Journal of Economics and Sustainable Development
ISSN 2222-1700 (Paper) ISSN 2222-2855 (Online)
Vol.9, No.18, 2018
www.iiste.org

# The Monetary Approach to the Exchange Rate of Bangladesh: A Cointegration Approach

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**Abstract**
The paper estimates a model to determine the exchange rate movements for the Bangladeshi Taka (BDT) face to face US Dollar (USD) using monetary approach. The results using yearly data for the period of 1976 to 2016 assure long-run relationships among the variables. The study uses the Johansen cointegration technique and finds that exchange rate is cointegrated for the monetary fundamentals. As such, the model is compatible with standard international economic theory. The study uses the Vector Error Correction Model (VECM) and finds the long run as well as the short run relationships among the monetary fundamentals and the exchange rate. The study uses the CUSUM and CUSUM-SQ test to identify the structural stability of the model. It is found that there is a long run relationship among the considered variables and the model is structurally stable. The paper finds that the money supply and the GDP play the key role to determine the exchange rate, i.e., the money supply has a positive impact on the exchange rate and the GDP has a negative impact on the exchange rate. The paper does not support the monetarist hypothesis that a higher interest rate leads to appreciate the exchange rate. Therefore, the monetarist hypothesis deserves further rigorous empirical investigation in the context of Bangladesh. Although the inflation is statistically significant, it is not consistent with the many other variants of the monetary models.
**Keywords**: Monetary approach, ADF test, Cointegration, VECM test, Exchange rate, Bangladesh.

## 1. Introduction

The stability of exchange rate plays a significant role in international trading as well as in the economy of a country. The exchange rate determines the balance of trade of a country. A stable exchange rate can open the investment door greatly which is needed for the development of Bangladesh. The determination of exchange rate has improved greatly.

According to the work of Meese and Rogoff (1983), a monetary fundamental cannot prognosis the exchange rates. Meese and Rogoff (1983) represent the random walk model to determine the exchange rate. MacDonald and Taylor (1993) use the monetary approach model to determine exchange rate using the cointegration techniques and they find the dynamic relationships among the monetary fundamentals and the exchange rate that are superior to those generated by a random walk forecasting model.

Demir (2014) examines the response of monetary policy to the exchange rate. The findings suggest that the ECB methodically reacts to exchange rate behavior but that there is a small quantitative effects. The coefficients indicate consistency with the hypothesis in which the central bank does not care about the exchange rate fluctuations.

Fisher and Huh (2016) examine SVARs for three large and four small economies and use sign restrictions to define the shocks in the SVARs. The results suggest that a contractionary monetary policy shock takes place for the small economics and the peak appreciation occurs in the long run for the Euro region as well as Japan.

Kohlscheen (2014) investigates the effect of monetary shocks on the exchange rates of Chile, Mexico and Brazil. The author concentrates on one day exchange rate fluctuations and finds a potential reduction for inconsistent causality.

Kim and Lim (2018) use VAR model to examine the monetary policy shocks on exchange rate in Australia, Canada, Sweden, and United Kingdom. The authors find a contractionary monetary shock to conduct an effective exchange rate appreciation and also find a short delay in overshooting. Loria, Sanchez and Salgado (2010) find a strong short run and long run relationships among the Mexican monetary policy and the exchange rate. Ojede and Kam (2017) find a consistent relationship between monetary aggregates and the exchange rate.

Sun (1998) demonstrates Korean won/dollar real exchange rate working with cointegration model of Johansen. He states about the significance of the monetary approaches to the exchange rate. The author (1998) finds the long relationships between the exchange rate and the fundamental variables. He states that the net foreign assets, productivity differential, a volume of openness and house price index employ a significant contribution to report the exchange rate. Hoshikawa (2012) also uses the cointegration model to display the long run relation between the exchange rate and Japanese international reserves.

Sahminan (2005) uses terms of trade, inflation differential, and interest to determine the long-run equilibrium real exchange rate of Rupiah. The study finds the overvaluation of Rupiah exchange rate correlative to balance real exchange rate in the period briefly earlier on the crisis.

Hwang (2001) makes up cointegrating vector relationships among the macroeconomics approaches and the exchange rate for the United States dollar/Canadian dollar employing Johansen's cointegration test. Hwang (2001) shows the long run bondings among the monetary approaches and exchange rate. Hwang (2001) asserts that monetary approaches are the effective way to determine for an exchange rate. Moyakoshi (2000) shows the cointegration relations among the money supply, income, interest rate and the exchange rate with United States dollar, German mark and Japanese yen using Johansen cointegration test.

