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**Policy Analysis Unit (PAU)**

**Working Paper Series: WP 0603**

**Exchange Market Pressure and Monetary Policy**

**Sayera Younus, Ph.D.**

**December 2005**

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## Policy Analysis Unit\* (PAU)

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### **Exchange Market Pressure and Monetary Policy**

By

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**December 2005**

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## List of Contents

• Abstract	iv
1. Introduction	01
2. Theoretical Background	02
3. Literature Review	04
4. Model Variables	07
5. Econometric Methodology	08
5.1 Error Correction Model (ECM)	08
5.2 Vector Error Correction Model (VECM)	10
5.3 Variance Decomposition (VDCs) of Exchange Market Pressure (EMP) using BDT/USD Nominal Exchange Rate	11
5.4 Variance Decomposition (VDCs) of EMP using BDT/INR Nominal Exchange Rate	12
5.5 Impulse Response Function (IRFs) of the EMP using BDT/USD Nominal Exchange Rate	13
5.6 Impulse Response Function (IRFs) of EMP using BDT/INR Nominal Exchange Rate	13
5.7 Analysis of the results from ECM and VECM	13
5.8 Evidence from Raw data	13
<b>6. Conclusion</b>	16
<b>7. References</b>	26
<b>Tables</b>	
Table-1: Literature Review	04
Table-2: Dependent Variable: EMP (BDT vis-a-vis USD)	17
Table-3: Dependent Variable: EMP (BDT vis-a-vis INR Rupee)	18
Table-4: Variance Decomposition of EMP using BDT/USD Nominal exchange rate (NER) and Cholesky ordering as: $p_1^*$ , mm, d, y and EMP	19
Table-5: Variance Decomposition of EMP using BDT/INR NER and Cholesky ordering: $p_1^*$ , mm, d, y and EMP	20
<b>Figures</b>	
Figure-1: Trends of EMP and Domestic Credit Growth when BDT/INR NER is used	14
Figure-2: Trends of EMP and Domestic Credit Growth when BDT/USD NER is used	14
Figure-3: Trends of EMP and Inflation when BDT/INR NER is used	14
Figure-4: Trends of EMP and Inflation when BDT/USD NER is used	14
Figure-5: Trends of International Reserves of Bangladesh	15
Figure-6: Trends of Growth of International Reserves	15
Figure-7: Trends of Growth Rate BDT/INR VS. BDT/USD Nominal Exchange Rate	15
Figure-8: Trends of Growth Rate of BDT/USD and International Reserves	15
Figure-9: Responses of EMP due to shocks to d, mm, $p_1^*$ , and y estimated at lag 4 using BDT/USD exchange rate and Cholesky ordering: $p_1^*$ , mm, d, y and EMP.	21
Figure-10: Responses of EMP due to shocks to d, mm, $p_1^*$ , and y estimated at lag 8 using BDT/USD exchange rate and Cholesky ordering: $p_1^*$ , mm, d, y and EMP	22
Figure-11: Responses of EMP due to shocks to d, mm, $p_2^*$ , and y estimated at lag 4 using BDT/INR exchange rate and Cholesky ordering: $p_2^*$ , mm, d, y and	23
Figure-12: Responses of EMP due to shocks to d, mm, $p_2^*$ , and y estimated at lag 8 using BDT/INR exchange rate and Cholesky ordering: $p_2^*$ , mm, d, y and EMP	24
Appendix: Variable List	25

# Exchange Market Pressure and Monetary Policy

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December 2005

## Abstract

The objective of this study is to examine empirically the impact of monetary policy on exchange market pressure (EMP) in Bangladesh. EMP is measured as the sum of percentage change of international reserves scaled by the monetary base and percentage change of nominal exchange rate appreciation. Domestic credit, the domestic component of monetary base, which is considered the variable directly controlled by policy makers is used as measure of monetary policy. Because Bangladesh is a small open economy and the U.S. and India are the major trading partners of Bangladesh. BDT/USD and BDT/INR nominal exchange rates are used to estimate separate EMP models. The percentage change in the consumer price index of the U.S. and India are used as the foreign inflation rates.

Quarterly data from 1976:2 to 2003:1 are used to examine Girton and Roper's (1977) monetary model of the EMP. Engle and Granger's (1987) two-step single-equation error correction model (ECM) and Impulse response functions (IRFs) and variance decompositions (VDCs) derived from a vector error correction model (VECM), are used to examine the model. The estimated coefficient of domestic credit derived from the ECM shows that domestic credit has a significant and negative impact on EMP. The IRFs and VDCs derived from the VECM also indicate that monetary policy, measured by domestic credit, has a significant and negative impact on EMP. This implies that the monetary authority in Bangladesh may reduce the exchange market pressure by either reducing foreign reserves or depreciating domestic currency.

*Keywords: Monetary Policy, Exchange Market Pressure.*

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## **Exchange Market Pressure and Monetary Policy**

-Sayera Younus, Ph.D.

### **I. Introduction**

Effective management of foreign exchange is very important to achieve tolerable inflation and a desired level of economic growth for a country. The intention of this paper is to examine the impact of monetary policy on exchange market pressure (EMP), and determine whether the Bangladesh Bank deals with it by depreciating the exchange rate, by drawing down on official reserves, or by using a combination of the two.

The monetary approach to the balance of payments is based on the assumption of fixed exchange rate, while the monetary approach to exchange rate determination is based on perfectly flexible exchange rate. In practice, many countries have neither a fixed nor a perfectly flexible exchange rate. In order to overcome the limitations of the traditional monetary approach to the balance of payments and exchange rate determination, Girton and Roper (1977) developed the concept of exchange market pressure, which can be used in a fixed exchange rate regime, a flexible exchange rate regime and a managed float exchange rate regime. In the fixed exchange rate regime, the change of the exchange rate will be zero, while in flexible exchange rate regime, the change of international reserves will be zero, and in the managed float, the exchange market pressure is absorbed by either currency depreciation, or reserves losses, or a combination of the two. Girton and Roper (1977) defined EMP as the sum of the percentage change in the nominal exchange rate appreciation and percentage change in international reserves scaled by the monetary base.

This study uses Girton and Roper's (1977) EMP model rather than monetary approach to balance of payments or the monetary approach exchange rate determination models to examine the exchange market pressure in Bangladesh. This is the first study that uses Girton and Roper's (1977) EMP model in Bangladesh. The traditional monetary approach uses either the exchange rate or international reserves as a dependent variable. This study uses sophisticated econometric techniques, namely Engle and Granger's (1987) single-equation error correction model (ECM) and a vector error correction model (VECM) to estimate the exchange market pressure. These techniques allow us to capture the non-stationarity properties in individual series. The existing literature on exchange market pressure does not use these techniques.

An analysis of the EMP model appropriate for Bangladesh because it experienced managed, pegged but adjustable flexible exchange rate regimes since the country's inception in 1971 until May 31, 2003. On May 31, 2003 the government of Bangladesh introduced a floating exchange rate system.

Following independence, Bangladesh's currency, the BDT continued to be pegged to U.K.'s pound sterling, the latter being the intervention currency. In order to control capital flight, the Government of Bangladesh imposed restrictions on foreign exchange. In the controlled exchange regime, a secondary market developed to satisfy the excess demand for foreign currency. In the secondary market, the foreign currency price was much higher than the official exchange rate. In May 1975, a major

step toward effective exchange management took place with a massive devaluation (by 37 percent) of the BDT. Since then, the central bank of Bangladesh pursued a policy of depreciating the Taka to improve the balance of payment deficits. It is worthwhile to mention here that in order to reduce balance of payment deficits, Bangladesh devalued her currency about 130 times over a thirty-year period.

In 1985, the intervention currency was changed to the U.S. dollar. This change was made because most of the official trade in Bangladesh is performed in the U.S. dollar rather than the pound sterling. In order to determine the strength of the Taka against foreign currency, a real effective exchange rate (REER) index was introduced in 1985.<sup>2</sup> Since then, the nominal exchange rate of Taka in relation to the U.S. dollar is determined daily by monitoring the REER index, the U.S. dollar being the intervention currency. Under the 'structural adjustment program' and the 'Financial Sector Reform Program' 'Taka' was declared convertible on the current account beginning March 24, 1994. Finally, the Bangladesh Government introduced a floating exchange rate system on May 31, 2003.

