Nonlinearity between RER and Trade Balance: A Case Study of Pakistan

Sidra Nazir1* and Muhammad Jawad2

1Department of Economics, PMAS Arid Agriculture University, Rawalpindi, Pakistan
2Department of Econometrics and Statistics, Pakistan Institute of Development Economics, Islamabad, Pakistan

Abstract

Exchange rate is an important factor to bring change in trade balance of any country. In this study the true relationship that is nonlinear, has been examined empirically between trade balance and real exchange rate for Pakistan vs. USA. By using monthly data (1980m1 to 2014m2) linear and nonlinear models are estimated by using Johansen cointegration technique (1988). The negative sign of RER2 confirms the nonlinear relationship in case of bilateral trade between these two countries. Existence J-curve in case of Pakistan has been confirmed by long run and short run results, as in long run exchange rate improves the trade balance but in short run it depreciated Hussain and Bashir and Magee. Finally the nonlinear model showed better forecast performance examined by RMSE and MAE.

Keywords: Exchange rate; Trade balance; Non-linear model; Cointegration; J-Curve

JEL classification: C4, F1, F3, F31

Introduction

Exchange rate has very important impact on macroeconomic variables, due to appreciating or depreciating of exchange rate, economy suffers a lot in every sector specially trade sector. Developing countries like Pakistan affected by fluctuations in exchange rate due to currency devaluation. As Pakistan’s most of trade done in term of dollar, due to fluctuations in dollar there is great impact on Pakistan’s trade i.e. with USA. The trade balance between these countries is affected by the fluctuations in exchange rate in short run and long run. In case of Pakistan different exchange rate system was adopted such as: pegging US $, floating exchange rate and combination of both. Since 2000 Pakistan is using floating exchange rate system. In this system state bank of Pakistan itself manage the system to control the exchange market.

From the literature most of studies has found those try to find the actual relationship between the exchange rate and trade balance among two countries. Domestically there are number of studies in this context but none of study found who analyzed the nonlinear relationship between these variables and compared both linear and nonlinear relationships. Such as: Hussain and Bashir calculated the linear relationship between exchange rate and trade balance of Pakistan vs. UK and USA, but checked the nonlinearity of variables. Another study of Shahid and Afzal [1-3] analyzed the currency devaluation effect on the exports, in case of Pakistan, India and Bangladesh, but not considered the concept of nonlinearity. Also in the paper of Parveen et al. [4] estimated the linear model by using ZLS technique. Many international studies are available in this context like: Karamelikli [5], Lin and Fu [6], Aliyu and Tijani [7], Hasani et al. [8] Chinn [9] and Magee estimated and confirm the nonlinear relationship between trade balance and exchange rate.

In this study we tried to find true relationship between exchange rate and trade balanced of Pakistan with USA. We analyzed the relationship graphically so we added the RER2 in the model to estimate the nonlinear model. As in previous studies in context of Pakistan has not capture the nonlinear relationship between these variables. To estimate the both linear and nonlinear model we applied Johansen cointegration [10] technique by using monthly data since 1980m1-2014m2. At last we compare the both model’s performance by forecasting. We compare it by analyzing the RMSE and MAE. We also checked the J-curve existence in case of Pakistan by examining the results of short run and long run.

The main purpose of this study is to check the true relationship between exchange rate and trade balance. Another aim is to check the existence of J-curve in case of Pakistan and finally to check the performance of linear and nonlinear model by forecasting.

After the introducing this study the Literature Review has explained, in the third section Methodology of this study has given, the forth section is comprises on Results and Discussion and finally Conclusion and References are given.

Literature Review

Chinn used monthly data to test the variables through different techniques like linear techniques of cointegration and nonlinear ACE (Alternating conditional expectation) technique by comparing the forecast results through RMSE and MAE and concluded that relationship is most of nonlinear. And through nonlinear best forecast results can be calculated.

Mohammad and Hussain [11] estimated the effect of real exchange rate devaluation on balance of trade in Pakistan. This article observed the existence of the Marshall Lerner condition in Pakistan using data since 1970-2008 by using impulse response function which satisfied the J-curve concept. Johansson Cointegration test has been used to find the long run relationship between concerned variables. That showed existence of cointegration relationship. This paper has not examined the nonlinear relationship between variables and explained the same concepts as in given in other literature of Pakistan.

