Volume–IX, Issue–02, July -December, 2014

Exchange Rate and Trade Balance of Bangladesh: Causality and Cointegration Analysis

MD. GOLAM MOSTOFA*
MD. ABDUR RASHID**

ABSTRACT

We investigate the interrelationship between the monthly trade balance and exchange rate data of Bangladesh. We find the existence of cointegration between these two variables. Error correction model reveals that the speed of adjustment coefficient of the trade balance equation corrects about 13% of any deviation from the long-run path within a month with a unidirectional causality running from exchange rate to trade balance. While the speed of adjustment coefficient of the exchange rate equation corrects only 0.003% within a month. This is somewhat slow and statistically insignificant.

Keywords: Trade balance, Exchange rate, Cointegration, Granger causality, Error correction, Speed of adjustment

1. INTRODUCTION

The relationship between trade balance and exchange rate is an important issue for both monetary and fiscal policy analysis of all economies. Most of the underdeveloped economies usually suffer from trade deficit due to imprecise implementation of monetary and fiscal policies. Currency devaluation is sometimes harmful and useful sometimes to achieve the import target of a country. Theoretically, however, exchange rate is a useful factor that determines the trade balance of a small open economy. In some theoretical and empirical models of exchange rate determination trade balance is treated as an exogenous variable under the assumption of unidirectional causality running from the trade balance to the exchange rate variable. As a result, the causal linkage may flow in the opposite direction. It is, therefore, possible to observe causal linkages flowing in both directions.

---

* Associate Professor, Department of Population Science and Human Resource Development, University of Rajshahi, Bangladesh. e-mail: mgm_pops@yahoo.com

** Assistant Porfessor, Department of Business Administration, Northern University Bangladesh. e-mail: sarkarrashid@yahoo.com

*** The paper was originally presented at the 1st Conference on Entrepreneurship, SMEs, Development and Management (ICESDM 2013), 30 June, 2013, Rajshahi, Bangladesh

Balance of Trade refers to the difference between the value of a country's merchandise exports and the value of its merchandise imports. Bangladesh is a small open economy. The trade regime of Bangladesh has undergone many changes over the years. It had difficulties in import financing during the 1970s immediately after her independence. Initially, it followed the line of import substitution, which implies restricting imports. But with the change in government policy towards promoting a laissez-faire economy and with inflows of foreign aid in increased volumes, Bangladesh started to import more in the early 1980s. There was a marked departure in the trade policy of Bangladesh when its trade policy was substantially liberalized with the implementation of the financial sector reforms program in the 1990s. Since 1992, Bangladesh has continued to liberalize its trade regime, by, inter alia, greatly reducing tariffs and eliminating some quantitative restrictions on imports. Despite the substantial reforms of the financial sector, Bangladesh has been experiencing deficits in trade balance.

A number of research has been considered the trade balance models along the lines of the Marshall-Lerner (ML) and found that the ML condition holds in the long-run with varying degree of the J-curve effects in the short-run, see for example, Boyd *et al*. (2001), Mahmud *et al*. (2004), Rose (1991), and Wilson (1993). Bahamani-Oskooee and Ratha (2004) is a good survey on ML and J-curve showing mixed results on this issue. Many empirical analyses conducted to investigate how exchange rate changes affect the trade balance of developing and developed countries using multi-country panel regressions and econometric models (Wilson, 2001). Despite the vast theoretical and empirical research on how exchange rate changes affect trade balance, there is still considerable disagreement concerning the relationships between these economic variables and the effectiveness of currency devaluation as a tool for increasing a country's balance of trade.