In order to examine how the monetary authority in Bangladesh handles exchange market pressure, this study estimates two-exchange market pressure models. One model uses the BDT/USD nominal exchange rate and the other uses BDT/INR nominal exchange rate to construct EMP. The U.S. and India are the major trading partners of Bangladesh.<sup>3</sup> At the same time, India is a significant competitor of Bangladesh.<sup>4</sup> It is generally believed that in the developing countries currency devaluation is not a very popular policy tool to reduce exchange market pressure due to the possibility of higher debt burden and its impact on the domestic price level. It is a crucial issue to investigate empirically whether the monetary authority in Bangladesh reduces EMP by depreciating the domestic currency or depletion of international reserves or a combination of the two.

## 2. Theoretical Background

Exchange market pressure arises due to disequilibrium between the growth rates of domestic supply of, and demand for, money. An excess supply of money creates an excess domestic demand for goods and services, which in turn increases demand for foreign goods and services, and results in reserves flowing out of the domestic money market. Girton and Roper (1977) argue that an excess supply of money relative to demand will result in some combination of currency depreciation and an outflow of foreign reserves. Following the models by Kim (1985), and Shiva and Bahmani-Oskooee (1998), a variant of the Girton-Roper model is outlined below:

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<sup>2</sup> REER is calculated by the following formula:  $REER\ index = (ERI * CPI)_B / \sum (ER * CPI)^{w_i}$  where, ER=Exchange rate, CPI=Consumer Price Index, w=trade-weight share for each country, i=Particular country and B is for Bangladesh.

<sup>3</sup> During the period of 2004, Bangladesh exports to the U.S. were \$1697.52, which was 25.72% of the total exports, while imports from India were \$1745.06, which was 17.36% of total imports (source: Direction of Trade, Quarterly 2005).

<sup>4</sup> The BDT/INR exchange rate is a cross rate, which is calculated from the BDT/USD and the INR/USD nominal exchange rates.

$$M^d = kPY \dots\dots\dots(1)$$

$$M^s = A(R + D) \dots\dots\dots(2)$$

$$P = EP^* \dots\dots\dots(3)$$

$$M^d = M^s \dots\dots\dots(4)$$

Equation (1) represents the demand for nominal balances where P stands for the domestic price level and Y is real income, k is a fraction of nominal income that people want to hold as cash. Equation (2) is a nominal money supply equation. The money supply is the sum of the net foreign assets (R), the foreign component of the monetary base and the domestic assets (D), the domestic component of the monetary base multiplied by the money multiplier (A=M2/Monetary Base). Equation (3) represents a purchasing power parity condition where E is the nominal exchange rate, which is defined as the domestic currency per unit of foreign currency, P\* is the foreign price level.<sup>5</sup> Equation (4) represents a money market equilibrium identity where money demand equals money supply.

Substituting (1) and (2) into (4) we get

$$kPY = A(R + D) \dots\dots\dots(5)$$

Replacing P by EP\*, we get

$$k(EP^*)Y = A(R + D) \dots\dots\dots(6)$$

In terms of percentage change and rearranging terms, equation (6) can be rewritten as:

$$r - e = -d + p^* + y - a \dots\dots\dots(7)$$

Where, r=the percentage change in international reserves;  
 e= the percentage change in the nominal exchange rate depreciation;  
 d=the percentage change in domestic credit;  
 p\*=the percentage change in the foreign price level;  
 y=the percentage change in domestic real income; and  
 a=the percentage change in the money multiplier;

Equation (7) states that an increase in the exchange market pressure due to an increase in the domestic credit decreases EMP either by reserves depletion or by currency depreciation. However, an increase in domestic real income, or foreign price level, or money multiplier also increases EMP.

Girton and Roper (1977), Connolly and Silveira (1979), and Shiva and Bahmani-Oskooee (1998) propose to include a variable Q=(e/r) to see whether the monetary authority respond to absorb exchange market pressure either by the exchange rate depreciation or reserves depletion. A significant and positive coefficient of Q implies that the monetary authority absorb more pressure by the exchange rate depreciation, while a significant and negative Q implies that more

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<sup>5</sup>An (\*) asterisk indicates foreign variable;

pressure is absorbed by reserves losses. An insignificant coefficient implies that the monetary authority is not sensitive to components of EMP. The coefficient of Q is important in the sense that it allows us to see whether a country follows a traditional monetary approach to balance of payments or exchange rate determination model or Girton and Roper's (1977) exchange market pressure model where they use the sum of the growth rate of nominal exchange rate and the growth rate of the international reserves as an EMP variable.

### 3. Literature Review

Several studies deal with exchange market pressure and monetary policy including Girton and Roper (1977), Connolly and Silveira (1979), Hodgson and Schneck (1981), Kim (1985), Wohar and Lee (1992), Mah (1998), Bahmani, and Shiva (1998), Mathur (1999), Pollard (1999), Pentecost, Hooydonk and Poeck (2001) & Tanner (2001). In Table-1, a brief description of the empirical findings of the above studies are given.

**Table-1: Literature Review**

<b>Author (s)</b>	<b>Country(s) /Period (s)</b>	<b>Hypothesis Tested</b>	<b>Method -ology</b>	<b>Results</b>
Girton and Roper (1977)	Canada 1952-1974	Monetary approach to EMP	Cochrane –Orcutt's	The growth rate of domestic credit is significant and negative while the growth rate of the U.S. monetary base is significant positive. The growth rate of domestic income and foreign income are statistically significant and positive, while the growth rate of foreign income is statistically significant and negative
Connolly and Silveira (1979)	Brazil sample period 1955 to 1975 and 1962 to 1975	Monetary Approach to EMP	Cochrane –Orcutt	Domestic credit as a measure of monetary policy variable, the U.S. wholesale price index as a foreign inflation and the three-year moving average of real GDP as a measure of income performs well in the latter sample; all the variables are statistically significant with the expected sign. In the sample period from 1955 to 1975, only the coefficient of domestic credit is significant. The coefficient of Q turns out to be insignificant
Hodgson and Schneck (1981)	Canada, France, West Germany, Belgium, the Netherlands, Switzerland, and the UK For the UK	Monetary Approach to EMP	2 SLS	The coefficient of domestic inflation is significant for Canada only, while the coefficients on domestic and world income are significant only for France. The coefficient of the growth rate of domestic money multiplier is significant and negative for Germany, Belgium, the Netherlands and Switzerland. The coefficient of the growth rate of the world money multiplier is insignificant for all the countries. The



	Sample period covers 1964:2 to 1976:1 for Germany and for the rest of the countries from 1959:2 to 1976:1			coefficient on the growth rate of world reserves is significant and positive for France and Belgium, and the coefficient of the growth rate of the world credit is significant and positive only for the Netherlands. The coefficient of home domestic credit is significant and negative for all countries except for France and Switzerland. The coefficient on the rate of change in the forward exchange rate is significant and positive for Belgium, the Netherlands and Switzerland
Kim (1985)	Korea 1980 to 1983	Monetary Approach to EMP	OLS	Domestic credit and Korea's real wage income variable are statistically significant with the expected sign except for the foreign rate of inflation.
Wohar and Lee (1992)	Japan 1959 to 1991	Girton and Ropers (1977)EMP model	Cochrane-Orcutt	In the first model, domestic credit, the money multiplier, domestic income, the foreign money supply, and inflation and interest rate differentials between domestic economy and the U.S. are all statistically significant with the expected sign except for foreign income. In the second alternative model, the foreign interest rate, domestic credit, money multiplier, domestic income, and the inflation and interest rate differentials between Japan and the United States are also significant with the expected signs except for foreign inflation. The estimated results perform poorly in terms of the significance of the variables for the restricted Girton and Ropers (1977) model. In this case, only the coefficients of the domestic credit and domestic income are statistically significant with the expected signs. They find a statistically significant and negative coefficient for $Q=(-e-1)/(r-1)$ implying that monetary authority absorb more pressure by reserves losses.
Mah (1998)	Korea 1980:1 to 1993:1	Girton and Ropers (1977) EMP model	Hildreth-Lu search method	Domestic credit, the trade-weighted foreign wholesale price index, domestic real income and the money multiplier all coefficients are statistically significant with the expected sign