*Corresponding author: Sidra Nazir, Ph D Scholar, Department of Economics, PMAS Arid Agriculture University, Rawalpindi, Pakistan, Tel: +92 51 9292122; E-mail: sidranazi.shah@gmail.com

Received February 01, 2017; Accepted March 07, 2017; Published March 09, 2017


Copyright: © 2017 Nazir S, et al. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.
Parveen, Qayyum and Ismail has evaluated the factors which are determinants of exchange rate. A linear model has estimated using 2SLS model. Annual data has used to get the required results. By using ADF it has known that all variables are non-stationary are integrated of order I (1). From this article it has concluded that inflation is one of the most important factors to affect the volatility of exchange rate other than imports and exports. So Pakistan monetary Policy and fiscal Policy are important in managing the exchange rate.

In the paper of Hussain and Bashir the imperfect substitute model was used to estimate the dynamic of trade balances. In the model separate equation has used for import and export. To calculate the results cointegration analysis has done also J-curve effect has tested. In this study IRF has also estimated by combining the effect of cointegration and ECM for testing bilateral trade between UK and US. From the cointegration it is confirmed that there is long run relationship between these variables. REER positively related with trade balance. The results are related to the theory. IRF also confirmed the existence of J-curve in bilateral trade with UK and US. So in case of Pakistan evidence with other countries that currency depreciates improve the trade balance.

Shahid and Afsal has tested the effect of REER on exports and also analyzed the currency devaluation effect on exports, in this paper only export sector has taken, not whole trade balance has taken to check the effect of REER as taken in previous studies. Multiple regression models has estimated to check the variation in exports by exchange rate, interest rate, money supply and Government expenditure for all three countries, Pakistan, India and Bangladesh. From the study it has concluded that due currency devaluation Pakistan and Bangladesh’s import increases.

In the study of Hassan, Akhondzadeh, Babazadeh and salami has estimated the same concept as in previous paper has done. As in previous paper bilateral trade take in to the consideration. In this study linearity has tested and also transition variables has tested for uncertainty by different models, according to the results null hypothesis of linearity has rejected and first order model STAR (Smooth transition autoregressive) has selected. The results confirms the nonlinear relationship between the variables, exchange rate has used for measure of uncertainty and LSTR model has estimated that exchange rate has used for measure of uncertainty and LSTR model has estimated that exchange rate uncertainty has no significant impact on trade balance, but as exchange increases uncertainty increases and causes reduction in the elasticity of balance of trade with relationship in other variables [12].

