study being examining the impact of exchange rate depreciation on trade balance of India with respect to bilateral trade with USA, exchange rate (ER) and trade balance (TB) of India with USA form the variables of study. Since the bilateral trade is through means of U.S dollars, U.S dollar has been the proxy for exchange rate. The trade balance is measured as the difference between export earnings of India from U.S and import payments for U.S. Data on trade balance are compiled from U.S Census Bureau and exchange rate of rupee against U.S dollar are procured from RBI Handbook of Statistics on Indian Economy. The study covers monthly data from August, 2009 to October, 2017 with 99 observations to test short run and long run sensitivity of India's trade balance with U.S for rupee depreciation. The study period begins from 2009 and by then the rampant fluctuations in trade due to 2007-08 crisis subsidised and hence results are not affected by structural breaks in the data series. This ensures the reliability of results.

3.2. Model Specification

The trade balance model proposed and tested by Rose (1990) has later served as the effective theoretical framework for studies on the relationship between trade balance and exchange rate. Bahmani-Oskooee and Swarnjit (2003) developed refined version of trade balance model. The present study approaches to this balance model. The general form trade balance function could be presented as follows:

$$TB = f(ER) \text{ ------------- } (1)$$

The empirical model of the trade balance function to be tested is:

$$TB = \alpha + \beta ER + et \text{ ----------- (2)}$$

Where TB is the trade balance of India with respect to Indo-US trade, ER is the exchange rate of rupee against US dollar, α is the regression constant, β is the parameter to be estimated and et is the error term.

3.3. Estimation Techniques

The review of empirical literature on the underlying subject has guided in identifying appropriate econometric tools and techniques for the present study. The time series data are required to test for stationarity before feeding them for further analysis and it is done by applying unit root test. Clearing the stationarity test, variables are tested for long run cointegration by using Johansen's methodology. Subsequently, fitting an error correction model, if co-integration is established, otherwise, estimate a vector auto regression model and test for causality to study the direction of causal relationship between the variables in the short run. Variance de-composition is approached to measure how much variability in an endogenous variable is because of changes in its own value and also because of changes in the other endogenous variable. Finally, impulse response function has been run to measure the response of one endogenous variable to the shocks of other endogenous variable. These econometric analyses are made using E-views software.

4. ANALYSIS OF RESULTS

4.1. Verifying the Stationarity of Data

Empirical research using time series data, prior to advanced study, has to test for unit root problems in the data series and ensure stationarity of data. Stationary of data series could be found when its mean and variance are constant overtime and the value of covariance between two time periods depends only on the distance or lag between the two time periods and not on the actual time at which the covariance is computed (Gujrati and Sangeetha, 2007). The present study also tests the stationarity of time series data on exchange rate of rupee against U.S dollar and trade balance of India vis a vis USA. The most accepted Augmented Dickey Fuller (ADF) method of unit root test is used for the purpose. The ADF test, in the present study, estimates the following regression.

$$Yt = bo + \beta \Delta Yt_{-1} + \mu_1 \Delta Yt_{-1} + \mu_2 \Delta Yt_{-2} + \sum_{i=1}^{m} \mu i \Delta Yt_{-1} + e_t \text{ -------------- (3)}$$

Yt represents the series to be tested, bo is the intercept term, β is the coefficient of intercept in the unit root test, μ1 is the parameter of the augmented lagged first difference of the dependent variable, Yt represents the i^{th} order autoregressive process, et is the white noise error term. The number of lagged difference is decided as per Alkaire Info Criterion (AIC). The results of ADF unit root test are presented in Table-1.

Table-1. Augmented Dickey –Fuller Test of Stationarity

Variables	Order	t-statistic	Critical Value		P-value	Order of Integration	Level of Significance	Decision
TB	I(0)	-3.59027	1%	-3.50739	0.0079	I(0)	5%	Reject H0
			5%	-2.89511				
			10%	-2.58474				
	I(1)	-5.26176	1%	-3.50833	0.000			
			5%	-2.89551				
			10%	-2.58495				
ER	I(0)	-1.07002	1%	-3.50224	0.7248	I(1)	1%	Reject H0
			5%	-2.89288				
			10%	-2.58355				
	I(1)	-4.30628	1%	-3.50224	0.0008			
			5%	-2.89288				
			10%	-2.58355				

