The impact of monetary policy on exchange rate dynamics of Bangladesh: a co integration approach

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The Impact of Monetary Policy on Exchange Rate Dynamics of Bangladesh: A Co Integration Approach

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Abstract:

This paper estimates the impact of monetary policy on exchange rate of Bangladesh using co-integration method. Time series data are used to estimate the impact of monetary policy on exchange rate of Bangladesh. Money supply and exchange rate determination model states that money supply has positive relationship with exchange rate i.e. an expansionary monetary policy of a country depreciates its currency. The findings of this paper ensured the expected result of money supply and exchange rate determination model that broad money as a measure of monetary policy has significant positive impact on exchange rate determination. This is a common finding in the literatures of exchange rate determination. This study also shows that although broad money as a measure of monetary policy does not Granger cause official exchange rate, broad money, annual average inflation rate and current account balance Granger cause official exchange rate.

Introduction

Money supply does play a very crucial role to determine exchange rate fluctuation in an open economy like Bangladesh. Theoretically money supply has positive relation with exchange rate but the empirical analysis may have any effect. This study shows that there is a long run relationship among the concerned time series variables i.e. official exchange rate, broad money supply as per cent of GDP, annual average inflation rate and current account balance as per cent of GDP. Granger causality analysis shows that exchange rate does not Granger cause broad money supply but overall all other variables significantly Granger cause official exchange rate implying that current account balance and monetary policy have a significant impact on exchange rate determination jointly.

Pioneering works initiated by Mundell and Fleming in theoretical arena of open economy widely known as Mundell Fleming model did a very comprehensible and remarkable work explaining the interaction between three important relationships i.e. IS, LM and BP relationship. Among other things it provided the effects of changing money supply on an economy. More precisely, Mundell Fleming model also provides very essential view how money supply fluctuation can affect the exchange rate of an economy. Transactions between two economies mainly depend on price of

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currency of one economy in terms of another. In that sense, there is no way to minimize the importance of exchange rate in an open economy. Bangladesh is not unique in terms of quality. Fortunately in recent times outcome of the monetary policy has seemed praiseworthy. Besides these, through appropriate monetary management in recent years, Bangladesh has been able to contain the inflation rate at a 10-year average of 7.94 percent. Bangladesh has experienced two exchange rate regimes namely fixed exchange rate and floating exchange rate in last 45 years of her independence.

This paper encompasses the period from 1981 to recent years and it is synchronized as follows. First section represents backgrounds and motivational description. A description of theory and methodology is discussed in the subsequent section of the introduction. After theory and methodology section, the results of co-integration model is discussed which leads to analytical econometric model.

Literature review

The main objective of this study is to analyze the dynamic pattern and long run relationship between exchange rate and monetary policy. Although many rich literatures of exchange rate and money supply are available, very few studies have been done in this dynamic field due to unavailability of data in Bangladesh.

Eichenbaum and Evans (1993) found no significant evidences of the role of monetary policy shock on exchange rate. On the other hand, to find out the impact of monetary policy shocks on the exchange rate in Australia, Canada and New Zealand, Zettelmeyer (2000) showed that a 100 basis point appreciates the exchange rate by 2-3 per cent. In another paper named '*The Impact of Monetary Policy on the Exchange Rate: A Study Using Intraday Data'*, using intraday data authors found that unanticipated tightening of 25 basis points directs to a quick appreciation of around 0.35 percent (Kearns and Manners, 2006). Result obtained also indicated that an unanticipated 100 basis points increase appreciates exchange rate by around 1.5 per cent. Generally money supply has a positive impact on domestic exchange rate. Meerza (2012) found a positive impact of money supply, a common finding of exchange rate model, on exchange rate.

However in the very recent time, in a very important paper '*Liquidity and Exchange Rates',* (Júnior, 2013) shows liquidity created by private banks and other private financial institutions plays more vital role than monetary policy in advanced economies.

Bangladesh is very small part of open economy in the world in one hand. On the other hand, like many other developing countries, government has to control many tools of open economy related issues. Fortunately for the citizen of the country and unfortunately for the open economy in the recession period, the intervention of Bangladesh government, more precisely due to central bank of Bangladesh, in many of the policy tools including exchange rate related issues brought out

auspicious impacts. In this situation, interesting result of these countries by analyzing dynamic pattern is always expected. Due to unavailability of data, very few works like many others developing countries have been done on exchange rate determination in Bangladesh. Very recently published a paper entitled '*Exchange Rate Determination of Bangladesh: A Cointegration Approach',* shows how exchanged rate is determined in Bangladesh. The author of this paper found that relative money supply, inflation rate and relative real income establishes an positive long run impacts on exchange rate indicating a depreciation of taka and appreciation of USD (Meerza, 2012). Meerza (2012) also found the evidences of appreciation of local currency in response to the interest rate.