Hossain and Ahmed (2009) view the exchange rate policy in Bangladesh for the period 2000-08. The study shows that Bangladesh maintains a dirty float de facto exchange rate regime. Khondker et al. 2012 use the three markets Keynesian model to test the changing effect of exchange rate on Bangladesh's aggregate output (GDP). The work shows the relations between GDP and a vector of variables including terms of trade, government expenditure, and private sector credit. Meerza (2012) finds that nominal exchange rate is cointegrated with the several macroeconomic variables (money supply, IPI, interest rate and inflation). Finally, Azar (2013) considers money stock, price level, aggregate output and interest rates to determine the movements of the exchange rates and estimates successfully a version of the monetary approach to foreign exchange rates applied to the US dollar for the post-1973 floating exchange rate period.

The central bank of Bangladesh keeps an eye on the external value of Taka and sometimes it takes effective steps to smooth the excessive volatility of Taka because sound movements of exchange rates in Bangladesh help to expand the opportunities. Exchange rates are still one of the most polemic affairs both theoretically and empirically in international finance. Besides these, recent empirical models disregard the dynamic existence of a long run relationship between nominal exchange rate and economic fundamentals (Beckmann et al. 2011).

The objectives of this paper are to model the relationship between the exchange rate and considered macroeconomic variables suggested by the economic theory.

## 2. Theoretical framework

The study uses the monetary approach model of exchange rates.

$$\frac{M}{P} = L(Y, I) \quad (1)$$

Where, M, P, L, Y and I indicate the money supply, the price level, the money demand, the income and the interest rate.

The study uses the Purchasing Power Parity (PPP) as the basic assumption of monetary approach.

$$S = \frac{P}{P^*} \quad (2)$$

Where, S, P, P* denote the nominal exchange rate, the domestic price and the foreign price.

The exchange rate can be disclosed as the difference between domestic and foreign money supply, Gross Domestic Product (GDP), interest rate and inflation rates.

$$S = \alpha_0 + \alpha_1 (m - m^*) + \alpha_2 (y - y^*) + \alpha_3 (i - i^*) + \alpha_4 (\pi - \pi^*) \quad (3)$$

Where,

S is the logarithm of the nominal exchange rate.

$m - m^*$ is the logarithm of the ratio of the home to the foreign real money supply.

$y - y^*$ is the logarithm of the ratio of the home to foreign GDP.

$i - i*$ is the logarithm of the ratio of the home to the foreign interest rate.

$\pi - \pi*$ is the logarithm of the ratio of the home to the foreign inflation rate.

This equation can be rewritten as follows:

$$S_t = \alpha_0 + \alpha_1 M_t + \alpha_2 Y_t + \alpha_3 I_t + \alpha_4 \pi_t + u_t \quad (4)$$

Kurihara and Fukushima (2015) also use the same model to test the exchange rate for Japan.

## 3. Data Source

All data are collected from World Development Indicators .The study uses the yearly data for the period of 1976 to 2016 because monthly data of all considered variables are not available. The dependent variable for this paper is nominal exchange rate and the independent variables are the money supply, gross domestic product (GDP), interest rate and inflation rate.

## 4. Methodology

*4.1 Unit root test*

Non-stationary values force to diverge from long-run equilibrium (Granger and Newbold 1974). For this reason, the study uses the Unit Autoregressive Root tests to check the stationary of the series for the short run dynamics as well as the long run relation among all the variables. The study uses the Augmented Dickey-Fuller (ADF) test

(Dickey and Fuller 1981).

*4.1.1 Augmented Dickey-Fuller (ADF)*

The Augmented Dickey-Fuller (ADF) test forms of calculating the following regression:

$$\Delta y_t = \mu + \gamma y_{t-1} + \sum_{j=1}^{\rho} \gamma_j \Delta y_{t-j} + \varepsilon_t \tag{5}$$

Where Δ uses as the first difference operator and $\varepsilon_t$ represents the white noise error term and $\rho$ reports as the number of lags in the dependent variable. This equation identifies ADF tests without trend, respectively.

$$\Delta y_t = \mu + \beta_t + \gamma y_{t-1} + \sum_{j=1}^{\rho} \gamma_j \Delta y_{t-j} + \varepsilon_t \tag{6}$$

This equation shows ADF tests with the trend, respectively. In this manner, the ADF unit root test sets a null hypothesis $H_0: \gamma = 0$ as well as an alternative hypothesis $H_A: \gamma < 0$ .

*4.2 Johansen Cointegration Test*

The study uses the Johansen (1988) maximum likelihood approach to identify a long run relationship among all the variables. Cointegration means that in the face of being individually non-stationary, a linear coalescence between two or more time series can be stationary. Cointegration of two or more time series signals that a long run cointegrated relation is available among all the variables.