Source: Author's Data Analysis

The stationary condition under ADF test requires that the computed t value is more negative than the critical t value (t statistic < critical value). The computed t statistic will have a negative sign and large negative t value is generally an indication of stationarity (Gujrati and Sangeetha, 2007). The time series data on trade balance (TB) meets this condition of stationarity at level (I(0)). Exchange rate is non-stationary at level (I(0)) attains stationary after first order of differencing (I(1)). This confirms that trade balance data is stationary at 5 percent level of significance and exchange rate at 1 percent level of significance. Upon the confirmation of stationarity of data series, the presence of long run relationship between trade balance and exchange rate is examined through cointegration test.

4.2. Long-Run Co-Integration between Trade Balance and Exchange Rate

The study administers cointegration test to measure whether trade balance and exchange rate are cointegrated in the long run. Johansen's method is widely accepted method to measure cointegration among the variables and the same is adopted in this study as well. The cointegration model under Johansen method is tested using the following equation.

$$Xt = a + \sum_{j=1}^{p} \beta j\, Xt - j + et \text{ ------------------------- } (4)$$

Xt is an n×1 vector of non-stationary I(1) variables, a is an n×1 vector of constants, p is the maximum lag length, βj is an n×n matrix of coefficient and et is a n×1 vector of white noise terms. The coefficient value (β) indicates the degree of co-integration among exchange rate and trade balance, while the sign preceding to the coefficient indicates whether the long run relationship between the variables is positive or negative. The cointegration result for the present study is presented in Table-2.

Table-2. Results of Johansen Co-integration Test.

Cointegration Test	Level	Max.Eigen Value	t-Statistic	C.V at 5%	Prob.
Trace Test	H0: r=0 (none)	0.223692	26.05157	15.49471	0.0009
	H1: r≤1 (at most 1)	0.018001	1.743823	3.841466	0.1867
Max.Eigen	H0: r=0 (none)	0.223692	24.30775	14.26460	0.0010
	H1: r≤1 (at most 1)	0.018001	1.743823	3.841466	0.1867

* Trace test & Max-eigenvalue tests indicate no cointegration at the 0.05 level
Source: Author's Data Analysis

The Johansen cointegration result shows that both in trace test and Max.Eigen test at the null hypothesis, t-statistic is less than critical value at 5 percent level of significance and hence trade balance and exchange rate are not cointegrated. Thus, the hypothesis that there is no long run cointegration between India's trade balance with US and exchange rate of rupee against dollar is accepted. In the absence of long run relationship, we cannot estimate error correction model and fitting the data into a Vector Auto Regression (VAR) model is more appropriate as found in econometric literature (Gujrati and Sangeetha, 2007).

4.3. Long Run Convergence of Short Run Deviations - Estimating VAR

Since the introduction of vector auto regression by Sims (1980) it has been applied in a wide range of macroeconomic research contexts. Rather than relying upon the specific coefficient results that are also provided, researchers focus on impulse response functions (IRFs), which show the behaviour of a variable of interest over a period of time after a shock to other variables in the system. The time path of the trade balance after a shock to the exchange rate can thus be studied in the context of VAR (Bahmani-Oskooee and Scott, 2010). When the cointegration test fails to exhibit the long run cointegration relationship between trade balance and exchange, the long-run dynamics of the relationship between the model variables can be estimated by running Vector Auto-regression Model (VAR). VAR model does not make any prior assumption of which variable is endogenous and which is exogenous. In this bivariate model, following equations are estimated.

$$Yt = b_{10} - b_{12}Xt + Y_{11}Yt\_{}_1 + Y_{12}Xt\_{}_1 + \varepsilon yt \text{-----------------} \quad (5)$$

$$Xt = b_{20} - b_{21}Yt + Y_{21}Yt\_{}_1 + Y_{22}Xt\_{}_1 + \varepsilon xt \text{ -----------------} \quad (6)$$

Where b is the unknown coefficient, εyt and εxt are the error terms, $t\_{}_1$ is the lag term, Y is trade balance of India with respect to U.S and X is exchange rate of rupee against dollar. The VAR results are presented in Table- 3.