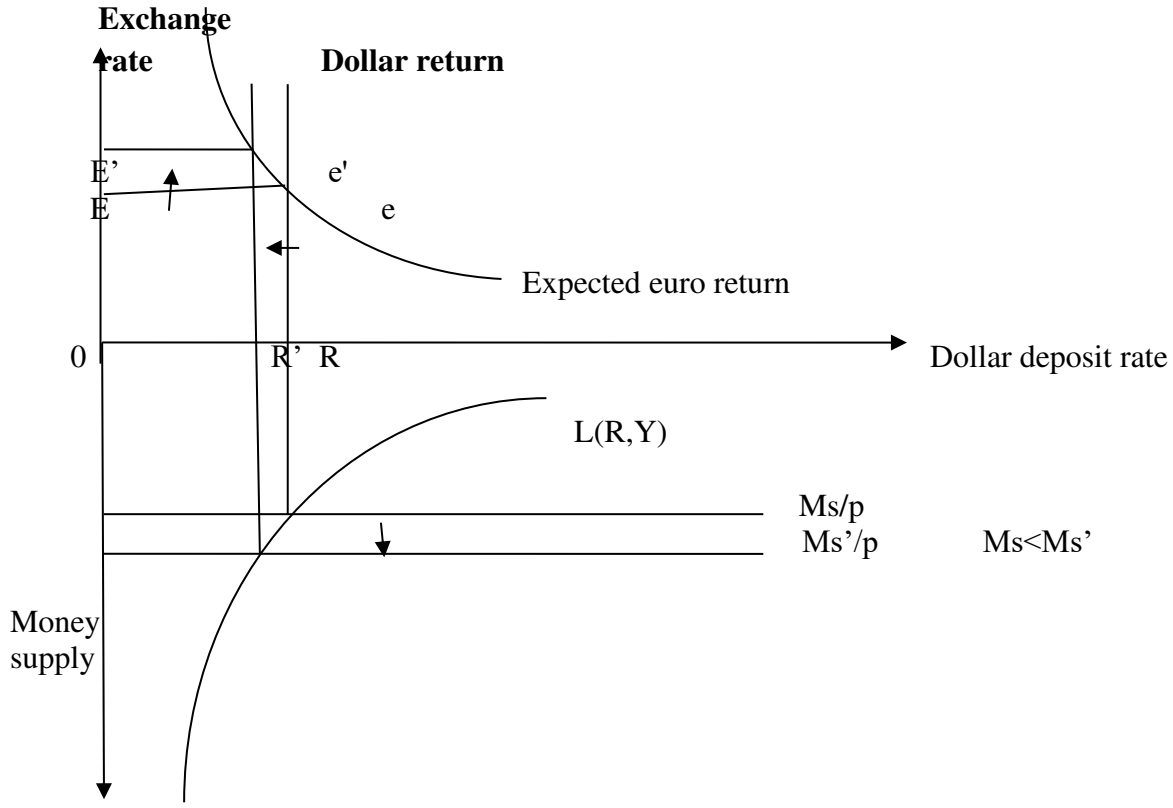
Theory of 'Exchange Rate': Definition

Exchange rate is defined as the price of one country's currency in terms of another country's currency (Krugman and Obstfeld, 2009). On the other hand, the rate at which one currency can be exchanged for another. For example, the higher the exchange rate for one dollar in terms of taka, the lower the relative value of the taka.

Exchange rate mechanism:

Standard theory of money supply and exchange rate system says that an increase in the money supply will force the interest rate down as money demand vacillation alters the desire of people for liquid assets and thus the prices and rates of return on bonds. In the open economy where, interest parity between nations must be preserved the exchange rate will increase (currency depreciation) in order to create the expectation that it will fall faster in the future. This increase in the exchange rate makes domestic goods more attractive, by increasing both foreign and domestic demand for domestically produced goods. This then encourages output growth (Krugman and Obstfeld, 2009). This can be described in a simple way, as an expansionary monetary policy increases the aggregate demand, the output of an economy also increases. A rise of output of an economy induces consumers to increase their consumption of domestic goods and foreign goods which puts pressure to increase import in an open economy. As a result it ultimately implies local currency depreciation. The above theory can be grasped by the following graph:

Figure 1
Exchange rate determination



Source: Paul R. Krugman and Maurice Obstfeld; International Economics: Theory and Policy (Eight Edition).