Shiva and Bahmani-Oskooee (1998)	Iran 1959 to 1990	Using a modified version of the Girton and Roper (1977) EMP model, examine whether the central bank of engages in black market activity	OLS	Domestic credit, foreign inflation (U.S.), real domestic income and the money multiplier are all statistically significant with the expected sign except for the foreign inflation. The coefficient of Q is negative and statistically significant implying that the central bank in Iran is not engage in a black market activity because the EMP is mostly absorbed by losing reserves. Using the official exchange rate, they find a statistically significant and negative coefficient on the domestic credit and the money multiplier. However, the coefficients of foreign inflation and real domestic income are not significant. The coefficient of Q is statistically significant and positive. This implies that more of the pressure is absorbed by the official exchange rate.
Mathur (1999)	India 1980:1 to 1998:7	Modified version of the Girton and Roper's (1977) EMP model	OLS	The coefficients of domestic credit and domestic income appear to be statistically significant with the expected negative and positive signs respectively for all the six variants of the modified Girton and Roper (1977) model. The coefficient of the expected rate of appreciation also appears to be significant for all the equations except one.
Pollard (1999)	Barbados (1968 to 1993), Guyana (1964 to 1985), Jamaica (1964 to 1993), Trinidad and Tobago (1967 to 1993).	Modified version of Girton and Roper's (1977) monetary approach to EMP	OLS	The coefficients of credit and the money multiplier are statistically significant for all the countries. The coefficient of purchasing power parity is significant for all countries with the exception of Barbados; The coefficient of domestic real GDP is statistically significant and positive for all countries. The coefficient of the foreign money supply growth is positive and statistically significant for Barbados and Guyana, while foreign real GDP growth does not have any impact on the two countries. The coefficient of U.S. inflation has a positive and significant impact on Jamaica and Trinidad foreign exchange market pressure and the coefficient of the changes in U.S. interest rate has a significant negative impact on foreign exchange markets in Jamaica only.
Pentecost, Hooydonk and Poeck	Belgium, France, Italy, Spain and Finland 1980 to 1994	Modified version of Girton and	OLS	The coefficient of the money supply growth differential has a statistically significant and expected positive sign for Belgium and France, and a statistically significant and negative sign for Finland and Italy. It is

(2001)		Roper's (1977) monetary approach to EMP		insignificant for Spain. The coefficient of the long-term interest differential is statistically significant and negative for France, Italy, Spain and Finland, but insignificant for Belgium. The coefficient of competitiveness has a statistically significant and expected positive sign for Belgium and France and a statistically significant and negative sign for Spanish and Finland, while it is insignificant for Italy. The coefficients of the current account deficit and budget deficit have an expected negative sign for Belgium and France and statistically significant and positive sign for Italy, Spain and Finland. The estimated results for all countries, in general, support the alternative specification of the exchange market pressure.
Tanner (2001)	Brazil, Chili, Mexico, Indonesia, Korea, and Thailand 1990 to 1998	Modified version of Girton and Roper's (1977) monetary approach to EMP	VAR	The response of the EMP is positive and significant as expected due to shock to domestic credit for all countries except for Korea. The response of EMP Korea is statistically significant and negative. The response of the EMP due to shock to the interest rate differential is weaker than that of the shock to domestic credit. The response of EMP due to a shock to the interest rate differential is statistically significant and negative for Indonesia, Thailand, Brazil and Mexico

The review of literature that examined exchange market pressure and monetary policy based on developed and developing countries show that Girton and Roper's (1977) exchange market pressure model performed well in most of the countries. Domestic credit as a measure of monetary policy was significant in all studies, while foreign inflation and money multiplier were not significant in most of the studies. Domestic income and foreign income also has significant impact on the EMP variable in many cases. The limitation of the Girton Roper's (1977) study is that this study assumes that purchasing power parity holds, which may not be true for some of the countries. This could be one of the reasons that some of the countries do not perform well in respect of significance of the variable.

#### 4. Model Variables

Quarterly data from 1976:2 to 2003:1 are employed to estimate Engle and Granger's (1987) two-step single equation error correction model (ECM) and a vector error correction model (VECM) containing the following variables. This variables are also adopted by Girton and Roper (1977) and other studies.

d = percentage change of domestic credit scaled by the monetary base;

$e$  = percentage change of nominal exchange rate (BDT/USD or BDT/INR);<sup>6</sup>  
 $r$  = percentage change of international reserves scaled by the monetary base;  
 $p_i^*$  = percentage change of foreign consumer price index (India and the U.S.);  
 $y$  = percentage change of industrial production;  
 $mm$  = percentage change of the money multiplier;  
 $Q_i = (e/r) = Q_i$  is included to examine whether monetary authority is sensitive to components of EMP.

Seasonally adjusted data are used for all the variables except for the exchange rate. All the variables are in log-differenced form. A description of the variables is given in detail in the data appendix.

## 5. Econometric Methodology

Before estimating the model, the statistical properties of each variable are analyzed. A series of Dickey-Fuller (1981) unit root tests are used to examine each series up to two unit roots. Log level data are used to run the test for the presence of one unit root, while first-differenced data are used to run the test for the presence of a second unit root, given that the first unit root is present. Two sets of the unit root tests are performed using the BDT/USD and the BDT/INR exchange rates. The augmented Dickey-Fuller (ADF) unit root tests suggest that the log of the domestic credit scaled by the monetary base, the log of the foreign (the U.S. or India) price level, the log of real output, and the log of money multiplier contain one unit root and therefore need to be differenced once to attain stationarity. The composite value of EMP in level also fails to reject the null hypothesis of unit root for both BDT/USD and BDT/INR nominal exchange rate.

According to Engle and Granger (1987), an equation estimated with differenced data will be mis-specified if the variables are cointegrated and cointegration is ignored.<sup>7</sup> Therefore, cointegration among the I(1) variables is tested using the techniques developed by Johansen and Juselius (1990). Both the trace and maximum eigen-value tests suggest two cointegrating vectors for each EMP model using BDT/USD and the BDT/INR exchange rates. The presence of co-integration in the integrated series suggests that the model should be estimated using an error correction model (ECM).

### 5.1 Error Correction Model (ECM)

Two sets of equations are estimated in this paper. First, two U.S. variables and four domestic variables are used to estimate the model (growth rate of BDT/USD exchange rate and growth rate of domestic international reserves are used to construct EMP). Three domestic variables (domestic credit, real income, money multiplier) and a foreign variable (U.S. inflation) are used to estimate the long-run equilibrium model and a short-run dynamic model. Following Engle and Granger (1987) a two-step procedure is used to estimate the model. In the first step, a long-run equilibrium model is estimated

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<sup>6</sup> The U.S. and India's exchange rate are included because the USA and India are the two major trading partners of Bangladesh.  $i=1(\text{USA})$  and  $2(\text{India})$ .

<sup>7</sup> Variables are cointegrated if each variable is I(d), but a linear combination of the variables is I(d-b),  $b>0$ .

with OLS using log levels of the variables. In the second step, the lagged value of the residual derived from the first step is used in the second equation to estimate the short-run dynamic model. The same procedure is repeated with the second set of equations containing growth rate of BDT/INR exchange rate and domestic international reserves to construct EMP. India's inflation and same three domestic variables are used as independent variable. The coefficient on the lagged residual is the speed of adjustment. The significance of the coefficient of the lagged residual implies that the variables are cointegrated. The larger the coefficient is, the greater the responses of the variables to fill the gap of the deviation from long-run equilibrium (Enders 1995).