Table-3. VAR Results

Auto regression	D(TB)	D(ER)
CointEq1	-0.606673 (0.14210) [-4.26928]	0.001126 (0.00034) [3.27689]
D(TB(-1)	-0.193645 (0.13391) [-1.44606]	-0.000641 (0.00032) [-1.97758]
D(TB(-2)	-0.084100 (0.10450) [-0.80477]	-0.000335 (0.00025) [-1.32610]
D(ER(-1)	-25.59625 (41.9292) [-0.61046]	0.254562 (0.10141) [2.51012]
D(ER(-2)	55.17011 (41.4561) [1.33081]	-0.035002 (0.10027) [-0.34908]
C	20.19820 (42.0883) [0.47990]	0.171376 (0.10180) [1.68347]
R-squared	0.410348	0.173292
Adj. R-squared	0.377589	0.127364
Sum sq. resids	14492851	84.78509
S.E. equation	401.2875	0.970596
F-statistic	12.52647	3.773105
Log likelihood	-708.6094	-130.2551
Akaike AIC	14.88769	2.838649
Schwarz SC	15.04797	2.998920
Mean dependent	20.12708	0.191252
S.D. dependent	508.6478	1.039015

Source: Author's Data Analysis

The results imply that the regression model wherein trade balance depends on exchange rate reflects significant but negative long run response of trade balance for short run deviations in exchange rate. The trade balance of India with respect to U.S respond inversely at lag 1 and positively at lag 2 to re-establish the equilibrium relationship once depreciation occurs in Indian rupee. The impact does not appear to be statistically significant. It implies that the value of trade balance improves for exchange rate depreciation in the short run and but deteriorate in the longer time path. It is pertinent to note that the VAR results contradict with economic theory which argues that trade balance deteriorates initially for currency depreciation but improves in the long run. VAR does not seem to have evidence for J-curve pattern of trade balance of India with U.S. However, the VAR results need to be validated by advanced econometric tests. VAR does not explain the direction of flow of causal relationship between trade balance and exchange rate in the short run and hence Granger causality test is administered.

4.4. Causal Flow of Relationship between ER and TB

Subsequent to testing the long run cointegration between trade balance and exchange rate and long run convergence of short run deviation, the presence of short run causal relationship between trade balance and exchange rate is examined through Granger causality test. Causality is a statistical feedback concept which is widely used in the building of forecasting models (Ray, 2012). The Granger (1969;1988) seeks to determine whether past values of a variable help predicting changes in another variable. The Granger causality technique measures the information given by one variable in explaining the latest value of another variable. In addition, it also says that variable Y is Granger caused by variable X if variable X assists in predicting the value of variable Y. If this is the case, it means that the lagged values of variable X are statistically significant in explaining the variable (Ray, 2012).

It examines the reaction between trade balance and exchange rate such as, trade balance Granger cause exchange rate and exchange rate Granger cause trade balance. It implies that the value after exchange rate help us to predict the value for the next period of trade balance and also the value after trade balance help us to predict the value for the next period of exchange rate. The Granger method estimates the regression equations. In this study of two-way variables (trade balance and exchange rate) the following two equations are estimated for Granger causality regression test. If the causality runs from Exchange Rate (ER) to Trade Balance (TB), the Granger causality regression equation is;

$$TBt = n + \sum_{\alpha 11} TBt - 1 + \sum_{\beta 11} ERt - 1 + \varepsilon_1 t \text{ ---------------------- } (6)$$

If the causality runs from Trade Balance (TB) to Exchange Rate (ER), the Granger causality regression equation is;

$$ER = n + \sum_{\alpha 12} ERt - 1 + \sum_{\beta 12} TBt - 1 + \varepsilon_2 t \text{ ------------------------ } (7)$$

From the equation (6), ERt-1 Granger causes TBt if the coefficient of the lagged values of ER as a group β11 is significantly different from the zero based on F-test. Similarly, from equation (7), TBt-1 Granger causes ER if β12 is statistically significant. Table-4 shows the flow of causal relationship between TB and ER.