According to the theory of money supply and exchange rate, if money supply increases holding the other things constant, consequently the domestic interest rate falls which depreciates the domestic currency.

Exchange Rate Systems

How exchange rate system treated by government determines the countries exchange rate system. Exchange rate system normally falls into one of the following categories:

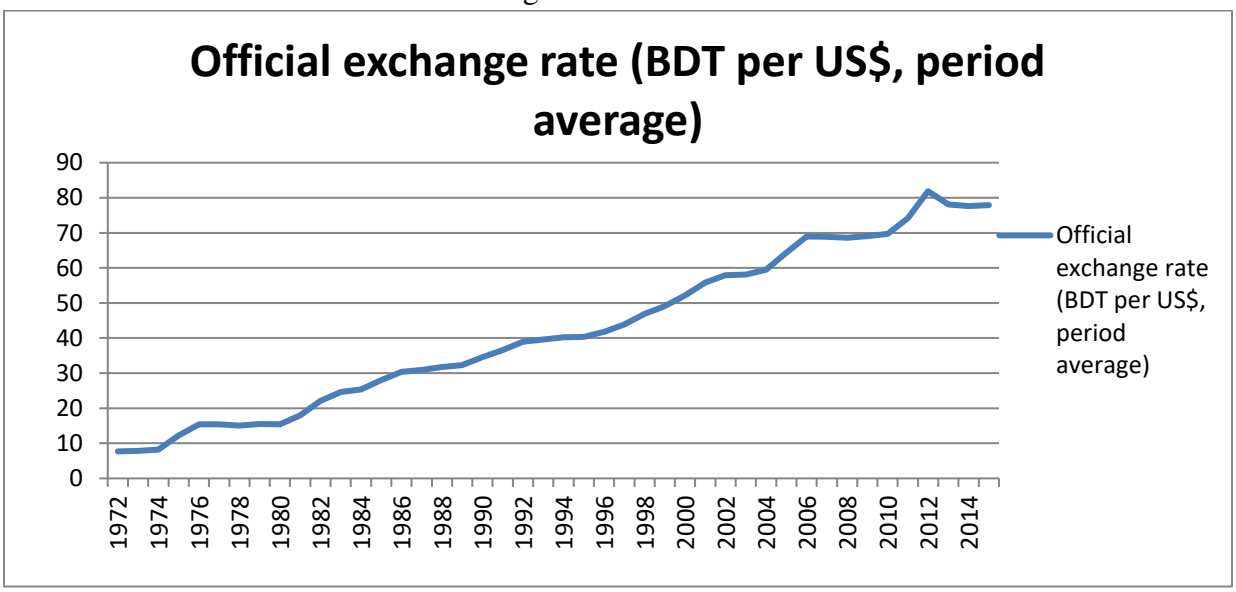
i. Floating Exchange Rate
ii. Fixed Exchange Rate

Floating exchange rate can be defined when central bank does not have the minimum role in the exchange rate determination (Taslim and Chowdhury, 1995). Market will determine equilibrium exchange rate by the interaction of demand and supply in the market. On the other hand, in a fixed exchange rate the central bank generally sets the fixed value of the domestic currency against international currencies and generally sacrifices the monetary policies to achieve only that goal.

Historical overview of Exchange Rate System of Bangladesh

Bangladesh Bank (BB) has set floating exchange rate as the exchange rate regime of the country on May 29, 2003. This became actually effective on 1 June, 2003 when banks started to buy and sell rates of dollar and other currencies according to supply and demand situation under the free-floating system, (Priyo, 2009). Before 2003, Bangladesh followed a fixed exchange rate from the beginning of the independence of the country and after May 29, 2003 it started to follow a managed flexible exchange rate. Although central monetary authority of Bangladesh has started to follow managed flexible exchange rate, the exchange rate of Bangladesh can ideally be portrayed as fixed exchange rate. Like fixed exchange rate, BB has to keep an eye on the market to mediate in money market for selling US dollar and purchasing transactions whenever needed.

