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

Qayyum, Abdul and Nazir, Sidra and Jawad, Muhammad

Pakistan Institute of Development Economics, Islamabad

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by

Abdul Qayyum[1], Sidra Nazir[2] and Muhammad Jawad[3]

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; have 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 RER^2 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 (2013) and Magee (1973). Finally the nonlinear model showed better forecast performance examined by RMSE and MAE.

Keywords: *Exchange Rate, Trade Balance, Non-Linear Model, Cointegration, J-Curve*

[1] Joint Director, Pakistan Institute of Development Economics, Islamabad. Email: qayyumdr@gmail.com
[2] PhD Scholar, Department of Econometrics and Statistics, Pakistan Institute of Development Economics, Islamabad. Email: sidranazir_14@pide.edu.pk
[3] PhD Student, Department of Econometrics and Statistics, Pakistan Institute of Development Economics, Islamabad. Email: m.jawad66@yahoo.com

1. 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 (2013) 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 (2013) 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 (2012) estimated the linear model by using 2SLS technique. Many international studies are available in this context like; Karamelikli (2016), Lin and Fu (2015), Aliyu and Tijani

(2015), Hasani etal (2014), Chinn (1991) and Magee (1973) 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 RER^2 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 (1988) 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.

2. LITERATURE REVIEW

Chinn (1991) 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 (2010) 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.

Parveen, et. al., (2012) have 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 Policey and fiscal Policey are important in managing the exchange rate.

In the paper of Hussain and Bashir (2013) 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 Afzal (2013) 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 expenditures for all three countries, Pakistan, India and Bangladesh. From the study it has concluded that due currency devaluation Pakistan and Bangladesh's export increases.

In the study of Hassani, et. al., (2014) 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 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.

In the study of Lin and Fu (2015) 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) has calculated by ratio of CPI of Korea and US. Also RER^2 has included incorporating the effect of nonlinear of variables on trade balances and also national income of countries. From the result of unit root (ADF) it is shown that all variables are I (1), but problem here is that author use ADF test for testing unitroot

for monthly data that is not appropriate due to seasonal effect could generate the biased results, so data should be seasonally adjusted or we can use seasonal unit root test. By applying Johansen cointegration on two models linear and nonlinear model by adding RER^2 and then error correction models has estimated. From the results it is concluded that there is significant nonlinear relationship between RER and trade balance. In the end RMSE has testing best results of forecasting. These results also show that nonlinear results are better than linear.

Another study in case of Nigeria by Aliyu and Tijjani (2015) has tested the asymmetric cointegration between exchange rate and trade balance by using monthly data. This relationship has estimated by threshold cointegration and asymmetric ECM (Error Correction Model). This study satisfies the negative relationship between the trade balance and exchange rate, with the impact of exporting crude oil.

3. METHODOLOGY

3.1. Economic Model

According to the theories of absorption and elasticities we took the income and exchange rate as independent variables. To find the true relationship between exchange rate and bilateral trade balance in case of Pakistan and USA, two models are formulated as in Lin and Fu (2015) and Hussain and Bashir (2013) did, given below:

Linear Mode:

$$lnem = f(PY, AY, RER) \quad (1)$$

$$lnem_t = \beta_0 + \beta_1 RER_t + \beta_2 AY_t + \beta_3 PY_t + \mu_t \quad (2)$$

No Linear Mode:

$$lnem = f(PY, AY, RER, RER^2) \quad 3$$

$$lnem_t = \beta_0 + \beta_1 RER_t + \beta_2 RER^2{}_t + \beta_3 AY_t + \beta_4 PY_t + \mu_t \quad 4$$

Engle and granger (1987) was pioneer in the field of cointegration, they uses the two step approach. This approach can identify only one cointegrating vector, so for finding more than one cointegrating vector multivariate technique has been proposed that is Johansen (1988) cointegration technique. That uses the vector autoregressive model (VAR) to estimate model. For explanation of VECM the long run models of our study expressed as:

The RER^2 has included in model to capture the nonlinear effect of variables *lnem* and RER, as graphically we cannot draw the straight line with the data. The VECM proposed by Johansen (1988) expressed as:

$$\Delta y_t = \pi y_{t-1} + \sum_{j=1}^{p} \Gamma_j \Delta y_{t-j} + \mu_t \quad 6$$

Where y_t contain all variables such as $y_t = \{lnem, PY, AP, RER\ and/or\ RER^2\}$. Through Trace and Maximum Eigen value test proposed by maximum likelihood approach by Johansen (1988) have used to find the rank of π matrix, which is $g \times g$ matrix to calculate the number of cointegrating vectors. For example if there is 'r' cointegrating vectors then π will be product of two matrix $\alpha\ and\ \beta$ having order $g \times r$, i.e. $\pi = \alpha\beta'$. Where α matrix explains the speed of adjustment and β contains long run coefficient of parameters.

Lastly we applied the Root Mean Square Error (RMSE) and Mean Absolute Error (MAE) tests to check the forecasting performance of both linear and nonlinear models. Both RMSE and MAE measures distance of forecast error with no difference in positive and negative error. As RMSE uses the square of forecast error and MAE uses absolute values of forecast errors. Have

larger deviation from true values have greater impact on RMASE then MAE. The evaluation criterion of RMSE and MAE is having smaller value shows better forecast for models. The formulas of RMSE and MAE are below:

$$RMSE = \sqrt{\frac{\sum_{i=1}^{N}(\hat{y}_i - y_i)^2}{N}} \quad \text{and} \quad MAE = \frac{\sum_{i=1}^{N}|\hat{y}_i - y_i|}{N}$$

Where; N = number of forecast, $\hat{y}_i \; and \; y_i$ denotes the predicting and true values.

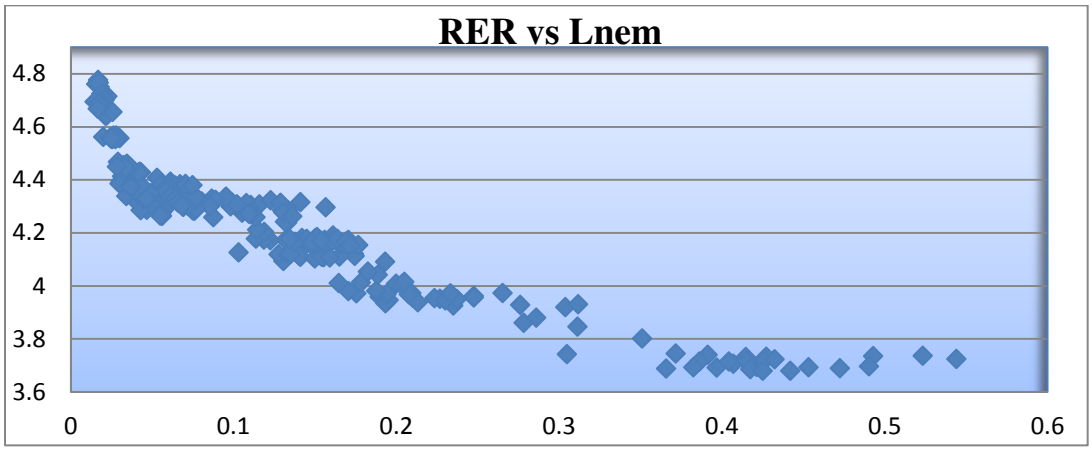
To identify the nonlinear relationship between real exchange rate and trade balance; we constructed the variables as: The bilateral trade balance (E/M) where E and M are the US-Pak export and import values in term of US dollar respectively. The bilateral trade balance, which is in ratio form and have no unit of measurement and can be taken as real or nominal terms. The trade balance is transformed into natural log and denoted as *lnem* for this study. The real exchange rate (RER) is in the natural log transformation as $ln(RER), ln(ER * (CPIus / CPIpak)$, where ER is the monthly exchange rate of Pakistani rupee against U.S. dollar; CPI_{us}, 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 Pakistani and American industrial production indices, as the Pakistani national income and U.S. national income, denoted respectively by PY and AY.