Table-4. Results of Granger Causality Test

Null Hypotheses	Observations	F-statistic	Prob.	Decision
ER does not Granger Cause TB	96	4.25698	0.00□4	Reject H_o
TB does not Granger Cause ER	96	3.58708	0.0168	Reject H_o

Source: Author's Data Analysis

The results of Granger causality test show the presence of bidirectional causality between trade balance and exchange rate. The causality runs from exchange rate to trade balance and also from trade balance to exchange rate. The value after depreciation of Indian rupee against U.S dollar assists in predicting trade balance of India with US. And also the value after trade balance explains the rupee depreciation. The F-statistic of both null hypothesis, as presented in Table-4, is statistically significant, the hypotheses are rejected. This leads to the conclusion that depreciation of Indian rupee against U.S dollar Granger cause trade balance of India with respect to U.S and trade balance of India with respect to U.S Granger cause depreciation of Indian rupee. Thus, in the short run, there exists feedback causal relationship among the exchange rate and trade balance.

The causality test shows only the direction of causal flow of relationship among the variables in the short run. It does not explain how much variability in India's trade balance with respect to U.S is caused by the rupee depreciation over the long run and how much is due to the own changes of trade balance. To factor this, variance decomposition is administered.

4.5. Variance Decomposition

Variance decomposition explains how much change in a variable is owing to change in its own variable and how much is due to changes in the other endogenous variable. A bivariate general linear model can be presented as in the equation (8).

$$Y = a + bX + c \qquad \text{-------------} (8)$$

Where, Y is a dependent variable or response variable, and X is independent variable or explanatory factor. For each unit change in X, there is a corresponding variation in Y. The variance decomposition focuses on the 'response variable' i.e. Y which responds to the variations in the independent variable i.e. X. The variance of Y for the shocks of other endogenous variable in the model (X and Y) can be presented as follows.

$$Var(Y) = E(Var[Y|X]) + Var(E[Y|X]) \qquad \text{---------------} (9)$$

Where, Var(Y) is variance of Y, E(Var[Y|X]) is explained variation of Y directly due to changes in X and Var(E[Y|X]) reflects unexplained variation comes from somewhere other than X. Hence the variance decomposition bringsout the variance of Y owing to: (1) the expected variance of Y with respect to X, and (2) the expected variance of X with respect to Y.

The equation (9) has been estimated for measuring the expected variances in trade balance for the shocks in rupee depreciation as well as for changes in self i.e. trade balance. The results are presented in Table-5.

Table-5. Variance Decomposition of Trade Balance

Period	S.E	TB	ER
1	401.2875	100.0000	0.000000
2	409.1249	99.98738	0.012625
3	420.7497	95.98043	4.019566
4	430.2694	94.03424	5.965755
5	435.8767	92.71417	7.285826
6	441.8167	91.37452	8.625478
7	447.0724	90.14149	9.858509
8	452.0049	88.91258	11.08742
9	456.8196	87.72870	12.27130
10	461.4683	86.60157	13.39843

Source: Author's Data Analysis

The variance decomposition shows that a given variance in India's trade balance with respect to U.S could be attributed to changes in its own value as well as rupee depreciation. It has been found that only 13 percent variance in India's trade balance with respect to U.S is explained by the lagged values of rupee depreciation against U.S dollar and 87 percent of variances in trade balance appears to be due to changes in its own shocks over the period of time. The rupee depreciation does not seem to be significantly affecting the trade balance of India with respect to U.S. Thus, the result of variance decomposition does not support the theoretical argument. To ascertain the accurate nature of pattern of trade balance curve over the period of time for depreciation of rupee in India, impulse response function has been fitted as it has not been captured by the variance decomposition and other econometric tools.

4.6. Impulse Response of TB to the Shocks of ER

Impulse response function explains the responsiveness of the endogenous variable in the system to shocks to each of the other endogenous variables. For each endogenous variable in the system, a unit shock is applied to the error, and the effects over time are recorded. Consenting with Sims (1980); Demirden and Pastine (1995) also suggested the use of impulse response analysis in determining the existence of J-curve. It was Koop *et al.* (1996) and

Pesaran and Shin (1998) later improvised on the usage of impulse response function to test J-curve through VAR approach. The new generalised impulse response function controls for intermediate effects and is insensitive to the ordering of the variables (Bahmani-Oskooee and Scott, 2010). This study also estimates impulse response function which was widely applied and accepted. Impulse response function predicts the change in India's trade balance for a given percentage depreciation of Indian rupee. It also measures the response of exchange rate over a long run for a given shock of trade balance. The impulse response function provides better clarity on the direction, nature and size of relationship over the long run. The result of the impulse response function for the present study is presented in Figure-1.