The cointegration test follows the Vector Auto regression (VAR) model:

$$M_{i,t} = \prod_{11} M_{i,t-1} + \prod_{12} Y_{i,t-1} + \prod_{13} I_{i,t-1} + \prod_{14} \pi_{i,t-1} + \prod_{15} S_{i,t-1} + \varepsilon_{S_{i,t}} \tag{7}$$

$$Y_{i,t} = \prod_{21} M_{i,t-1} + \prod_{22} Y_{i,t-1} + \prod_{23} I_{i,t-1} + \prod_{24} \pi_{i,t-1} + \prod_{25} S_{i,t-1} + \varepsilon_{Y_{i,t}} \tag{8}$$

$$I_{i,t} = \prod_{31} M_{i,t-1} + \prod_{32} Y_{i,t-1} + \prod_{33} I_{i,t-1} + \prod_{34} \pi_{i,t-1} + \prod_{35} S_{i,t-1} + \varepsilon_{I_{i,t}} \tag{9}$$

$$\pi_{i,t} = \prod_{41} M_{i,t-1} + \prod_{42} Y_{i,t-1} + \prod_{43} I_{i,t-1} + \prod_{44} \pi_{i,t-1} + \prod_{45} S_{i,t-1} + \varepsilon_{\pi_{i,t}} \tag{10}$$

$$S_{i,t} = \prod_{51} M_{i,t-1} + \prod_{52} Y_{i,t-1} + \prod_{53} I_{i,t-1} + \prod_{54} \pi_{i,t-1} + \prod_{55} S_{i,t-1} + \varepsilon_{S_{i,t}} \tag{11}$$

Matrix notation can be constructed:

$$\begin{pmatrix} M_{i,t} \\ Y_{i,t} \\ I_{i,t} \\ \pi_{i,t} \\ S_{i,t} \end{pmatrix} = \begin{pmatrix} \prod_{11} & \prod_{12} & \prod_{13} & \prod_{14} & \prod_{15} \\ \prod_{21} & \prod_{22} & \prod_{23} & \prod_{24} & \prod_{25} \\ \prod_{31} & \prod_{32} & \prod_{33} & \prod_{34} & \prod_{35} \\ \prod_{41} & \prod_{42} & \prod_{43} & \prod_{44} & \prod_{45} \\ \prod_{51} & \prod_{52} & \prod_{53} & \prod_{54} & \prod_{55} \end{pmatrix} \begin{pmatrix} M_{i,t} \\ Y_{i,t} \\ I_{i,t} \\ \pi_{i,t} \\ S_{i,t} \end{pmatrix} + \begin{pmatrix} \varepsilon_{S_{i,t}} \\ \varepsilon_{Y_{i,t}} \\ \varepsilon_{I_{i,t}} \\ \varepsilon_{\pi_{i,t}} \\ \varepsilon_{S_{i,t}} \end{pmatrix} \tag{12}$$

Johansen recommends two different likelihood ratio tests of the significance of the canonical correlations and thereby the reduced rank of the matrix: the trace test and Maximum Eigen Value Test i.e.

$$\lambda_{trace(r)} = -T \sum_{i=r+1}^{k} \ln(1 - \widehat{\lambda_i}) \tag{13}$$

$$\lambda_{\max(r,r+1)} = -T \ln(1 - \widehat{\lambda_{r+1}}) \tag{14}$$

Here, T is the sample size and $\widehat{\lambda_i}$ is the ith largest canonical correlation. The trace tests the null hypothesis of r cointegrating vectors against the alternative hypothesis of n cointegrating vectors. The maximum eigenvalue test, in contrast, tests the null hypothesis of r cointegrating vectors against the alternative hypothesis of r+1 cointegrating vectors. Asymptotic critical values can be obtained from Johansen and Juselius (1990). Analogously the time series variables of Bangladesh are tested to investigate the long run relationship among the variables.

*4.3 Vector Error Correction Model (VECM)*

The cointegration among variables solely exhibits a long run equilibrium relationship. In fact, there may be disequilibrium in the short run. To investigate the short run dynamics among the concerned time series variables, Vector Error Correction Model (VECM) should be developed.