Figure 2
Exchange rate series over time



Source: World Bank

Economic Model

To support the objective, time series analysis has to be analyzed. For this vector error correction model will be run that whether exchange rate and measures of monetary policy are co-integrated or not in the long run i.e. whether there is long run relationship. The vector error correction model is:

$$\text{ex\_rate}_t = \alpha + \beta_1 \text{broadm\_pgdp}_t + \beta_2 \text{inflation\_annual}_t + \beta_3 \text{cab\_pagdp}_t + U_t \quad \text{-----} \quad (1)$$

-- where the subscript t denotes the time series, α is as usual intercept term, β is coefficient matrix, and U_t is disturbance term. As usual ex_rate_t denotes official exchange rate of taka per USD, broadm_pgdp represents broad money supply as percent of GDP, inflation_annual means average annual inflation rate and cab_pagdp represents current account balance as per cent of GDP of Bangladesh. Broad money is taken as a measure of monetary policy and the main concerned variable.

Data Collection

The study is mainly based on secondary time series data. Data have been collected from the World Bank. Relevant writings of some scholars have also been consulted. The collected data has been processed using Microsoft Excel and Stata14 and analysis has been made in order to make the study more analytical, informative and useful to the users.

Methodology

Spurious relationship arises in the time series regression analysis if one fails to find out stationary time series variables. However their linear combination among the non-stationary variables provides the long run relationship, if the variables are co-integrated. The observations provided by Stock and Watson's (1988) show that co-integrated variables share common stochastic trends which are considered a very useful way to understand co-integration relationships (Enders, 2004). The concerned time series variables are co-integrated only if the individual variable shows similar statistical properties. If one finds variables that are co-integrated, a meaningful long run equilibrium relationship among the variables will be found and any departure from that equilibrium relationship must be stochastically bounded (Banerjee et al., 1993).

To test the order of integration of the concerned variables, the dynamic properties will be examined by performing the unit root test. Two different tests will be applied: the Augmented Dickey-Fuller (ADF) test, and the Phillip-Perron (PP) test. These two different tests will be run with and without a time trend and a constant. Almost all of the trend coefficients become insignificant and hence, the trend is ignored. Although the ADF test for testing unit root is widely used test, sometimes it performs poorly, in particular in the case of serial correlation. By incorporating lagged difference terms in the regression model, Dickey and Fuller tried to correct for serial correlation but the size and the power of the ADF test has been noticed to be very sensitive to the number of these terms. On the other hand, Phillips and Perron test has recovered this problem.

The existing evidence of unit root in each of the series will specify that one is able to perform co-integration tests in one form or another for the four variables in the present study. Again a set of variables can be said to be co-integrated and their liner combination will be stationary if each of the variables is integrated of order one (Engle and Granger, 1987). Engle and Granger (1987) stated that a linear combination of two or more non-stationary series may be stationary and if such a stationary linear combination exists then the non-stationary time series are said to be co-integrated. This can be clearly specified as if two variables Y_t and Z_t contain stochastic trends and are integrated of the same order, say I(1), the variables are generally referred to be co-integrated only if the equation

$$\boldsymbol{Y_t - \beta Z_t = v_t}$$

is I(0). The above equation which is stationary linear combination of two I(1) series is called the cointegrating equation and may be interpreted as having a long-run equilibrium relationship among the variables. Besides it is a single equation, it does have several limitations. First, it has no orderly process for separate estimation of the multiple co-integrating vectors. Second, it depends on a two-step estimator. Many authors have tried to develop various methods to avoid the above problems. The maximum likelihood estimators of Johansen (1988) and Stock and Watson (1988) can estimate and able to test the evidence of multiple co-integrating vectors. The speed of adjustment parameter and co-integrating vector are also estimated by this. Enders (2004) stated that both of those methods mainly depend on ranks of the matrix and its characteristics roots.