Following Girton and Roper (1977) a variable  $Q_i$  ( $=e/r$ ) is also included in the model to examine whether the monetary authority in Bangladesh is sensitive to the components of EMP.<sup>8</sup> A significant positive coefficient of  $Q_i$  will imply that the monetary authority in Bangladesh responds to EMP by depreciating currency. A significant and negative coefficient of  $Q_i$  will imply that the monetary authority in Bangladesh responds to exchange market pressure by reserve losses. In that case, the central bank sells foreign currency instead of currency depreciation. The insignificance of the  $Q_i$  will imply that the EMP is not sensitive to its components. The results from the short-run dynamic models are reported in Tables 1 and 2.

Table-2 shows the estimated results from Engle and Granger's (1987) two-step single equation model containing U.S. variables. The coefficient of the growth rate of the domestic credit is significant at the 1-percent level. The coefficient of domestic credit (-0.96) implies that a 10-percent increase in the domestic credit causes the exchange rate to depreciate by ( $e=-0.96*10$ )=-9.6-percent, or a loss of reserves by ( $r=-0.96*10$ )=-9.6-percent, or a combination of the two.

The coefficient of the lagged value of the error term also appears to be significant. A significant error correction term implies that the variables are cointegrated. However, the coefficients on U.S. inflation and real income and money multiplier are not significant, which imply that these variables do not have an impact on EMP in Bangladesh. The results remain the same when estimating the model adding a new variable  $Q_1$ .  $Q_1$  is added to see whether EMP is sensitive to its components. The coefficient of  $Q_1$  turns out to be insignificant, implying that the monetary authority is not sensitive to the components of EMP. They adjust both international reserves and the exchange rate to reduce EMP.<sup>9</sup>

Table-3 shows the estimated single equation results using India's variables. The coefficient of domestic credit is negative and significant at 1-percent level. India's inflation and error correction terms are also significant at 5-percent and 1-percent levels, respectively, with the expected signs. A significant and positive coefficient of India's inflation implies that an increase in the India's inflation increases foreign exchange market pressure in Bangladesh and a significant error correction term implies that the

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<sup>8</sup>  $i=1, 2$ ; 1 being USA, and 2 India.

<sup>9</sup> This paper estimates the model using the BDT/USD nominal exchange rates as a dependent variable where the estimated coefficients turn out to be all insignificant. This paper also estimates the model using international reserves as a dependent variable. In that case, the coefficient of domestic credit is statistically significant and negative at 1- percent level.

variables are cointegrated. However, the money multiplier and real income are not statistically significant. The results do not change when the  $Q_2$  variable is added to the model. The coefficient of  $Q_2$  turns out to be insignificant.<sup>10 11</sup>

## 5.2 Vector Error Correction Model (VECM)

In order to see the robustness of the results from the ECM, this paper derives impulse response function (IRFs) and variance decomposition (VDCs) from vector error correction models (VECM) using both exchange rates: BDT/USD and BDT/INR. The VDCs show the portion of the variance in the forecast error for each variable explained by innovations to all variables in the system. This study is mostly interested in the portion of the forecast error variance of exchange market pressure that is explained by shocks to the domestic credit ( $d$ ), foreign price levels ( $p_i^*$ ), domestic real income ( $y$ ), and the money multiplier ( $mm$ ). If these factors explain a significant portion of the forecast error variance in the EMP then we can say these factors have significant impact on EMP.

The IRFs show the dynamic response of each variable in the system to shocks from each variable in the system. Ordinarily we expect the response of the exchange market pressure to be significant and negative due to shocks to domestic credit and money multiplier. On the other hand, we expect a significant and positive impact of domestic real income and foreign inflation on the EMP.

Hafer and Sheehan (1991) argue that VAR results can be very sensitive to the choice of lag length. Therefore, Akaike's Information Criterion (AIC) and Schwartz's Information Criteria (SIC) are used to select the lag length for the VECM model. Lag orders of one through eight are tested.<sup>12</sup> A lag order of four produces the minimum AIC and SIC in each case. The Q-statistics show white noise residuals for each equation at lag order four. Therefore, a lag of four is used to derive VDCs and IRFs from the VECM. To see the robustness of the results, a lag of eight is also used to estimate the model. This paper reports the estimated results using optimal lag 4 in upper portions of Tables 3 and 4 and the results using lag 8 in the lower portions of Tables 3 and 4.

To estimate VDCs and IRFs, orthogonalization of the VECM residuals is required. Cholesky decomposition is used to orthogonalise the residuals. The Cholesky decomposition requires the variables to be ordered in a particular way such that variables placed higher in the ordering have a contemporaneous impact on all variables lower in the ordering, but the variables lower in the ordering do not have a contemporaneous impact on the variable higher in the ordering. In the Cholesky ordering, "...due to the cross-equation residual correlation when a variable higher in the ordering changes all the variables lower in the ordering are assumed to change" (Wheeler 1999, page 277).

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<sup>10</sup> This paper also estimates the model using BDT/INR exchange rate and the international reserves as dependent variables where the estimated coefficients are all insignificant. The estimated coefficients from international reserves as a dependent variable have two significant coefficients, domestic credit (negatively at 1-percent level), and India's inflation (positively at 5-percent level).

<sup>11</sup> This paper also estimates the model with OLS using growth rates (excluding error correction terms) of U.S. and India's variables with and without the  $Q_i$  variable. This time only the domestic credit variable appears to be significant at 5-percent level with the expected sign in the U.S. equations. In the India's equations, domestic credit and India's inflation appear to be significant at the 5-percent level with the expected negative and positive signs respectively.

<sup>12</sup> A maximum lag length of eight is used to preserve sufficient degrees of freedom.

Therefore, it is important to decide a proper ordering of the variables. The Cholesky ordering of the variables for this study is:  $p_i^*$ ,  $m$ ,  $d$ ,  $y$ , and  $EMP$ .<sup>13</sup> The foreign inflation variable is placed first in the ordering according to the small country assumption; foreign inflation is exogenous. Placing foreign inflation higher in the ordering implies that foreign inflation has a contemporaneous impact on money multiplier, domestic credit, domestic real income, and  $EMP$ , while these variables have no contemporaneous impact on foreign inflation.  $EMP$  is placed last in the order allowing all other system variables to have a contemporaneous impact on  $EMP$ . This assumption is consistent with previous single-equation studies that treat  $EMP$  as an endogenous variable, while treating all other system variables as exogenous.

The money multiplier is assumed to remain constant within a given quarter. Hence, the money multiplier is placed above other domestic variables. This assumption allows the money multiplier to have a contemporaneous impact on other domestic variables, but domestic variables have no contemporaneous impact on the money multiplier. As a policy variable, domestic credit is placed above real income in the ordering. This allows monetary policy to have a contemporaneous impact on real income. However, policy decisions respond with a lag to changes in real income.<sup>14</sup>

### **5.3 Variance Decomposition (VDCs) of EMP using BDT/USD Nominal Exchange Rate**

In order to know the impacts of a shock, VDCs for time horizons of 4, 6, 12, 16 and 20 are computed. The estimates of the forecast error variance are considered significant if the point estimate is at least two times as large as the standard error. Twenty-five hundred Monte Carlo simulations are used to calculate the standard errors. Because this study is most concerned with the forecast error variance in the exchange market pressure ( $EMP$ ) explained by the foreign (U.S. and India) price level, money multiplier, domestic credit, and real income, VDCs of  $EMP$  derived from using the VECM model are reported in Tables 4 and 5. Table-4 shows the VDCs derived from estimating VECM model using BDT/USD dollar nominal exchange rate, and Table-5 shows the VDCs derived from estimating VECM model using BDT/INR Rupee nominal exchange rate.

Table-4 indicates that domestic credit can explain a significant portion of the forecast error variance in  $EMP$  at time horizons 4, 8, and 12, while estimating at lag length 4 using BDT/USD exchange rate. The forecast error variance explained by the domestic credit at time horizon 12 is 30.56-percent. None of the other variables are significant. The results change if we change the lag length. At lag 8, the forecast error variance explained by domestic credit is significant at time horizons 4, 8, 12, 16, and 20. Domestic credit is the only significant variable regardless of the lag length.

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<sup>13</sup> This paper also estimates VECM models adding the  $Q_i$  variable, but the IRFs and VDCs of  $EMP$  due to shocks to  $Q_i$  are never significant.