In the study of Lin and Fu the nonlinear relationship between exchange rate and trade balance has been observed. In this article different studies have been observed and critically examined and discussed. Five variable has used in this study for observing the bilateral trade concept. Ratio of exports and imports, real Exchange rate (RER) discussed. Five variable has used in this study for observing the bilateral different studies have been observed and critically examined and exchange rate and trade balance has been observed. In this article of uncertainty and LSTR model has estimated that exchange rate relationship between the variables, exchange rate has used for measure of uncertainty and LSTR model has estimated that exchange rate relationship between the variables, exchange rate has used for measure of uncertainty and LSTR model has estimated that exchange rate relationship between the variables, exchange rate has used for measure of uncertainty and LSTR model has estimated that exchange rate relationship between the variables, exchange rate has used for measure of uncertainty and LSTR model has estimated that exchange rate relationship between the variables, exchange rate has used for measure of uncertainty and LSTR model has estimated that exchange rate relationship between the variables, exchange rate has used for measure of uncertainty and LSTR model has estimated that exchange rate relationship between the variables, exchange rate has used for measure of uncertainty and LSTR model has estimated that exchange rate relationship between the variables, exchange rate has used for measure of uncertainty and LSTR model has estimated that exchange rate relationship between the variables, exchange rate has used for measure of uncertainty and LSTR model has estimated that exchange rate relationship between the variables, exchange rate has used for measure of uncertainty and LSTR model has estimated that exchange rate relationship between the variables, exchange rate has used for measure of uncertainty and LSTR model has estimated that exchange rate relationship between the variables, exchange rate has used for measure of uncertainty and LSTR model has estimated that exchange rate relationship between the variables, exchange rate has used for measure of uncertainty and LSTR model has estimated that exchange rate relationship between the variables, exchange rate has used for measure of uncertainty and LSTR model has estimated that exchange rate relationship between the variables, exchange rate has used for measure of uncertainty and LSTR model has estimated that exchange rate relationship between the variables, exchange rate has used for measure of uncertainty and LSTR model has estimated that exchange rate relationship between the variables, exchange rate has used for measure of uncertainty and LSTR model has estimated that exchange rate relationship between the variables, exchange rate has used for measure of uncertainty and LSTR model has estimated that exchange rate relationship between the variables, exchange rate has used for measure of uncertainty and LSTR model has estimated that exchange rate relationship between the variables, exchange rate has used for measure of uncertainty and LSTR model has estimated that exchange rate relationship between the variables, exchange rate has used for measure of uncertainty and LSTR model has estimated that exchange rate relationship between the variables, exchange rate has used for measure of uncertainty and LSTR model has estimated that exchange rate relationship between the variables, exchange rate has used for measure of uncertainty and LSTR model has estimated that exchange rate relationship between the variables, exchange rate has used for measure of uncertainty and LSTR model has estimated that exchange rate relationship between the variables, exchange rate has used for measure of uncertainty and LSTR model has estimated that exchange rate relationship between the variables, exchange rate has used for measure of uncertainty and LSTR model has estimated that exchange rate relationship between the variables, exchange rate has used for measure of uncertainty and LSTR model has estimated that exchange rate relationship between the variables, exchange rate has used for measure of uncertainty and LSTR model has estimated that exchange rate relationship between the variables, exchange rate has used for measure of uncertainty and LSTR model has estimated that exchange rate relationship between the variables, exchange rate has used for measure of uncertainty and LSTR model has estimated that exchange rate relationship between the variables, exchange rate has used for measure of uncertainty and LSTR model has estimated that exchange rate relationship between the variables, exchange rate has used for measure of uncertainty and LSTR model has estimated that exchange rate relationship between the variables, exchange rate has used for measure of uncertainty and LSTR model has estimated that exchange rate relationship between the variables, exchange rate has used for measure of uncertainty and LSTR model has estimated that exchange rate relationship between the variables, exchange rate has used for measure of uncertainty and LSTR model has estimated that exchange rate relationship between the variables, exchange rate has used for measure of uncertainty and LSTR model has estimated that exchange rate relationship between the variables, exchange rate has used for measure of uncertainty and LSTR model has estimated that exchange rate relationship between the variables, exchange rate has used for measure of uncertainty and LSTR model has estimated that exchange rate relationship between the variables, exchange rate has used for measure of uncertainty and LSTR model has estimated that exchange rate relationship between the variables, exchange rate has used for measure of uncertainty and LSTR model has estimated that exchange