Because of the fundamental association between exchange rate and trade balance, our main objective of this study is to evaluate empirical tests of the relationship between trade balance and exchange rate by the standard econometric techniques. Specifically, this paper investigates the long-run association between the trade balance and the exchange rate of Bangladesh using Engle-Granger cointegration analysis and testing for the Granger causality within the error correction framework. To our knowledge, there is no such study took place that considers these two problems jointly for Bangladesh. Our study with monthly data finds a long-run association between trade balance and exchange rate and establishes a unidirectional causality running from exchange rate to trade balance with stable speed of adjustment coefficients. The speed of adjustment to disequilibrium in the long-run for the exchange rate equation is 0.01%, which is somewhat slow and statistically insignificant. On the other hand the speed of adjustment coefficient to disequilibrium in the long-run for the trade balance equation is

40%, which indicates that about 40% of any deviation from the long-run path is corrected within a month. This error correction equation reveals that unidirectional Granger causality running from exchange rate to trade balance exists for Bangladesh which is as expected for small open economies.

This paper is organized as follows. The data, sources of data, and description of the variables are given in section 2. Section 3 describes the methodology used for the proposed study. Empirical results with discussion of the results are reported in section 4. Finally section 5 concludes the paper.

2. DATA, SOURCES OF DATA, AND THE VARIABLES

Monthly time series data from July 1981 to December 2010 with a total of 354 observations on the exchange rate (Ex) and trade balance (TB) of Bangladesh are collected from the various issues of the 'Economic Trends' published monthly by the Statistics Department of Bangladesh Bank. Although Bangladesh has trade linkages with many other countries, this study uses Bangladesh Taka/ US dollar exchange rate as Ex series. The trade balance of Bangladesh is computed as the difference between the value of merchandise exports and the value of merchandise imports.

3. METHODOLOGY

In this study we use the unit root tests, cointegration and error correction approaches to modeling non stationary time series, and test for non-causality within the error correction framework.

3.1 Unit Root Tests

A stationary series is generally characterized by a time-invariant mean, variance and co-variances. However, most of the macroeconomic time series are found to be non stationary. The non stationarity of a time series variable can be tested by the unit root tests developed by Dickey and Fuller (1979, 1981). These tests are generally known as Dickey-Fuller (DF) and augmented Dickey-Fuller (ADF) tests. With reference to our two time series variables namely, trade balance and exchange rate variables if found to be stationary then the standard regression method can be applied to estimate the relationship between them. If however, the variables are found to be first order integrated, denoted I (1), i.e. the variables are non stationary in levels then we apply the Engle-Granger (1987) co integration method to estimate and test the relationship between the two non stationary variables.

3.2 The Engle Granger (EG) Method

Engle and Granger (1987) developed four steps procedure to determine the relationship between two trending variables known as co integration analysis.

The first step of the Engle-Granger procedure is to pretest the variables under study for their order of integration. This can be achieved by the

Dickey-Fuller (DF) and augmented Dickey-Fuller (ADF) unit root tests. Standard econometrics packages e.g. LIMDEP, MICROFIT, E-Views, RATS, SHAZAM and many others can perform this test fairly easily. If the variables under study indicate that both the variables are I(1), then the second step is to estimate the long-run equilibrium relationship between the variables in the following forms.

$$TB_t = \beta_1 + \beta_2 Ex_t + \varepsilon_{1t} \quad (1)$$

$$Ex_t = \alpha_1 + \alpha_2 TB_t + \varepsilon_{2t} \quad (2)$$

where TB_t is the trade balance in time t, Ex_t is the exchange rate in time t, $\beta_1, \beta_2, \alpha_1$ and α_2 are the parameters, and $\varepsilon_{it} (i = 1,2)$ is the long-run equilibrium error. In order to determine if the variables are actually cointegrated, the residuals $\{\hat{\varepsilon}_{it}\}$ i.e. the estimated values of the deviation from long-run relationship must be tested for unit root non stationary by the DF and/or ADF tests. The observed test values must be compared with the critical values of the Engle-Granger co-integration test. If the residual series is found to be stationary, then the test concludes that the two I(1) variables are co-integrated. If the variables are found to be co-integrated then the third step of Engle-Granger procedure is to estimate an error correction model (ECM). The error correction models for the two variables are as follows.