<sup>14</sup> This study also estimates VECM by switching the order between domestic real income and money multiplier and domestic credit and money multiplier. Major policy conclusions do not change due to switching the ordering between real income and money multiplier and switching the ordering between domestic credit and money multiplier.

#### **5.4 Variance Decomposition (VDCs) of EMP using BDT/INR Nominal Exchange Rate**

Table-5 shows the variance decomposition of EMP due to shock to foreign inflation, money multiplier, domestic credit, and real income estimated for VECMs estimated at lags 4 and 8. The BDT/INR exchange rate is used to construct EMP. In order to know the magnitude of the shock, variance decompositions at time horizons 4, 8, 12, 16, and 20 are reported. The upper portion of Table-5 shows that domestic credit can explain a significant portion of the forecast error variance in EMP at time horizons 4 and 8, when estimating the VECM at lag 4. The forecast error variance explained by domestic credit at time horizon 8 is 34.42-percent. None of the other variables explain a significant portion of the forecast error variance in the EMP. These results hold if we change the lag length to 8. At lag 8, domestic credit can explain a significant portion of the forecast error variance of EMP at all time horizons.

#### **5.5 Impulse Response Function (IRFs) of the EMP using BDT/USD Nominal Exchange Rate**

The IRFs show the dynamic response of each variable in the system to shock from each variable in the system. The Cholesky ordering of the variables for this study is:  $p_i^*$ , mm, d, y and EMP.<sup>15</sup> A two-standard-deviation confidence interval is reported for each IRF. A confidence interval containing zero indicates lack of significance. The confidence interval for each IRF is computed from twenty-five hundred Monte Carlo simulations. The IRFs of EMP due to shocks to foreign price level, money multiplier, domestic credit, and real income are shown in Figures 1 to 4. In Figures 1 and 3 the optimal lag length of four is used to derive the IRFs estimating the VECM using Taka/Dollar and BDT/INR exchange rates. To see the robustness of the results, the IRFs derived from VECM using lag length 8 are also estimated and reported in Figures 2 and 4.

In Figures 9 and 10, the BDT/USD exchange rate is used to construct the EMP variable. Figure-9 shows the IRFs of EMP due to shocks to domestic credit, U.S. inflation, real income and the money multiplier.<sup>16</sup> In Figure-9, the response of EMP due to shock to domestic credit is significant and negative initially, remaining significant up to time horizon 13, and becomes insignificant thereafter. The IRFs of EMP due to shocks to U.S. inflation is insignificant initially, becomes significant and negative at time horizon 7, and remains significant thereafter. The impulse response function of EMP due to shock to the U.S. inflation appears with the wrong sign. None of the other variables are significant in Figure-9. As shown in Figure-10, the results remain the same when the lag length is increased to 8.<sup>17</sup>

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<sup>15</sup>  $i=1(\text{USA})$  and  $2(\text{India})$ .

<sup>16</sup> VECMs with  $Q_1$  and/or  $Q_2$ , included also estimated. The IRFs of EMP due to shocks to  $Q_1$  and  $Q_2$  were never significant.

<sup>17</sup> At lag 8, the response of the EMP due to shock to income becomes significant only for the 5<sup>th</sup> quarter and the response of EMP to a shock to U.S. inflation is significant for time horizons 6 to 9.



## **5.6 Impulse Response Function (IRFs) of Exchange Market Pressure (EMP) using BDT/INR Nominal Exchange Rate**

Figures 11 to 12 show the IRFs of EMP due to a shock to the domestic credit, foreign inflation, real income and money multiplier when BDT/INR exchange rate is used. Figure-11 shows the response of EMP due to shocks to domestic credit, foreign inflation, and the money multiplier estimated at lag 4 using BDT/INR nominal exchange rate. In Figure-11, the response of EMP declines sharply due to shock to domestic credit and remains negative and significant for the rest of the periods. The response of the EMP due to innovation to India's inflation is significant and positive for the first two quarters, which becomes insignificant thereafter. None of the other variables appears to be significant in Figure-11. As shown in Figure 12, the results remain the same when the lag length of 8 is used.

## **5.7 Analysis of the results from ECM and VECM:**

The results derived from VECM are better than single equation ECM because VECM takes into account endogeneity of the variables where a single-equation ECM considers each right-hand side variable as exogenous. This potentially creates a simultaneity bias in the coefficients. The results from VECM are more reliable because it takes into account the simultaneity problem.

The significance of the coefficient of domestic credit in terms of 't' ratio from ECM and IRFs and VDCs from VECM show that domestic credit has a significant impact on EMP for both exchange rates. However, domestic real income is never significant for any of the models analyzed here.<sup>18</sup> The estimated coefficient of foreign inflation (India) from ECM and IRFs estimated at lag 4 show significant and positive impacts on the EMP. The response of EMP due to shock to the U.S. inflation is significant and negative. However, the coefficient of the U.S. inflation from ECM and VDCs of EMP due to shock to U.S. inflation is not significant. The estimated coefficient of the money multiplier is never significant either using BDT/USD or BDT/INR exchange rate.

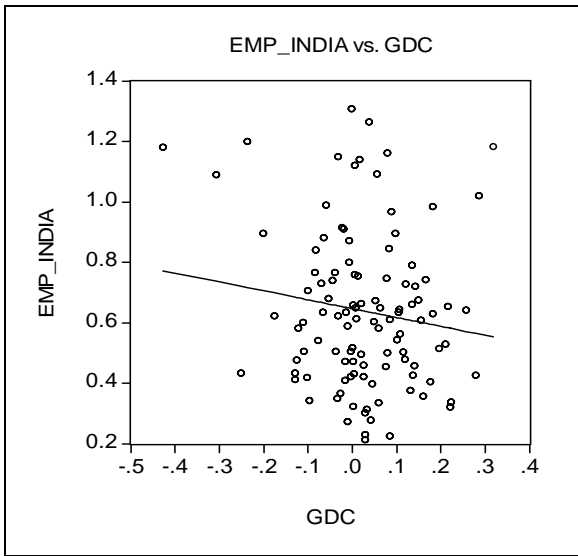
## **5.8 Evidence from Raw data**

An attempt has been made to analyze the raw data based on the sample period from 1976:q1 to 2003:q1. It is evident from Figure-1 and 2 that the relationship between EMP and growth of domestic credit is negative when BDT/USD and BDT/INR nominal exchange rate is used which is also supported by the two econometric techniques ECM and VECM method as discussed above.

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<sup>18</sup> At lag 8, the response of EMP due to shock to income becomes significant only for the 5<sup>th</sup> quarter.