4. 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.

Figure.1: Real Exchange Rate and Trade Balance between Pakistan and USA



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 graph between lnem 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 lnem 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.

Table.1: Augmented Dickey Fuller Unit Root Test

Variables	Intercept/ trend	Level ADF value	First difference ADF value	Lags	Decision
LNEM	Constant, Trend	-3.08	-7.100965	11	I(1)
AY	Constant, Trend	-3.12	-4.762930	14	I(1)
PY	Constant, Trend	-1.50	-8.780588	11	I(1)

RER	Constant, Trend	-0.39	-18.95004	0	I(1)
RER^2	Constant, Trend	-0.47	-19.50413	0	I(1)

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 I (1).

Table 2: Johansen Cointegration Results

Linear Model				**Nonlinear Model**			
Hypothesis		test statistics	Critical values	Hypothesis		test statistics	Critical values
H_o	H_a		5%	H_o	H_a		5%
(λ_{trace})				**(λ_{trace})**			
r=0	**r≥1**	68.648*	47.856	**r=0**	**r≥1**	123.031*	69.818
r≤1	**r≥2**	27.976	29.797	**r≤1**	**r≥2**	36.960	47.856
r≤2	**r≥3**	9.706	15.494	**r≤2**	**r≥3**	16.155	29.797
r≤3	**r≥4**	2.825	3.841	**r≤3**	**r≥4**	5.382	15.497
				r≤4	**r≥5**	0.192	3.841
(λ_{max})				**(λ_{max})**			
r=0	**r=1**	40.671*	27.584	**r=0**	**r=1**	86.070*	33.876
r≤1	**r=2**	18.269	21.131	**r≤1**	**r=2**	20.805	27.584
r≤2	**r=3**	6.880	14.264	**r≤2**	**r=3**	10.772	21.131
r≤3	**r=4**	2.825	3.841	**r≤3**	**r=4**	5.190	14.264
				r≤4	**r=5**	0.192	3.841

*Significant at 5 % level

For finding the relationship cointegrating relationship between the variables we applied the Johansen (1988) 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 such as Trace and Maximum Eigenvalue tests proposed by Maximum Likelihood Method of Johansen (1988). 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 Lnem. From the equation (7) the coefficient of variable AY shows positive significant relationship with lnem, if there is increases in USA income the trade balance will increases of Pakistan from USA. But PY and lnem 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 toward the nonlinearity of variable by adding RER^2 in model.

Long Run Linear Model

$$\begin{array}{lll} \text{Lnem} = & 0.02\ ay - 0.3\ py - 0.01\ rer & 7 \\ & (3.74)\ \ (-12.54)\ \ (-0.91) & \end{array}$$

Long Run Non Linear Model

$$\begin{array}{lll} \text{Lnem} = & 0.02\ ay - 0.03\ py + 0.05\ rer - 0.003\ rer^2 & 8 \\ & (4.66)\ \ (-18.05 \quad (2.74) \quad (-2.61) & \end{array}$$

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 lnem (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 (2013) and Lin and Fu (2015). The coefficient of AY and PY both shows same significant impact on lnem as shown in the linear **ECM** model.

After estimating the long run relationship between the variables by Johansen cointegrating test, we move toward estimating the Error Correction Model to check the impact of variables in short run on trade balance (lnem).