rate relationship between the variables, exchange rate has used for measure of uncertainty and LSTR model has estimated that exchange rate relationship between the variables, exchange rate has used for measure of uncertainty and LSTR model has estimated that exchange rate relationship between the variables, exchange rate has used for measure of uncertainty and LSTR model has estimated that exchange rate relationship between the variables, exchange rate has used for measure of uncertainty and LSTR model has estimated that exchange rate relationship between the variables, exchange rate has used for measure of uncertainty and LSTR model has estimated that exchange rate relationship between the variables, exchange rate has used for measure of uncertainty and LSTR model has estimated that exchange rate relationship between the variables, exchange rate has used for measure of uncertainty and LSTR model has estimated that exchange rate relationship between the variables, exchange rate has used for measure of uncertainty and LSTR model has estimated that exchange rate relationship between the variables, exchange rate has used for measure of uncertainty and LSTR model has estimated that exchange rate relationship between the variables, exchange rate has used for measure of uncertainty and LSTR model has estimated that exchange rate relationship between the variables, exchange rate has used for measure of uncertainty and LSTR model has estimated that exchange rate relationship between the variables, exchange rate has used for measure of uncertainty and LSTR model has estimated that exchange rate relationship between the variables, exchange rate has used for measure of uncertainty and LSTR model has estimated that exchange rate relationship between the variables, exchange rate has used for measure of uncertainty and LSTR model has estimated that exchange rate relationship between the variables, exchange rate has used for measure of uncertainty and LSTR model has estimated that exchange rate relationship between the variables, exchange rate has used for measure of uncertainty and LSTR model has estimated that exchange rate relationship between the variables, exchange rate has used for measure of uncertainty and LSTR model has estimated that exchange rate relationship between the variables, exchange rate has used for measure of uncertainty and LSTR model has estimated that exchange rate relationship between the variables, exchange rate has used for measure of uncertainty and LSTR model has estimated that exchange rate relationship between the variables, exchange rate has used for measure of uncertainty and LSTR model has estimated that exchange rate relationship between the variables, exchange rate has used for measure of uncertainty and LSTR model has estimated that exchange rate relationship between the variables, exchange rate has used for measure of uncertainty and LSTR model has estimated that exchange rate relationship between the variables, exchange rate has used for measure of uncertainty and LSTR model has estimated that exchange rate relationship between the variables, exchange rate has used for measure of uncertainty and LSTR model has estimated that exchange rate relationship between the variables, exchange rate has used for measure of uncertainty and LSTR model has estimated that exchange rate relationship between the variables, exchange rate has used for measure of uncertainty and LSTR model has estimated that exchange rate relationship between the variables, exchange rate has used for measure of uncertainty and LSTR model has estimated that exchange rate relationship between the variables, exchange rate has used for measure of uncertainty and LSTR model has estimated that exchange rate relationship between the variables, exchange rate has used for measure of uncertainty and LSTR model has estimated that exchange rate relationship between the variables, exchange rate has used for measure of uncertainty and LSTR model has estimated that exchange rate relationship between the variables, exchange rate has used for measure of uncertainty and LSTR model has estimated that exchange rate relationship between the variables, exchange rate has used for measure of uncertainty and LSTR model has estimated that exchange rate relationship between the variables, exchange rate has used for measure of uncertainty and LSTR model has estimated that exchange rate relationship between the variables, exchange rate has used for measure of uncertainty and LSTR model has estimated that exchange rate relationship between the variables, exchange rate has used for measure of uncertainty and LSTR model has estimated that exchange rate relationship between the variables, exchange rate has used for measure of uncertainty and LSTR model has estimated that exchange rate relationship between the variables, exchange rate has used for measure of uncertainty and LSTR model has estimated that exchange rate relationship between the variables, exchange rate has used for measure of uncertainty and LSTR model has estimated that exchange rate relationship between the variables, exchange rate has used for measure of uncertainty and LSTR model has estimated that exchange rate relationship between the variables, exchange rate has used for measure of uncertainty and LSTR model has estimated that exchange rate relationship between the variables, exchange rate has used for measure of uncertainty and LSTR model has estimated that exchange rate relationship between the variables, exchange rate has used for measure of uncertainty and LSTR model has estimated that exchange rate relationship between the variables, exchange rate has used for measure of uncertainty and LSTR model has estimated that exchange rate relationship between the variables, exchange rate has used for measure of uncertain
Where; \( N \) = number of forecast, \( \hat{y}_i \) and \( y_i \) denotes the predicting and true values.