Linear combination among the concerned variables implies while the variables may behave in different directions in the short run, they will tend toward a general manner in the long run. If this feature is demonstrated, the characteristics of the dynamic relationship between the variables can be depicted by a Vector Error Correction Model (VECM). Prakash (1999) interpreted the short run adjustment parameter of VECM model as the measure of the extent of error correction. On the other hand, the long run multiplier can be read as degree of transmission from one variable to other (Prakash, 1999). More specifically, consider the VAR model with p lags

$\mathbf{y_t = \lambda + A_1 y_{t-1} + A_2 y_{t-2} + ----------+ A_p y_{t-p} + \epsilon_t}$ ----------(2)

Where y_t is a K ×1 vector of variables, λ is a K × 1 vector of parameters, A_1–A_p are K ×K Matrices of parameters, and ϵ_t is a K × 1 vector of disturbances with mean 0, covariance matrix ∑ and ϵ_t is i.i.d. and normally distributed over time. we can write this VAR (P), from (2), model as in the VECM form-

$\mathbf{\Delta y_t = \lambda + \prod y_{t-1} + \sum_{i=1}^{p-1} \Gamma i \Delta y_{t-i} + \epsilon_t}$ ----------(3)

where $\prod = \sum_{i=1}^{p-1} Aj - Ik$, $\Gamma_i = -\sum_{i=i+1}^{j=p} Aj$.

Evidence and presence of causality is another significant inference of co-integration and error correction representation between the variables in at least one direction (Granger, 1988). Therefore, based on methodology, the stationary test of unit root is analyzed first followed by Granger causality and then co-integration test with specification of ECM.

Results

To perform the co-integration test, Augmented Dickey- Fuller (ADF) test is used to check whether the variables contain unit roots. Performing unit root test of each variable under the null hypothesis of non-stationary, all variables are found non stationary in the level form. But in the first differenced form, all of their test statics exceed their critical value at 1 per cent level of significant except annual inflation rate variable for which test statistics exceeds at 5 per cent level. In another way, Table (1a) shows that in every case, ADF fails to reject the null hypothesis of unit root in the level form. On the other hand , ADF test rejects the null hypothesis at 1 per cent level for all variables except annual inflation rate (which is also significant at 5 per cent level) implying all concerned time series variables are I(1) based on ADF test.

Table1a. Unit Root Test: Augmented Dickey –Fuller Test (ADF Test)

	Level Form			First-difference form		
Variables	Test Statistics (Without trend)	Test Statistics (With trend)	Decision	Test Statistics (Without trend)	Test Statistics(With Trend)	Decision
Ex_rate	0.536	-1.729	Non-stationary	-4.120***	-4.27**	Stationary
Broadm_pgdp	0.131	-1.739	Non-stationary	-3.848***	-4.045**	Stationary
Inflation_annual	-1.932	-1.588	Non-stationary	-3.491**	-3.588**	Stationary
CAB_pGDP	-1.736	-2.757	Non-stationary	-3.810***	-3.792**	Stationary

Source: Prepared by author

*** Significant at 10 percent level ** Significant at 5 percent level *** Significant at 1 percent level**

Table1b. Unit Root Test: Phillips and Perron Test (PP Test)

	Level Form	First-difference form

	Test Statistics(Without trend) (Z(rho))	Test Statistics(With trend) (Z(rho))	Decision	Test Statistics(Without trend) (Z(rho))	Test Statistics(With trend) (Z(rho))	Decision
Ex_rate	-0.343	-12.010	Non-stationary	-22.043***	-22.008***	Stationary
Broadm_pgdp	0.418	-5.085	Non-stationary	-25.855***	-26.515***	Stationary
Inflation_annual	-13.226**	-14.855*	Non-stationary	-27.680***	-27.583***	Stationary
CAB_pGDP	-15.247**	-25.016***	Stationary	-28.188***	-28.657***	Stationary

Source: Prepared by author

*** Significant at 10 percent level ** Significant at 5 percent level *** Significant at 1 percent level**

As mentioned in methodology part, ADF test fails to capture the size and power of the test. The Phillips and Perron tests are non parametric tests of the null of the existence of unit root and are considered more powerful, as they use consistent estimators of the variance. That is why Phillips and Perron test is performed to test whether a variable is stationary or not. Table 1(b) shows that, Phillips and Perron test fails to rejects the null hypothesis of non stationary at 1 per cent level in case of level form of without trend. Howver, the variables current account balance as per cent of GDP and annual inflation rate are stationary at 5 per cent in level form in without trend according to Phillips-Perron test. On the other hand, PP test is able to rejects the the null hypothesis of unit root at 1 per cent level for each variable. Analyzing ADF test and Phillips-Perron test, I can conclude that each of the concerned variables is non stationary and I(1).