$$\begin{aligned}\mathbf{\Delta lnem_t} = &- 0.693\mathbf{\Delta lnem_{t-1}} - 0.568\ \mathbf{\Delta lnem_{t-2}} - 0.371\ \mathbf{\Delta lnem_{t-3}} - 0.352\ \mathbf{\Delta lnem_{t-4}} - 0.203\ \mathbf{\Delta lnem_{t-5}} \\ &(-14.67) \quad (-9.93) \quad (-5.83) \quad (-5.53) \quad (-3.32) \\ &- 0.210\ \mathbf{\Delta lnem_{t-6}} - 0.115\ \mathbf{\Delta lnem_{t-7}} - 0.025\mathbf{\Delta ay_{t-1}} + 0.010\mathbf{\Delta ay_{t-2}} + 0.014\ \mathbf{\Delta ay_{t-6}} \\ &(-3.75) \quad (-2.20) \quad (4.29) \quad (2.72) \quad (4.51) \\ &- 0.004\mathbf{\Delta py_{t-5}} + 0.002\mathbf{\Delta py_{t-7}} - 0.005\mathbf{\Delta rer_{t-1}} + 0.003\mathbf{\Delta rer_{t-3}} - 0.\mathbf{005ECT_{t-1}} \quad \ldots\ldots\ldots\ldots (9) \\ &(-4.02) \quad (2.62) \quad (-3.19) \quad (2.04) \quad (-4.90)\end{aligned}$$

Diagnostics

Serial Correlation LM Test F value = 1.32 (0.21) Jarque Bera Normality = 1.68 (0.42)

Heteroscedasticity Test F value = 1.59 (0.30)

The results are given in equation (9) and (10) with the diagnostics results. As it can be seen that in equation (10) the RER^2 has removed because RER^2 fails to impact significantly on trade balance lnem in short run. The exchange rate has significant negative relationship with trade balance (lnem). 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

(2013) 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.

$$\Delta lnem_t = \underset{(-14.01)}{-0.658}\,\Delta lnem_{t-1} \underset{(-10.11)}{-0.567}\,\Delta lnem_{t-2} \underset{(-6.25)}{-0.374}\,\Delta lnem_{t-3} \underset{(-6.051)}{-0.357}\,\Delta lnem_{t-4} \underset{(-3.08)}{-0.169}\Delta lnem_{t-5}$$

$$\underset{(-3.04)}{-0.144}\Delta lnem_{t-6} + \underset{(3.04)}{0.011}\Delta ay_{t-1} + \underset{(2.59)}{0.009}\Delta ay_{t-2} + \underset{(4.13)}{0.013}\Delta ay_{t-6} \underset{(-3.06)}{-0.003}\Delta py_{t-5} +$$

$$\underset{(-2.17)}{-0.003}\Delta rer_t \underset{(-2.93)}{-0.005}\Delta rer_{t-1} \underset{(-4.39)}{-0.034}ECT_{t-1} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (10)$$

Diagnostics

Serial Correlation LM Test F value = 1.38 (0.21) Jarque Bera Normality = 1.26 (0.58)

Heteroscedasticity Test F value = 1.24 (0.25)

The ECT (9) of linear model and ECT (10) of nonlinear model show significant negative relationship that confirms the long run relationship between the variables and shows very slow speed of adjustment toward equilibrium in linear model but in nonlinear model it shows little fast adjustment to ward equilibrium about 0.03 units per months. The devaluation in domestic currency may change the trade balance in inverse direction in short run due to the adjustment of lags as in the study of Magee (1973). Diagnostics of both models shows that there is no autocorrelation and hetroscadasticity in the models, according to Jarque Berra test models shows that residuals are multivariate normal.

Table.3: Forecasting Performance of Models

Tests	Linear model	Nonlinear Model
Root Mean Square Error	0.128307	0.126655
Mean Absolute Error	0.099364	0.098702

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 (2015), as given in the Table 3 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 then linear model.

5. CONCLUSIONS

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). Empirically we observe the true relationship between real exchange rate and trade balance, whether it is linear or nonlinear by including RER^2 in model because through graph we couldn't generate the linear trend between variables. Using monthly data we applied Johansen cointegartion technique (1988) 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 (2015). 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 (2013), Lin and Fu (2015) and Magee (1973) 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 (2013). Lastly the forecast results also confirm the nonlinear models better interpretation for RER and trade balance in case of Pakistan and USA.

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