To identify the nonlinear relationship between real exchange rate and trade balance; we constructed the variables as: The bilateral trade balance (E/M) where E and M are the US-Pak export and import values in term of US dollar respectively. The bilateral trade balance, which is in ratio form and have no unit of measurement and can be taken as real or nominal terms. The trade balance is transformed into natural log and denoted as Inem for this study. The real exchange rate (RER) is in the natural log transformation as In(RER), ln (ER*(CPIus/CPIpak)), where ER is the monthly exchange rate of Pakistani rupee against U.S. dollar; CPIus, is the U.S. consumer price index and CPI pak Pakistani consumer price index. The real exchange rate square (RER\(^2\)) is the squared value of RER that measures the nonlinear relationship between real exchange rates and bilateral trade balance. The industrial production index taken as a proxy for the domestic and foreign income as GDP data is not available on monthly basis. The data is being gathered from IFS, Monthly Statistical Bulletin published by Pakistan Bureau of Statistics (PBS). The Pakistani and American industrial production indices, as the Pakistani national income and U.S. national income, denoted respectively by PY and AY.

Results and Discussions

Most of the researcher encounters the problem of nonlinearity of economic variables while dealing with linear models. The reason is that the actual relationship between the variable is nonlinear and we estimated the linear model that could generate the biased and misleading results.

To analyze the true relationship between the variables we have to examine the data graphically, how the data look like and how the variables actually changes. In the above Figure 1 between Inem and RER, these our study concerns, has displayed. This clearly shows the curved line; from the dot graph we cannot draw the straight line between the variables. This shows if RER changes one unit the slope of Inem changes differently across the curve, it’s called nonlinear relationship in variables. So we have to generate the nonlinear variables to capture the nonlinear effect of variables.

![RER vs Lnem](image)

To estimate the linear and nonlinear models monthly data has been used since 1980m1 to 2014m2. As data has taken on monthly basis so there is possibility of seasonal effect in the data so we have taken seasonally adjust series to apply further tests on data. First we checked the order of integration of the data on which series become stationary. According the ADF (Augmented Dickey Fuller) results given in above Table 1, all variables are non-stationary and have order of integration 1 (1).

For finding the relationship cointegrating relationship between the variables we applied the Johansen cointegrating technique on our linear and nonlinear model, for selecting the appropriate lags we select the 8 significant lags from selection criterion such as FPE, SBC, AIC and BIC. Both models use the 8 significant lags at 5% significant level. So from the Table 2 it has shown that from the two test statistics trace and Maximum Eigen test proposed by Maximum Likelihood Method of Johansen (1988), from the both tests from; for linear and nonlinear models it is decided that there is one cointegrating vector or have one long run cointegrating relationship between the variables.

After that we took the estimates of cointegration for both models linear and nonlinear for interpreting long run coefficients. In the equation: (7) of Linear model, the long run estimates of linear model has given, the coefficient are normalized on variables Inem. From the equation (7) the coefficient of variable AY shows positive significant relationship with Inem, if there is increases in USA income the trade balance will increases of Pakistan from USA. But PY and Inem that shows if income of people increases the TB (trade balance) will depreciate. As people started to increase import the TB depreciate in Long run. As the coefficient of RER is not significantly different from the zero, so these results shows some misleading concept, as exchange rate considered one of the most important determinant for effecting the trade balance, so we move towards the nonlinearity of variable by adding RER\(^2\) in model.

**Long run linear model**

\[
\text{lnem}=0.02\text{ay} - 0.03\text{py} - 0.01\text{rer} \\
(3.74) (-12.54) (-0.01)
\]  

**Long run nonlinear model**

\[
\text{lnem}=0.02\text{ay} - 0.03\text{py} + 0.05\text{rer} - 0.003\text{rer}^2 \\
(4.66) (-18.05) (2.74) (-2.61)
\]  

From the equation (8) it can be examine that all variables has significant impact on trade balance and negative sign of RER\(^2\) confirms the nonlinear relationship between RER and Inem (trade balance). So having positive coefficient of RER and negative of RER\(^2\) shows that depreciating of Pakistani rupee improves the USA trade balance but as the depreciation increases it worsens the trade balance, as shown in the study of Hussain and Bashir and Lin and Fu. The coefficient of AY and PY both shows same significant impact on lnem as shown in the linear model.