**Figure-1**  
Trends of EMP and Domestic Credit  
when BDT/INR NER is used



**Figure-2**  
Trends of EMP and Domestic Credit  
when BDT/USD NER is used

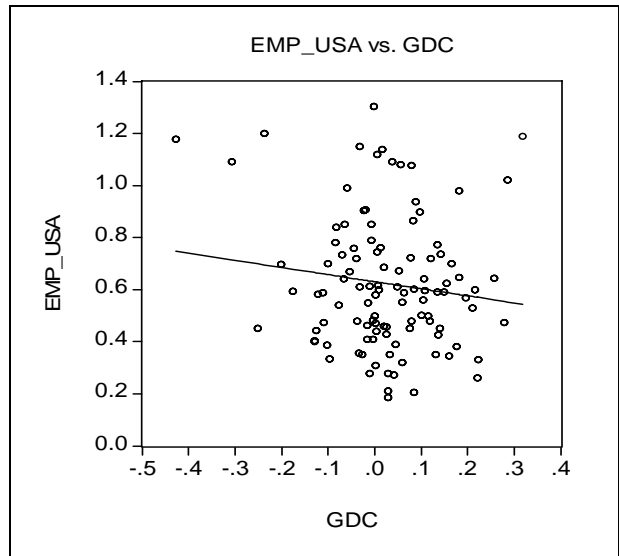
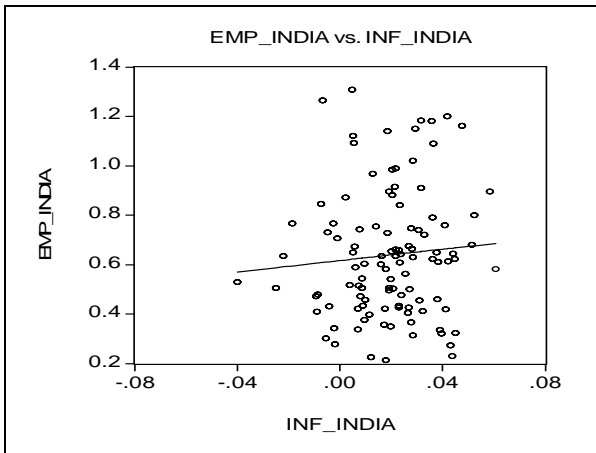
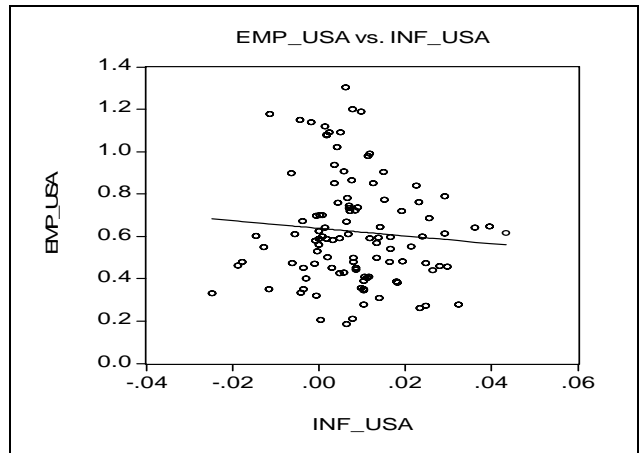


Figure-3 and 4 shows the positive and negative relationship between EMP and inflation in India and USA respectively which is also supported by the ECM and VECM methods.

**Figure-3**  
Trends of EMP and Inflation  
of India when BDT/INR NER is used

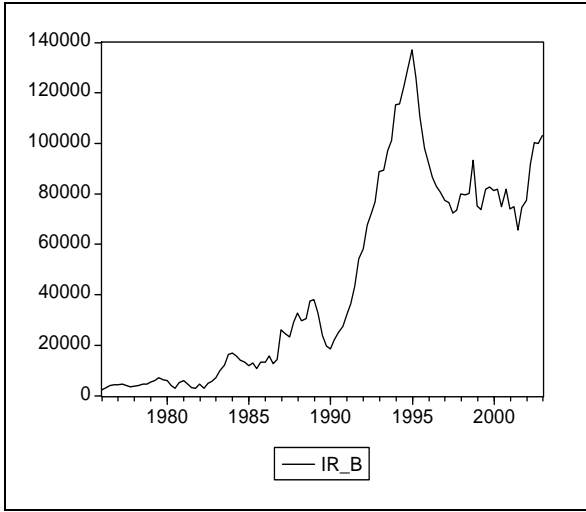


**Figure-4**  
Trends of EMP and Inflation  
of USA when BDT/USD NER is used



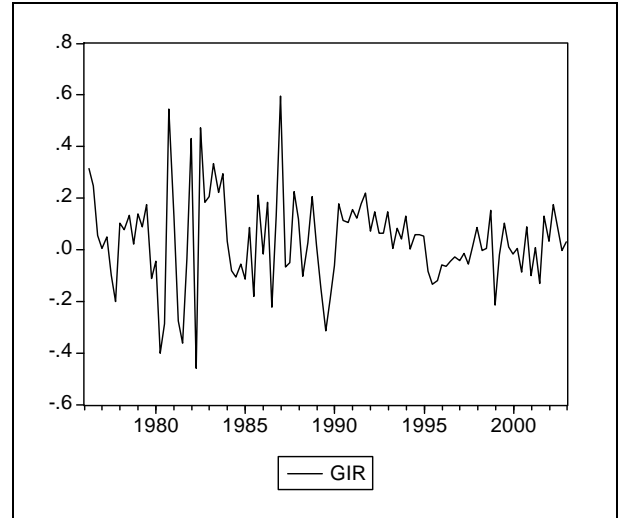
**Figure-5**

**Trends of International Reserves of Bangladesh**



**Figure-6**

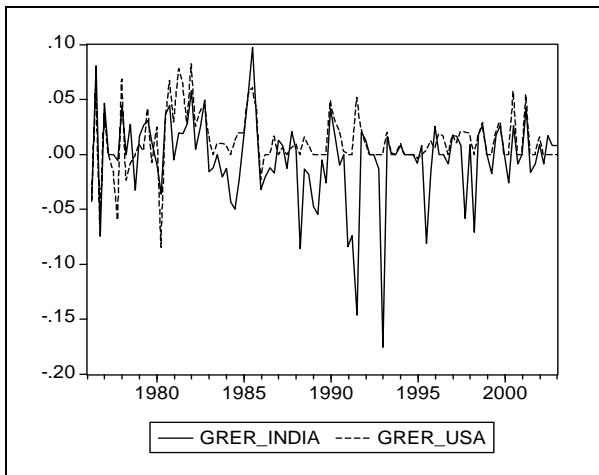
**Trends of Growth of International Reserves**



An analysis of the trends of international reserves in level (Figure-5) and in growth (Figure-6) show that during the period from 1990 to 1995 the level of international reserves rose rather fast before coming down in 1997, and resumed another uptrend in 1999. On the other hand, in Figure-6 the growth rate of international reserves appear to be more volatile before 1990 and the volatility reduced significantly after 1990.

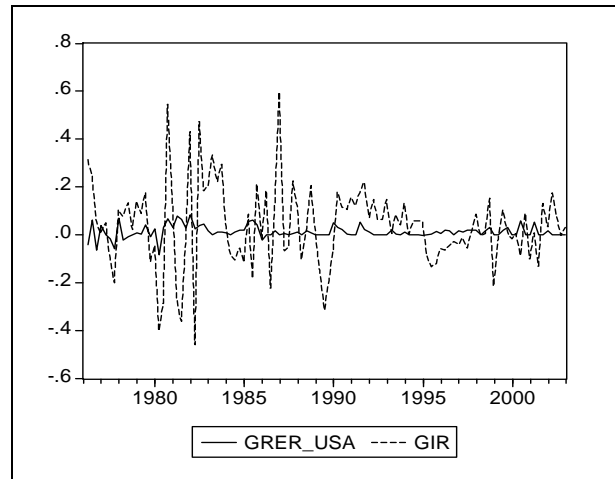
**Figure-7**

**Trends of Growth Rate BDT/INR VS. BDT/USD Nominal Exchange Rate**



**Figure-8**

**Trends of Growth Rate of BDT/USD and International Reserves**



It is evident from Figure-7 that BDT/INR is more volatile than BDT/USD. Figure-8 shows that the growth of international reserves is more volatile than BDT/USD nominal exchange rate.

## 6. Conclusion

This paper provides evidence supporting the claim that domestic credit has a significant and negative impact on exchange market pressure using either the BDT/USD or the BDT/INR exchange rate. ECM, VECM and Trend analysis show that domestic credit has a significant impact on EMP in each model estimated. We do not find evidence of the impact of domestic real income on EMP for either of the two cases. The impact of the money multiplier on EMP is not significant in any of the model analyses here. However, the IRFs estimated in this paper show a significant and positive response of EMP due to a shock to India's inflation and significant and negative impact due to shock to the U.S. inflation which is also supported by the trend analysis. The ECM also supports the significant and positive coefficient of India's inflation. However, the coefficient of EMP from ECM and VDCs of EMP due to shock to the U.S. inflation does not support the significant impact of the U.S. inflation on EMP. The coefficient of  $Q_i$  is never significant in the VDCs or IRFs. This implies that the monetary authority in Bangladesh responds to EMP by depreciating currency and losing international reserves. This is true for both exchange rates (BDT/USD or BDT/INR). Therefore, as a policy prescription, we can say that the monetary model of exchange market pressure can be used to determine the level of intervention needed to maintain exchange rate stability in Bangladesh.