Granger causality test reveals whether there is a prediction power of explanatory variables. If there are two variables, say, X and Y and X Granger causes Y if and only if present and past values of X have power to predict Y (Kirchgässner and Wolters, 2007). Null hypothesis of Granger causality contains that there is no predictive power of explanatory variables to the independent variable. In other way, explanatory variable is assumed to be excluded in the model. To avoid detailed result of Granger causality, the result of first part will be used in Table 2(a) and Table 2(b) which summarizes the result of Granger causality.

Table 2a: Granger causality relationship among variables

Direction	**Null Hypothesis**	**Chi-Square Statistics**	**P-value**	**Results**
Broadm_pgdp → Ex_rate	Broadm_pgdp does not Granger Cause Ex_rate	0.010	0.920	Null hypothesis cannot be rejected
Inflation_annual → Ex_rate	Inflation_annual does not Granger Cause Ex_rate	1.725	0.189	Null hypothesis cannot be rejected
CAB_pGDP → Ex_rate	CAB_pGDP does not Granger Cause Ex_rate	4.217	0.040	Null hypothesis can be rejected at 5%
All →Ex_rate	Broadm_pgdp, Inflation_annual and CAB_pGDP do not Granger Cause Ex_rate	7.846	0.049	Null hypothesis can be rejected at 5 %

Source: Prepared by author

According to the obtained results of Granger causality, broad money as per cent of GDP and official exchange rate are not Granger caused by any direction. Similar result holds for annual inflation rate and official exchange rate Table 2(b). Table 2(a) shows that although broad money as per cent of GDP and annual inflation rate do not Granger cause official exchange rate in Bangladesh individually, broad money as per cent of GDP, annual inflation rate and current account balance do combinedly Granger cause official exchange rate of Bangladesh. Similarly, all the concerned variables Granger cause broad money as per cent of GDP. Although the main concerned variables exchange rate and broad money as measure of money supply of Bangladesh are not Granger caused but they are overall Granger caused, Table 2(a).

Table 2b: Granger causality relationship among variables

Variables	Direction	Variables
Ex_rate	———	Broadm_pgdp
Ex_rate	———	Inflation_annual
Ex_rate	◄——►	CAB_pGDP
Broadm_pgdp	◄——►	Inflation_annual
Broadm_pgdp	———	CAB_pGDP
Inflation_annual	———	CAB_pGDP

Source: Prepared by author

Table 2(b) shows that broad money and average annual inflation rate are Granger caused by both directions. Similarly broad money and current account balance as a per cent of GDP are Granger caused by both directions.

Johansen co-integration rank test of lambda trace and lambda max test give the evidences of one rank implying I have only one co integrating equation. For example null hypothesis r=0 implies that there is no co integrating equation where alternative hypothesis is that there are one or more than one co integrating equations. Table (3) shows that at r=1, the null hypothesis of one co-integrating equation can not be rejected implying that there is one rank.

Table 3. Johansen Co-integration test

Null hypothesis	r=0	r≤1	r≤2	r≤3
Eigenvalue	-	0.561	0.383	0.189
λ trace	50.10*	22.92	6.98	0.08
5% Critical Value	47.21	29.68	15.41	3.76
λ max	27.18*	15.94	6.90	0.08
5% Critical Value	27.07	20.97	14.07	3.76

Source: Prepared by author
*denotes rejection of the hypothesis at the 0.05 level.

Table (4) represents coefficients of short run adjustment parameter α. Adjustment parameter also reflects speed of adjustment towards equilibrium and it also shows short run and long run causality. The coefficients of adjustments parameters are the error correction term. The error correction terms are interpreted as long run causal relationship with independent variables to dependent variable if the coefficient of the error correction term is negative and the coefficient is significant. On the other hand if the sign is positive and significant there is short run causality.

The first coefficient of adjustment parameters is positive and significant at 5 per cent level implying that there is short run causality running vector error correction model from broad money as per cent of GDP, annual inflation and current account balance as percent of GDP to official exchange rate.

Second coefficient of adjustment parameters is significant at 10 per cent level and the coefficient is negative. Since the sign is negative and the coefficient is significant, this implies that there is a long run causality running from the official exchange rate, annual average inflation rate and current account balance to broad money supply as per cent of GDP.