VECM considers,

$$\Delta S_t = \beta_0 + \sum_{j=1}^{m} \theta_k \Delta S_{t-j} + \sum_{j=1}^{m} \gamma_k \Delta M_{t-j} + \sum_{j=1}^{m} \tau_k \Delta Y_{t-j} + \sum_{j=1}^{m} \varphi_k \Delta I_{t-j} + \sum_{j=1}^{m} \sigma_k \Delta \pi_{t-j} + \lambda [S_{t-1} - \widehat{\alpha_0} - \widehat{\alpha_1} M_{t-1} - \widehat{\alpha_2} Y_{t-1} - \widehat{\alpha_3} I_{t-1} - \widehat{\alpha_4} \pi_{t-1}] + \varepsilon_t \tag{15}$$

Where Δ is the first difference operator, λ depicts the speed of adjustment from short run to the long run equilibrium, $\varepsilon_t$ is a purely white noise term.

 

## 5. Result and discussions

*5.1 Augmented Dickey-Fuller (ADF) Unit Root test*

Table 1. Augmented Dickey-Fuller (ADF) Unit Root test

| | Without trend | | With trend | |
|---|---|---|---|---|
| **Variable** | **Value** | **1st difference** | **Value** | **1st difference** |
| S | -2.940*** | -3.057*** | -1.580 | -4.117** |
| | (3) | (2) | (2) | (2) |
| M | o.117 | -4.122*** | -3.921** | -4.079** |
| | (1) | (2) | (2) | (2) |
| Y | 2.411*** | -2.466*** | 0.287 | -3.739*** |
| | (2) | (1) | (2) | (1) |
| I | -2.198** | -6.756*** | -3.003 | -4.206** |
| | (1) | (0) | (1) | (1) |
| Π | -2.738*** | -5.309*** | -2.745 | -5.212*** |
| | (3) | (3) | (3) | (3) |

Source: Authors calculation from STATA 12 software.

Notes: (1) figures within parentheses show lag lengths selected by the Akaike Information Criterion (AIC) (2) ***, **, * denote the rejection of the null hypothesis of unit root at 1%, 5%, and 10% significance level respectively.

Table 1 show that some of the variables are non-stationary in case of without trend as well as with trend. In order to get stationary value, the study uses the 1st difference process. Finally, ADF unit root test reject the null hypothesis for all variables in 1st difference at 1% significance level for without trend and at 1% as well as 5% significance level for with trend.

*5.2 Johansen Cointegration Test*

Table 2. Johansen Cointegration Test

| Null ($H_0$) | $\lambda_{trace}$ | 5% critical value | $\lambda_{max}$ | 5% critical value |
|---|---|---|---|---|
| r = 0 | 96.0432* | 68.52 | 41.28* | 33.46 |
| r≤1 | 54.7679* | 47.21 | 33.21* | 27.07 |
| r≤2 | 21.5580 | 29.68 | 12.87 | 20.97 |
| r≤3 | 8.6920 | 15.41 | 8.69 | 14.07 |
| r≤4 | .0048 | 3.76 | 0.0048 | 3.76 |

Source: Authors calculation from STATA 12 software.

Notes: (1) r denotes the number of cointegration vectors. (2) The lag order for each VAR is chosen by AIC as shown in parenthesis. (3) Star (*) denotes the rejection of the null hypothesis of unit root at 5% significance level respectively.

Table 2 reports that Johansen cointegration results for the monetary approach to the exchange rate of Bangladesh. The result shows that the null hypothesis of no cointegration, i.e., r=0, is rejected for the monetary approach. This is because either $\lambda_{trace}$ or $\lambda_{max}$ greater than the critical value at the 5% level of significance. The result provides evidence that there is at least two cointegrating vector in each case. In some cases, there is even more than one vector.

*5.3 Vector Error Correction Model*

Table 3. Vector Error Correction Model

| Variale | Long run relationship ( Johansen Normalized cointegrating equation) | | | |
|---|---|---|---|---|
| | **coefficient** | **Standard error** | **Z – value** | **P > \|z\|** |
| S | 1 | - | - | - |
| Constant | -7.046 | - | - | - |
| M | -.732 | .0923 | -7.93 | 0.000 |
| Y | .215 | .235 | .91 | 0.360 |
| I | -.103 | .03 | -3.46 | 0.000 |
| Π | .12 | .023 | 5.14 | 0.000 |

Source: Authors calculation from STATA 12 software.