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**Table-2: Dependent Variable: EMP (BDT vis-a-vis USD)**

Independent Variable	r-e	r-e	r	e
Constant	-9.38 (-1.57)	-9.35 (-1.56)	-4.85 (-0.79)	4.52*** (3.49)
d	-0.96*** (-6.53)	-0.96*** (-6.52)	-0.94*** (-6.22)	0.01 (0.46)
p <sub>1</sub> *	0.0008 (0.00)	-0.03 (-0.03)	-0.07 (-0.06)	0.06 (0.29)
y	-0.10 (-0.48)	-0.12 (-0.57)	-0.07 (-0.30)	0.03 (0.81)
mm	0.47 (1.51)	0.48 (1.54)	0.48 (1.51)	0.01 (0.25)
Q <sub>1</sub>	-	-1.45 (-0.43)	-	-
Lagged e-hat	-64.15*** (-3.18)	-64.74*** (-3.19)	-61.63*** (-2.96)	2.52 (0.58)
adj-R <sup>2</sup>	0.34	0.33	0.31	0.005

(\*\*\*) Implies significant at 1-percent level, while (\*\*) implies significance at 5-percent level.

**Table-3: Dependent Variable: EMP (BDT vis-a-vis INR Rupee)**

Independent Variable	r-e	r-e	r	e
Constant	-25.58*** (-2.81)	-25.92*** (-2.81)	-25.62*** (-2.89)	-0.02 (0.44)
d	-1.06*** (-7.05)	-1.05*** (-6.97)	-1.06*** (-7.21)	0.003 (0.07)
p <sub>2</sub> *	2.79** (2.78)	2.80*** (2.78)	2.66** (2.72)	-0.12 (-0.41)
y	-0.01 (-0.06)	-0.008 (-1.51)	-0.04 (-0.19)	-0.02 (-0.42)
mm	0.53 (1.67)	0.54 (1.68)	0.44 (1.42)	-0.09 (-0.90)
Q <sub>2</sub>	-	0.53 (0.26)	-	
Lagged e-hat	-47.75*** (-2.42)	-47.64*** (-2.40)	-54.54*** (-2.83)	-6.79 (-1.10)
Adj-R2	0.34	0.33	0.35	0.07

(\*\*\*) Implies significant at 1-percent level, while (\*\*) implies significance at 5-percent level.

**Table-4. Variance Decomposition of Exchange Market Pressure using BDT/USD nominal exchange rate and Cholesky ordering as:  $p_1^*$ , mm, d, y and EMP.**

VECM Lag	Time Horizon	$p_1^*$	mm	d	y
4	4	1.24 (4.19)	4.04 (6.54)	41.33** (11.75)	2.02 (4.06)
	8	10.21 (12.03)	3.29 (8.20)	36.71** (13.32)	4.24 (5.61)
	12	21.42 (17.14)	2.86 (8.52)	30.56** (13.51)	5.84 (6.13)
	16	29.48 (19.16)	2.16 (8.08)	25.53 (13.39)	6.58 (6.37)
	20	33.83 (19.98)	1.63 (7.66)	22.13 (13.30)	6.75 (6.52)
	8	4	2.44 (5.18)	1.92 (5.85)	33.88** (12.17)
8		13.66 (11.66)	1.41 (6.39)	34.34** (13.35)	10.89 (10.17)
12		16.63 (13.35)	5.24 (9.17)	34.81** (13.72)	11.49 (10.81)
16		17.44 (14.37)	6.47 (9.94)	32.69** (13.42)	12.99 (11.46)
20		16.96 (14.79)	6.04 (9.75)	32.18** (13.47)	12.68 (11.59)

Notes: Figures in the parenthesis are Monte Carlo simulated standard errors. The point estimates are considered significant if the point estimates are at least twice as large as their standard errors.

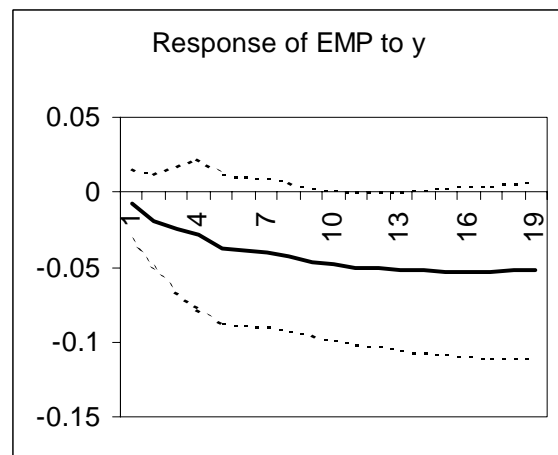
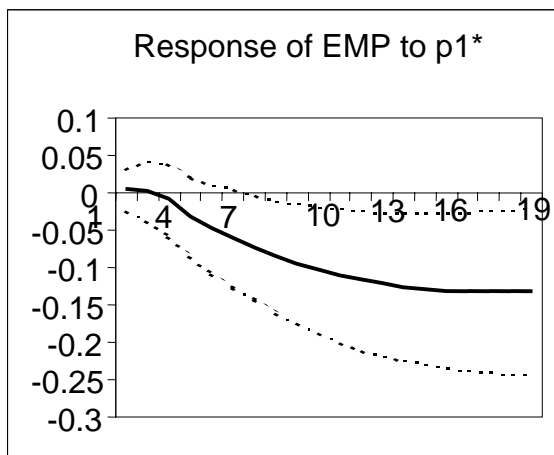
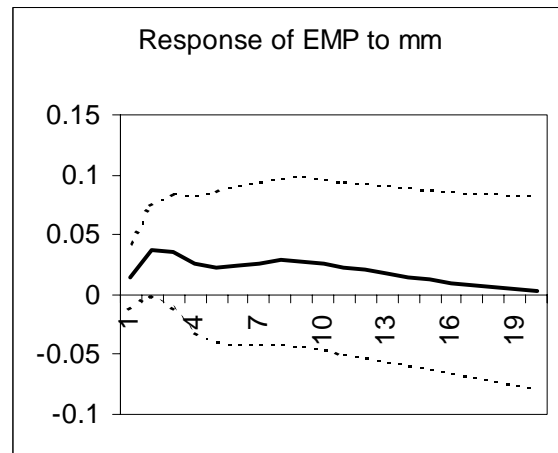
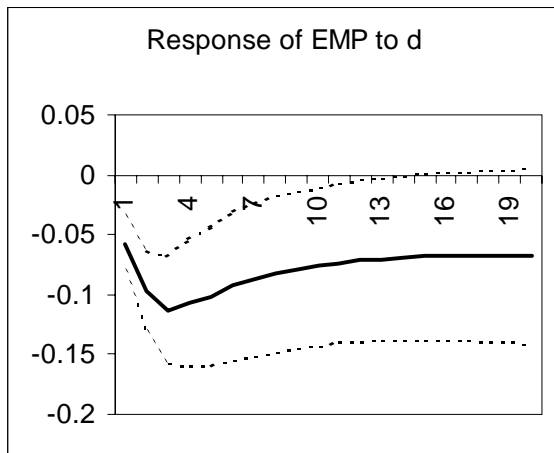
**Table-5. Variance Decomposition of Exchange Market Pressure using BDT/INR nominal exchange rate and Cholesky ordering:  $p_1^*$ , mm, d, y and EMP.**

VECM Lag	Time Horizon	$p_2^*$	mm	d	y
4	4	4.11 (4.61)	0.45 (3.32)	38.59** (12.01)	1.65 (4.06)
	8	6.13 (7.98)	1.80 (5.22)	34.42** (15.10)	2.73 (6.16)
	12	7.44 (9.45)	2.40 (6.30)	32.31 (16.87)	2.99 (7.24)
	16	8.20 (10.26)	2.72 (6.90)	31.15 (17.89)	3.11 (7.87)
	20	8.67 (10.76)	2.91 (7.26)	30.47 (18.53)	3.17 (8.27)
8	4	4.60 (6.37)	0.27 (3.68)	43.60** (12.66)	1.20 (4.54)
	8	4.79 (8.84)	2.67 (6.48)	45.70** (15.59)	5.53 (9.14)
	12	6.39 (11.00)	1.97 (6.65)	42.88** (16.63)	7.15 (10.84)
	16	9.87 (13.02)	1.69 (7.26)	39.22** (16.98)	7.91 (11.23)
	20	12.62 (14.40)	1.44 (7.59)	37.49** (17.25)	7.98 (11.23)