ECM for TB:

$$\Delta TB_t = \beta_{10} + \alpha_1 \hat{\varepsilon}_{1,t-1} + \sum_{i=1}^{p} \alpha_{11}(i) \Delta TB_{t-i} + \sum_{i=1}^{p} \alpha_{12}(i) \Delta Ex_{t-i} + \eta_{t,TB} \quad (3)$$

ECM for Ex:

$$\Delta Ex_t = \beta_{20} + \alpha_2 \hat{\varepsilon}_{1,t-1} + \sum_{i=1}^{p} \alpha_{21}(i) \Delta TB_{t-i} + \sum_{i=1}^{p} \alpha_{22}(i) \Delta Ex_{t-i} + \eta_{t,Ex} \quad (4)$$

Where β_{10}, α_1, $\alpha_{11}(i)$, $\alpha_{12}(i)$ are the parameters and $\eta_{t,TB}$ is the random disturbance term of the ECM for TB. Similarly, β_{20}, α_2, $\alpha_{21}(i)$, $\alpha_{22}(i)$ are the parameters and $\eta_{t,Ex}$ is the random disturbance term of the ECM for Ex.

The above ECM models can be represented in matrix form. In that case it is known as vector error correction (VEC) model. The ECM or the VEC model can be estimated by the ordinary least square (OLS) method. The appropriate number of lags (p) to be included in the ECM equations can be determined by the likelihood-ratio (LR) test, the AIC criterion, or by the rule of thumb value $p = 0.75T^{1/3}$ (approximated to its nearest integer), where T is the sample size under study.

The final step of Engle-Granger four steps procedures is to assess the model adequacy. The model adequacy can be tested by the Ljung-Box (1978)

Q-statistic based on the residuals obtained from model (3) and (4). The speed of adjustment coefficients α_1 and α_2 can be tested for statistical significance. It is required that these estimates should not be too large. In fact we expect these to be less than 1 in absolute value for stability of the system. The sign and the magnitude of these parameters would indicate the direction of adjustment and speed at which the variables would in the short-run to go back to its long-run equilibrium.

3.3 Granger causality within the ECM framework.

Granger non-causality of Ex to TB can be tested by testing the coefficients $\alpha_1 = 0$ and $\alpha_{12}(i)$=0 for all i jointly in equation (3). Similarly, causality from TB to Ex can be tested in equation (4) by extending the methodology developed by Granger (1969) for more comprehensive test of causality which is applied within the error-correction model. It is to be noted that even in the absence of co-integration between the two variables, the ECM or VEC model can still be estimated to test for short-run standard Granger causality (Bahmani and Payesteh, 1993). But in that case, the error-correction term i.e. $\hat{\varepsilon}_{1,t-1}$ should not be included in (3) and (4) for estimation purposes. In the absence of error correction term, the resulting models (3) and (4) represents a vector auto-regression (VAR) in difference.

4. EMPIRICAL RESULTS AND DISCUSSION OF THE RESULTS

4.1 Unit root test

The ADF unit root tests for the trade balance (TB) and the exchange rate (Ex) series are given in Table 1. The optimal lag in the ADF equation is determined by the minimum AIC criterion. Asymptotic 10% critical values are reported in parentheses next to the test values. These tests are performed in SHAZAM.

TABLE 1

RESULTS OF ADF UNIT ROOT TEST

Variables	Lag 18 +No trend	Trend +18 lags	Lag 13 + No trend	Trend +13 lags
Ex			-0.2365 (-2.57)	-2.5891 (-3.13)
TB	1.1881 (-2.57)	-0.8507 (-3.13)		
ΔEx			-3.8579 (-2.57)	-3.8539 (-3.13)
ΔTB	-6.6823 (-2.57)	-7.1602 (-3.13)		

Note: $\Delta z = z_t - z_{t-1}$, z *is the variable concerned.*

The ADF tests indicate that the null hypothesis of unit root is accepted for both the Ex and the TB series but rejected in their first difference. These variables are thus found to be non-stationary in levels but stationary in first difference i.e. both the variables are I(1). Therefore, application of the traditional regression approach to examining the relationship between exchange rate and trade balance might be spurious. This study, therefore, adopted the Engle-Granger co-integration approach to modeling non-stationary time series variables.