Table 4.Adjustment parameter Results of Vector Error Correction (VECM) model

	(1)	(2)	(3)	(4)
Variables	Ex_rate	Broadm_pgdp	Inflation_annual	CAB_paGDP
ECM(-1)	0.058**	-0.045*	-0.096***	0.069***
Standard Errors	0.024	0.025	0.031	0.016
Constant	1.604	1.647***	0.111	-0.120

Source: Prepared by author

***Significant at 10 percent level ** Significant at 5 percent level *** Significant at 1 percent level. Since I run VECM (1) model, I do not get short run coefficients of the model.**

Third coefficient of adjustment parameter is also negative and statistically significant at any conventional level. This implies that there is also a long run causal relationship between independent variables to dependent variable, annual average inflation rate. Since the fourth coefficient of adjustment parameter is positive and statistically significant at 1 per cent level, it implies there is a short run causal relationship among broad money as per cent of GDP, official exchange rate and annual inflation to current account balance as per cent of GDP of Bangladesh.

Since Johansen co integration test of lambda trace and lambda max reveals one co integrating ranks, there is one co integrating equation represented by Table 5. The equation is stationary which can also be clear from figure of co-integrating equation. According to the co integrating equation, there is long run equilibrium relationship among the concerned variables official exchange rate, broad money as per cent of GDP, average annual inflation rate and current account balance as per cent of Bangladesh GDP.

In the co-integrating equation, exchange rate is normalized to one. The coefficient of broad money of the co integrating equation is significant and the sign of the coefficient of broad money is positive and which is expected. This is a common finding like many other studies is that broad money as a measure of monetary policy has significant positive impact on exchange rate determination in the long run. In the model, inflation has a negative and significant impact on exchange rate which is unlikely. One of the reasons might be regular involvement of the central bank to control inflation and exchange rate. On the other hand, current account balance as per cent of GDP has been found very statistically significant and the coefficient is positive implying that the positive relationship exists in the long run and if the intervention of the central bank might have been reduced, current account balance might perform better than present as suggested by findings.

Table 5: Co-integrating Equation

Dependent Variable: Official Exchange Rate			
Regressors	Coefficients	Standard Error	z-Statistics[p-value]
Broad Money as per cent of GDP	0.503**	0.224	-2.24[0.025]
Annual Inflation Rate	-1.810**	0.819	2.21[0.027]
Current account balance as per cent of GDP	9.483***	2.034	-4.66[0.000]

Source: Prepared by author

Figure 3 of co-integrating equation shows stationary relationship implying that the model fits the data very well. The stability of Vector Error Correction Model (VECM) signifies that the vector error correction model is stable shown in figure 4.