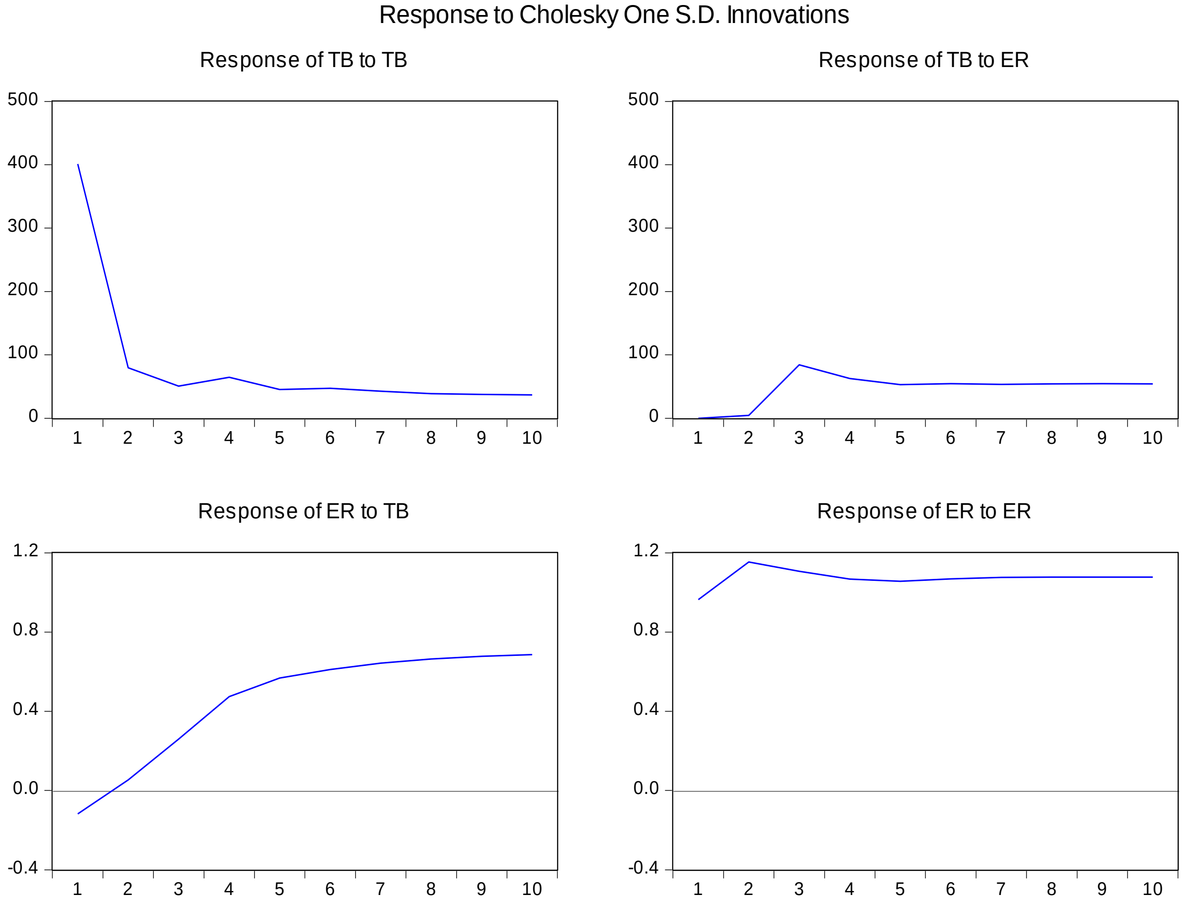

Figure-1. Impulse Response Function

Source: Author's Data Analysis

The result as presented in Figure-1, shows that the trade balance of India with respect to U.S responds positively in the short run and negatively over the period of time. The pattern of response of trade balance, in this case, to the rupee depreciation is an 'inverted delayed J-curve'. It substantiates the findings of VAR result. Thus the result is contrary to the economic theory. The trade balance of India with respect to U.S does not have evidence for J-curve.