4.2 The Engle-Granger co-integration method

The long-run relationship between TB and Ex given in equations (1) and (2) are estimated by the OLS method using SHAZAM package as follows.

$$TB_t = 2267.0 - 82.133Ex_t + \hat{\varepsilon}_{1t} \qquad (5)$$

(t-ratio) (15.52) (-26.44)
(p-value) (0.000) (0.000)

$$Ex_t = 33.151 - 0.00819TB_t + \hat{\varepsilon}_{2t} \qquad (6)$$

(t-ratio) (52.28) (-26.44)
(p-value) (0.000) (0.000)

The essence of the Engle-Granger co-integration test is to determine whether the residuals from (5) and (6) are stationary. There is, however, no theoretical consideration that which one of the two residuals is preferable to the other in performing the test.

We have used the Dickey-Fuller (DF) unit root test on the residuals obtained from (5) and (6) to perform the co-integration test. In order to do so we have estimated the following Dickey-Fuller regressions.

$$\begin{aligned} &\Delta\hat{\varepsilon}_{1t} = -0.3414\hat{\varepsilon}_{1,t-1} \\ &\tau - statistic \quad (-8.068) \end{aligned} \qquad (7)$$

$$\begin{aligned} &\Delta\hat{\varepsilon}_{2t} = -0.234\hat{\varepsilon}_{2,t-1} \\ &\tau - statistic \quad (-6.682) \end{aligned} \qquad (8)$$

Comparing the $\tau - statistics$ obtained from (7) and (8) with the Engle-Granger 5% critical value of -3.350 (obtained from Enders, 2004), the test concludes that both the residuals series are stationary and hence the two series, the trade balance and the exchange rate of Bangladesh are co-integrated. Therefore, the Granger representation theorem indicates that there exists error correction representation between the trade balance and the exchange rate of Bangladesh. The third step of Engle-Granger procedure is to estimate the short-run dynamics and the error correction model.

4.3 Short-run dynamics and the ECM estimates

Since the variables are co-integrated, we proceed to estimate the error correction models (3) and (4). In estimating the ECM we used $p = 5$ lags (using the rule of thumb) of the change of the variables as the right-hand-side variables of the ECMs. The ECMs are estimated by the OLS. The results of the estimated coefficients with their t-values and p-values, $\overline{R}^2$, DW, and the Ljung-Box Q-statistics with their p-values (in parenthesis) are reported in Table 2 and in Table 3 respectively.

TABLE 2

ECM ESTIMATION FOR TRADE BALANCE

Left hand side variable: ΔTB_t

Right hand-side variable	**Estimated coefficient**	**Standard error**	**t-ratio**	**p-value**
constant	-50.150	41.68	-1.203	0.230
$\hat{\varepsilon}_{1,t-1}$	-0.13309	5.03E-02	-2.647	0.009
ΔTB_{t-1}	-0.46676	6.64E-02	-7.034	0.000
ΔTB_{t-2}	-0.31566	6.70E-02	-4.710	0.000
ΔTB_{t-3}	-0.16952	6.73E-02	-2.520	0.012
ΔTB_{t-4}	-0.3204	6.50E-02	-4.928	0.000
ΔTB_{t-5}	-0.26498	5.71E-02	-4.645	0.000
ΔEx_{t-1}	-70.421	79.12	-0.8901	0.374
ΔEx_{t-2}	103.72	78.98	1.313	0.190
ΔEx_{t-3}	106.52	79.20	1.345	0.180
ΔEx_{t-4}	89.417	79.25	1.128	0.260
ΔEx_{t-5}	-124.07	78.98	-1.571	0.117