Figure 3
Co-integrating equation

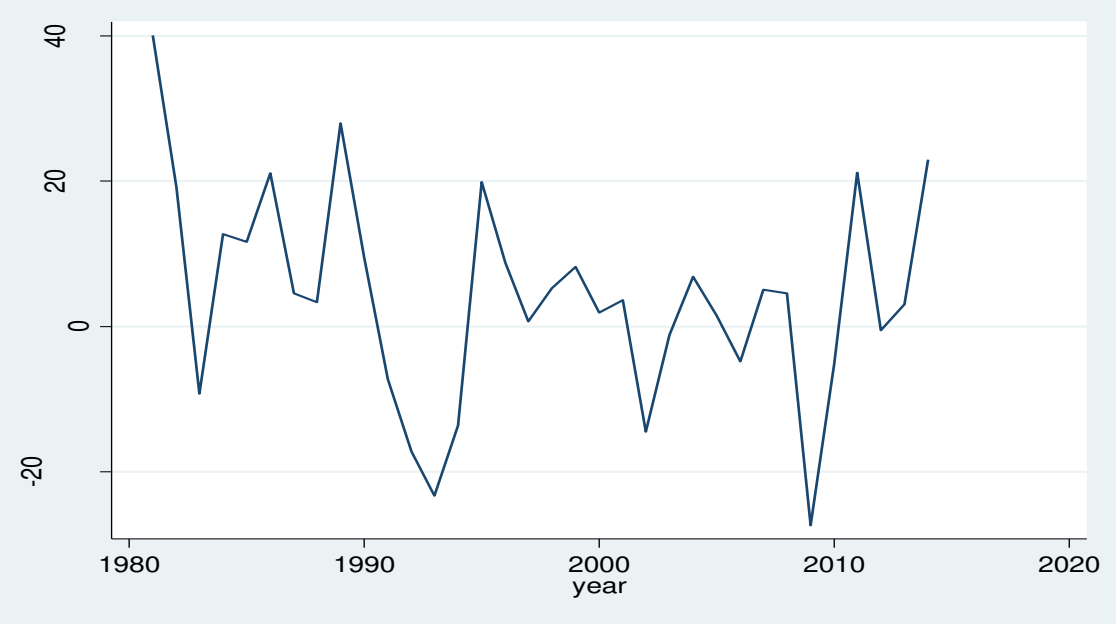
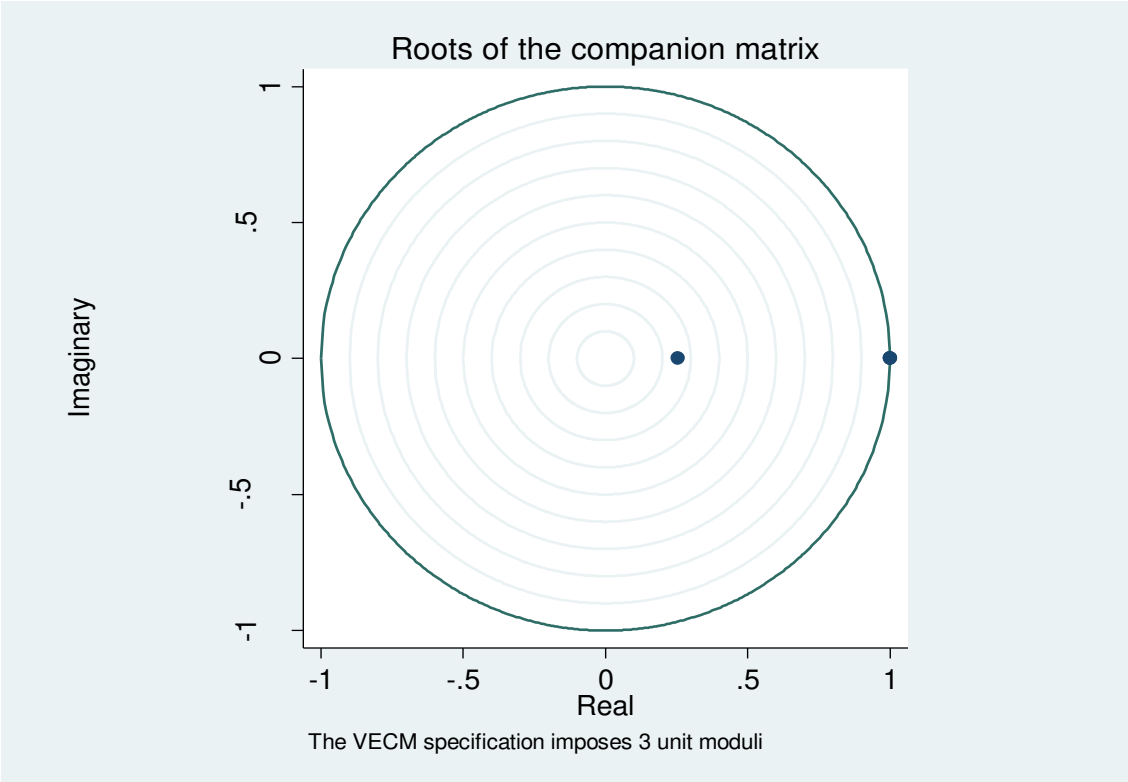


Figure 4
Stability of Vector Error Correction Model



How does the equation fit the data well? The answer of this particular question can be found from the post estimation of the model. Serial correlation problem or correlation among the successive error term is not major concern in the model. Since the null hypothesis of no autocorrelation at any lag can not be rejected at any conventional significant level, it can be stated that there is no autocorrelation in the model. Stability of the vector error correction model also states that the Vector Error Correction Model (VECM) model is stable.

On the other hand, since co integrating equation is statistically very significant and error terms are free from serial correlation, the model overall fits the data very well.

Conclusion

In fine on the basis of the regression result, there is a long run relationship on monetary policy and exchange rate but it can not provide significant relationship based on Granger causality. Besides money supply, current account balance and inflation have also significant effect on exchange rate. Using STATA14, significant impact of the variables of monetary policy on exchange rate (taka/dollar) is found. . Unfortunately there are some shortcomings in the model analyzed.

In spite of being the presence of some shortcomings, the empirical result fits the model with priory that shows the effect of money supply on exchange rate very well in the long run. Finally according to the model increasing money supply has a positive impact on exchange rate. So currency has to depreciate in the long run.

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