### Table 1: Augmented Dickey Fuller unit root test.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Intercept/ trend</th>
<th>Level ADF value</th>
<th>First difference ADF value</th>
<th>Lags</th>
<th>Decision</th>
</tr>
</thead>
<tbody>
<tr>
<td>LNEM</td>
<td>Constant, Linear Trend</td>
<td>-3.08</td>
<td>-7.100965(^*)</td>
<td>11</td>
<td>I(1)</td>
</tr>
<tr>
<td>AY</td>
<td>Constant, Linear Trend</td>
<td>-3.12</td>
<td>-4.762930(^*)</td>
<td>14</td>
<td>I(1)</td>
</tr>
<tr>
<td>PY</td>
<td>Constant, Linear Trend</td>
<td>-1.5</td>
<td>-8.780588(^*)</td>
<td>11</td>
<td>I(1)</td>
</tr>
<tr>
<td>RER</td>
<td>Constant, Linear Trend</td>
<td>-0.39</td>
<td>-18.95004(^*)</td>
<td>0</td>
<td>I(1)</td>
</tr>
<tr>
<td>RER(^2)</td>
<td>Constant, Linear Trend</td>
<td>-0.47</td>
<td>-19.50413(^*)</td>
<td>0</td>
<td>I(1)</td>
</tr>
</tbody>
</table>

\(^*\) Significant at 1% level.
RER2 in model because through graph we couldn’t generate the linear relationship between RER and trade balance, whether it is linear or nonlinear by including nonlinearity between the variables and shows very slow speed of adjustment toward equilibrium about 0.03 units per month. The devaluation in domestic currency may change the trade balance in inverse direction in short run due to the adjustment of lags in the economy like real exchange rate and income of that country. As in short run exchange rate worsens the trade balance and in long run it improves.

For any country the trade is one of the important determinants to affect its economy, the trade balance itself affected by the fluctuations in the economy like real exchange rate and income of that country. As there are many studies nationally and internationally those capture this issue in case of bilateral trade.

Conclusion

To compare the performance of both models we test the both models through forecasting, by using the test statistics of RMSE and MAE as done by Lin and Fu, as given in the Table 3, above the minimum value of RMSE and MAE shows the good model, so from the given results we say that nonlinear model better forecast the model and empirical results shows that residuals are multivariate normal.

For any country the trade is one of the important determinants to affect its economy, the trade balance itself affected by the fluctuations in the economy like real exchange rate and income of that country. As there are many studies nationally and internationally those capture this issue in case of bilateral trade.

In this study we analyzed the bilateral trade between Pakistan and USA by examining the effect of RER on trade balance (lnem). As in short run exchange rate and trade balance, whether it is linear or nonlinear by including RER2 in model because through graph we couldn’t generate the linear relationship between the variables.

## Table 2: Johansen cointegration results.

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Test statistics</th>
<th>Critical values 5%</th>
</tr>
</thead>
<tbody>
<tr>
<td>$H_0$</td>
<td>$H_1$</td>
<td>$(\lambda_{max})$</td>
</tr>
<tr>
<td>$r=0$</td>
<td>$r \geq 1$</td>
<td>68.648*</td>
</tr>
<tr>
<td>$r \leq 2$</td>
<td>$r \geq 3$</td>
<td>9.706</td>
</tr>
<tr>
<td>$r \leq 3$</td>
<td>$r \geq 4$</td>
<td>2.825</td>
</tr>
</tbody>
</table>

*Significant at 5 % level.

## Table 3: Forecasting performance of models.

<table>
<thead>
<tr>
<th>Tests</th>
<th>Linear model</th>
<th>Nonlinear model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Root mean square error</td>
<td>0.128307</td>
<td>0.126655</td>
</tr>
<tr>
<td>Mean absolute error</td>
<td>0.099364</td>
<td>0.098702</td>
</tr>
</tbody>
</table>
cointegration technique and found that there is long run relationship between variables, but in linear model RER shows insignificant effect on trade balance that are misleading results as exchange rate is one of the important factor to deteriorate the trade balance. But the long run nonlinear model showed significant results. The negative sign of RER [2] also confirms the nonlinear relationship between variables consistent with study of Lin and Fu. Moving toward ECM (Error Correction Model), these results conclude that shows in short run increase in exchange rate can depreciate trade balance of Pakistan-USA. These results are consistent with the study of Hussain and Bashir, Lin and Fu and Magee that in short run exchange rate have negative relationship with trade balance. As in short run exchange rate worsens the trade balance and in long run it improves, so confirms the existence of J-curve in case of Pakistan and support the study of Hussain and Bashir. Lastly the forecast results also confirm the nonlinear models better interpretation for RER and trade balance in case of Pakistan and USA.

References