5. CONCLUSION

The highly discussed J-curve hypothesis in economic theories and empirical literature does not find supporting evidence from the econometric results of this study in Indian case. Contrary to the theoretical predictions of Magee (1973) during 2009 – 2017 Indian trade balance had 'inverted J-curve' as response to rupee depreciation against American dollar. Going by the results, India's trade balance did not improve despite a very large (34.64%) amount of rupee deprecation during the study period. This emphasises the growing need to re-examine the validity of the theories which were advocated in a different global economic scenario. Very interestingly, a study by Umoru and

Eboreime (2013) produced inverted J-curve for Nigeria as is found in the present study as well. This deepens the call for re-looking at the validity of J-curve hypothesis. The result contrasts with Rose (1990) who explored sensitivity of trade balance to exchange rate shocks in India for pre-reform era. Noteworthy is that the study was conducted very long ago during when India was adopting inward looking policy and exchange rate was predominately pegged. The absence of J-curve for India during 2009-2017 and the presence of inverted J-curve could be attributed to two factors. Firstly, owing to trade liberalisation and economic reforms in several sectors, India's import of capital goods from USA is increasing significantly. Further, in India, the import demand of capital goods is more inelastic to price as it is an indispensable item of import. The free fall of rupee against U.S dollar makes import of capital goods costlier raising the import bill substantially. Secondly, India's exports to U.S did not gain much though Indian products became even more cheaper with continuous depreciation of rupee. The export demand seems to be less elastic to price. These phenomena would have caused deterioration in India's balance of trade. However, the future studies may empirically examine whether these factors significantly affect the trade balance.

The study output has significant policy implications. Dornbusch and Krugman (1976) realised that analysing the J- curve effect can lead to understand the short run volatilities in the economy, which directs policy makers towards appropriate monetary and fiscal policies for stabilization. In Indian case, government may re-look at allowing deliberately to the rupee to depreciate since currency manipulation does not pay any dividend. Rather it backfires India by putting more burden on import bill. India would benefit from the stable exchange rate. The government and the central bank of India may adopt appropriate policy measures to restrain further fall of rupee and correct the market rate whenever required to stabilise the same. Stability in rupee against dollar would enable in achieving favourable balance of payments in the long run.

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Annexure-1. India's Trade with USA (in million US $)

Year	M	E	TB	ER*
1991	1,999.40	3,192.40	1,193.00	22.689
1992	1,917.10	3,779.70	1,862.60	25.9206
1993	2,777.90	4,553.60	1,775.70	31.4458
1994	2,293.80	5,309.60	3,015.80	31.3742
1995	3,295.80	5,726.30	2,430.50	32.4232
1996	3,328.20	6,169.50	2,841.30	35.4294
1997	3,607.50	7,322.50	3,715.00	36.3196
1998	3,564.50	8,237.20	4,672.70	41.2677
1999	3,687.80	9,070.80	5,383.00	43.0485
2000	3,667.30	10,686.60	7,019.30	44.9401
2001	3,757.00	9,737.30	5,980.30	47.1857
2002	4,101.00	11,818.40	7,717.40	48.5993
2003	4,979.70	13,055.30	8,075.60	46.5819
2004	6,109.40	15,572.00	9,462.60	45.3165
2005	7,918.60	18,804.20	10,885.60	44.1
2006	9,673.60	21,830.80	12,157.20	45.307
2007	14,968.80	24,073.30	9,104.50	41.3485
2008	17,682.10	25,704.40	8,022.30	43.5049
2009	16,441.40	21,166.00	4,724.60	48.4049
2010	19,248.90	29,532.90	10,284.00	45.7262
2011	21,542.20	36,154.50	14,612.30	46.6723
2012	22,105.70	40,512.60	18,406.90	53.4376
2013	21,810.40	41,810.00	19,999.60	58.5978
2014	21,499.10	45,358.00	23,858.90	61.0295
2015	21,453.00	44,790.00	23,337.00	64.1519
2016	21,652.30	46,032.40	24,380.10	67.1953

*Exchange rate of Indian rupee against U.S dollar.
Note: M-imports, E-exports, TB-trade balance & ER-exchange rate
Sources: 1. United States Census Bureau, 2. Reserve Bank of India: Handbook of Statistics on Indian Economy.