$\overline{R}^2 = 0.305$ Durbin-Watson (DW) Statistic =1.89

Q(4)= 1.3488 (p-value=0.853) Q(8)= 6.3624 (p-value=0.607)

TABLE 3

ECM ESTIMATION FOR EXCHANGE RATE

Left-hand side variable: ΔEx_t

Right-hand side-variable	Estimated coefficient	Standard error	t-ratio	p-value
constant	0.1323	2.93E-02	4.523	0.000
$\hat{\varepsilon}_{1,t-1}$	3.20E-05	3.53E-05	0.9060	0.366
ΔTB_{t-1}	-4.50E-05	4.66E-05	-0.9671	0.334
ΔTB_{t-2}	1.35E-05	4.70E-05	0.2880	0.774
ΔTB_{t-3}	-3.08E-05	4.72E-05	-0.6512	0.515
ΔTB_{t-4}	-5.60E-05	4.56E-05	-1.227	0.221
ΔTB_{t-5}	-3.91E-05	4.00E-05	-0.9769	0.329
ΔEx_{t-1}	6.11E-02	5.55E-02	1.100	0.272
ΔEx_{t-2}	-4.03E-02	5.54E-02	-0.7271	0.468
ΔEx_{t-3}	4.45E-03	5.56E-02	0.8016E-01	0.936
ΔEx_{t-4}	-8.39E-03	5.56E-02	-0.1509	0.880
ΔEx_{t-5}	7.05E-02	5.54E-02	1.272	0.204

$\overline{R}^2 = 0.0075$ Durbin-Watson (DW) Statistic =1.98

Q(4)=0.3798 (p-value=0.984) Q(8)=13.2677(p-value=0.103)

In the Engle-Granger framework, most of the estimated coefficients of ECM (3) are statistically significant at the conventional level. On the other hand all of the estimated coefficients of the ECM (4) are statistically insignificant. However, the coefficients of the lagged residuals ($\hat{\varepsilon}_{1,t-1}$) of the estimated equation (3) and (4) reported in Table 2 and Table 3 respectively are of particular interest because they represent the speed of adjustment as well as stability of the system. The absolute values of the coefficients of $\hat{\varepsilon}_{1,t-1}$ are found to be less than one in both the equations, which indicates that the system is stable. Moreover, the estimated coefficient $\hat{\alpha}_1 = -0.13309$ of $\hat{\varepsilon}_{1,t-1}$ in the ECM (3) for TB is statistically significant at the conventional level. This value of the speed of adjustment indicates that approximately 13% of any deviation from the long–run path is corrected within a month (for monthly data). While, the estimated coefficient $\hat{\alpha}_2 = 0.000032$ of $\hat{\varepsilon}_{1,t-1}$ in the ECM (4) for Ex is statistically insignificant. This low value of $\hat{\alpha}_2 =$ 0.000032 indicates that the short-run exchange rate is unresponsive to the last month's disequilibrium error. The DW tests for both the models (3) and (4) indicate no significant positive or negative serial correlation in the residuals. Moreover, the Ljung-Box Q-statistics are statistically insignificant at the conventional level. The $\overline{R}^2$ of the ECM (4) explains only 0.75% of the total variation in the change of the exchange rate variable. On the other hand the $\bar{R}^2$ of model (3) indicates that approximately 31% of the total variation in the change of the trade balance is explained by the explanatory variables.

4.4 Granger causality test within the error correction framework

Granger causality test can be performed within the error correction model using F-test. The joint test values and the associated p-value of the tests are reported in Table 4.

TABLE 4
GRANGER CAUSALITY TEST

Direction of causality	F-test	p-value of F-test
H_0 : Exchange rate does not Granger cause trade balance, i.e. $H_0 : \alpha_1 = \alpha_{12}(i) = 0$ for all i (see equation 3)	**2.5117**	**0.021**
H_0 : Trade balance does not Granger cause exchange rate i.e. $H_0 : \alpha_2 = \alpha_{21}(i) = 0$ for all i (see equation 4)	**0.73024**	**0.62555**

Granger causality tests reported in Table 4 conclude that the exchange rate Granger cause trade balance while the trade balance does not Granger cause exchange within the error correction framework at the conventional level. Thus from the above test it appears that unidirectional causality running from exchange rate to trade balance exists for Bangladesh.