The long run equation:

$$\hat{S}=7.046 + .732\,\hat{M} - .215\,\hat{Y} + .103\,\hat{I} - .12\,\hat{\Pi}$$

Table 3 shows the long run Vector error correction model test results. Here, all coefficients are significant at 1% significance level. Concerning the considered variables, the estimated coefficient signs of the money supply and the GDP differentials show consistency with any other forms of the monetary models. More especially, the estimates show a negative impact of the GDP on the exchange rate between the Bangladeshi Taka (BDT) as well as U.S Dollar (USD), while there is a positive impact of the money supply on the exchange rate. The coefficient sign of the interest rate shows the consistency only with the Bilson's version. An increase in the interest rate differentials decreases the money demand which has a negative impact on the BD currency. Although the estimated sign of the coefficients of the inflation differential is statistically significant, its sign is not consistent with the many other variants of the monetary models. These results are also consistent with the previous studies of ''Papadamou and Markopoulos (2012)'' in the case of Norwegian Krone.

Table 4. Vector error correction model

| Variale | Short run relationship | | | |
|---|---|---|---|---|
| | Coefficient | Standard error | Z – value | p> \|z\| |
| _cel | -.0075 | .056 | -.13 | .893 |
| L1. | | | | |
| S | .392 | .173 | 2.27 | .023 |
| LD. | | | | |
| M | -.122 | .134 | -.91 | .362 |
| LD. | | | | |
| Y | -.231 | .336 | -.69 | .491 |
| LD. | | | | |
| I | -.003 | .011 | -0.28 | .778 |
| LD. | | | | |
| Π | -.006 | .006 | -.93 | .354 |
| LD. | | | | |
| Cons. | .038 | .014 | 2.67 | .008 |

Source: Authors calculation from STATA 12 software.

Table 4 shows the short run vector error correction model test results. Here, the independent variables such as real money supply, GDP, interest rate and inflation rate show the negative sign which means that all independent variables are insignificant and negatively related with the real exchange rate in the short run. An increase of the independent variables depreciates the exchange rate.

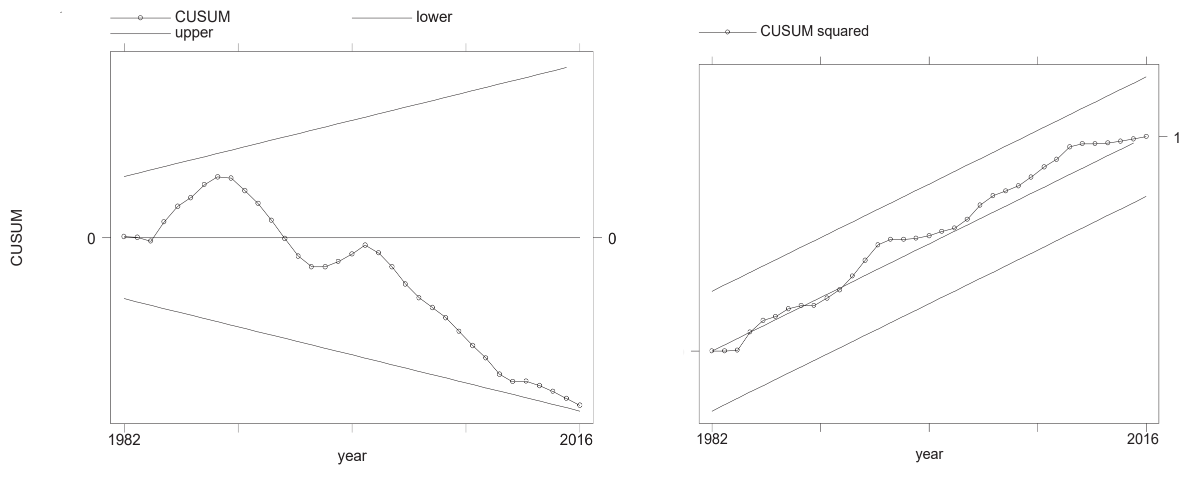


*Figure 1. CUSUM and CUSUM-SQ Test (5% significance level)*

The stability test is conducted by employing the CUSUM and CUSUM-SQ statistics. The CUSUM and CUSUM-SQ test for the residuals of functions that provide evidence of the structural stability in the short run as well as the long run. Here, the statistical results are between the upper and lower limit. So the empirical results show that the model is stable.

## 6. Conclusion

In this paper, Johansen cointegration approach provides evidence on the presence of long-run relationships among the variables of monetary fundamentals and exchange rate. The results find that the money supply and the GDP play an effective role to determine the exchange rate. A higher money supply depreciates the exchange rate and a higher GDP appreciates the exchange rate (theoretically similar). The interest rate does not support the monetarist hypothesis. The interest rate shows the consistency only with the Bilson's version. An increase in the interest rate decreases the money demand which has a negative impact on the BD currency. Therefore, the monetarist hypothesis deserves further rigorous empirical investigation. Although the inflation is statistically significant, it is not consistent with the many other variants of the monetary models. The monetarist needs to more empirical research on the inflation rate.

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