Considering the above analysis within the error correction framework the exchange rate model casts doubt about the adequacy. While the error correction model (3) for trade balance describes the data adequately well for Bangladesh.

5. CONCLUSIONS

This paper tested the equilibrium of trade balance and exchange rate hypothesis for Bangladesh using monthly data for the period July 1981 to December 2010. Augmented Dickey-Fuller test confirms that both the exchange rate and the trade balance are unit root non-stationary processes in level but stationary in first difference. The study then applied the Engle-Granger four steps procedure in order to determine whether there is any long-run relationship exists between the exchange rate and the trade balance. The results from the co-integration tests support the existence of long-run equilibrium between the trade balance and the exchange rate of Bangladesh. The estimated speed of adjustment coefficient of the ECM for the trade balance equation indicates that approximately 13% of any deviation from the long-run path is corrected within a month. While the speed of adjustment coefficient of the ECM for the exchange rate equation indicates that approximately 0.003% of any deviation from the long-run path is corrected within a month. This low value of the speed of adjustment of the exchange rate model indicates that the short-run exchange rate is unresponsive to the last month's disequilibrium error. The exchange rate equation within the ECM framework indicates no Granger causality exists from trade balance to exchange rate of Bangladesh. While, the unidirectional causality running from exchange rate to trade balance exists within the ECM for the trade balance equation which is as expected as Bangladesh is a small open economy.

REFERENCES

Bahmani-Oskooee M, Payesteh S. 1993. Budget Deficits and the Value of the Dollar: An Application of Cointegration and Error-correction Modeling. *Journal of Macroeconomics* **15:** 661-677.

Bahmani-Oskooee M, Ratha A . 2004. The J-Curve: a literature review. *Applied Economic* **36:** 1377-1398.

Boyd D, Caporale GM, Smith R . 2001. Real Exchange Rate Effects on the Balance of Trade: Cointegration and the Marshall-Lerner Condition. *International Journal of Finance and Economics* **6 :** 187-200.

Dickey DA, Fuller WA. 1979. Distribution of the Estimates for Autoregressive Time Series with a Unit Root. *Journal of the American Statistical Association* **74:** 427-431.

Dickey DA, Fuller WA. 1981. Likelihood Ratio Statistics for Autoregressive Time Series with a Unit Root. *Econometrica* **49:** 1057-1072.

Enders W. 2004. *Applied Econometric Time Series.* Second Edition, Wiley.

Engle RF, Granger CWJ. 1987. Co-Integration and Error Correction: Representation, Estimation, and Testing. *Econometrica* **55:** (2) 251-276.

Granger CWJ. 1969. Investigating Causal Relations by Econometric Models and Cross-Spectral Methods. *Econometrica* **37:** 424-438.

Ljung G, Box G. 1978. On a Measure of Lack of Fit in Time Series Models. *Econometrica* **65:**297-303.

Mahmud SF, Ullah A, Yucef EM. 2004. Testing Marshall-Lerner condition: a non-parametric approach. *Applied Economics Letters* **11 :** 231-236.

Rose AK. 1991. The Role of Exchange Rates in a Popular Model of International Trade: Does the Marshall-Lerner Condition Hold? *Journal of International Economics* **30:** 301-316.

Wilson P. 2001. Exchange Rates and the Trade Balance for Dynamic Asian Economies - Does the J-Curve Exist for Singapore, Malaysia, and Korea? *Open Economies Review* **12:** 389 – 413.

Wilson WT. 1993. J-curve Effect and Exchange Rate Pass-Through: An Empirical Investigation of the United States. *The International Trade Journal* **7:** (4) 463 – 483.