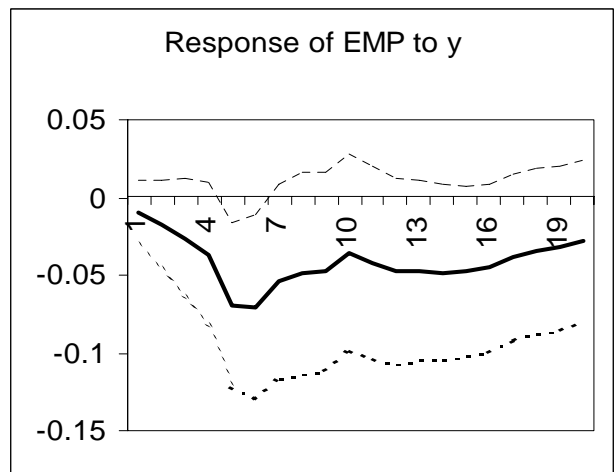
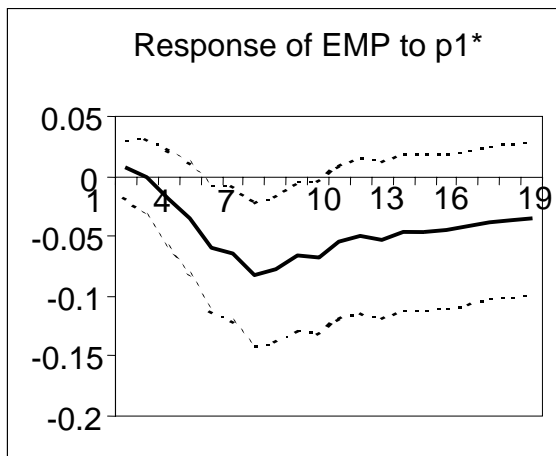
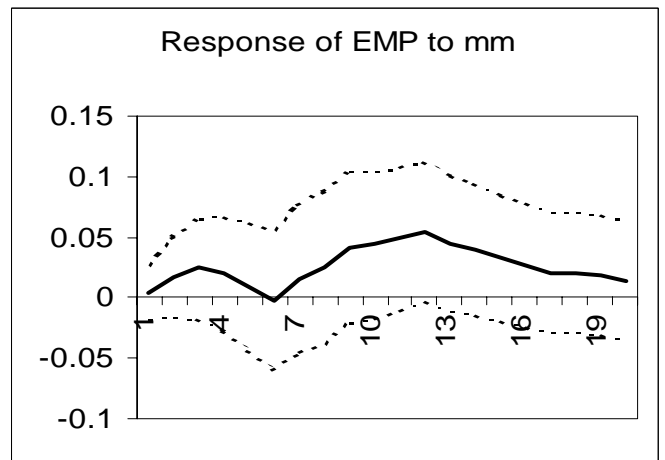
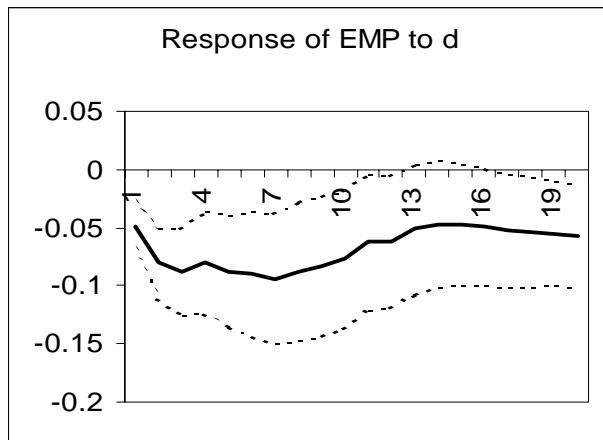
Notes: Figures in the parenthesis are Monte Carlo simulated standard errors. The point estimates are considered significant if the point estimates are at least twice as large as their standard errors.



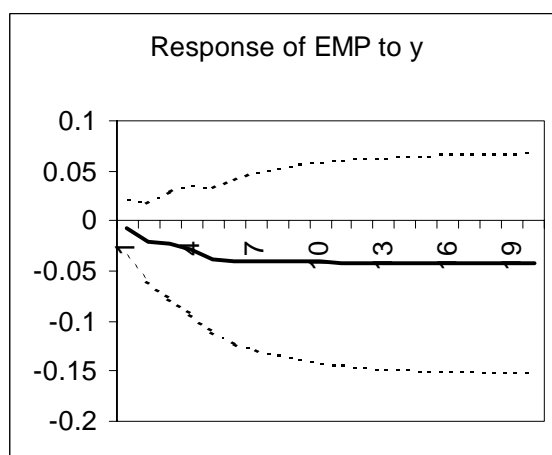
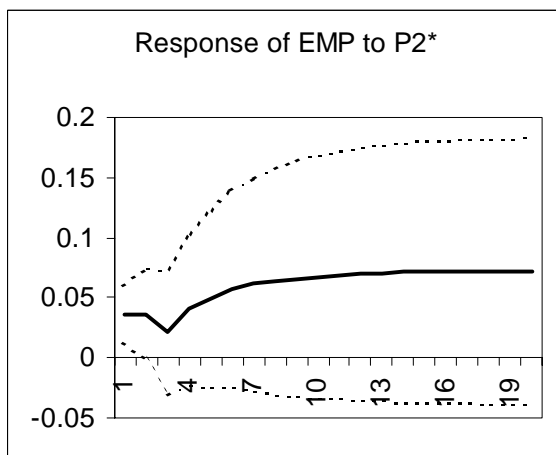
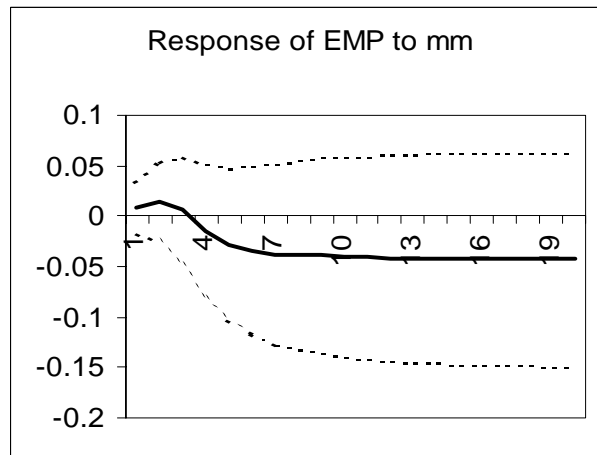
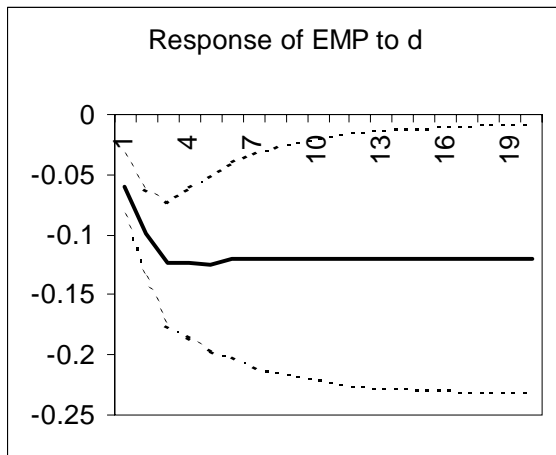
**Figure-9: Responses of EMP due to shocks to  $d$ ,  $mm$ ,  $p_1^*$ , and  $y$  estimated at lag 4 using BDT/USD exchange rate and Cholesky ordering:  $p_1^*$ ,  $mm$ ,  $d$ ,  $y$  and EMP.**



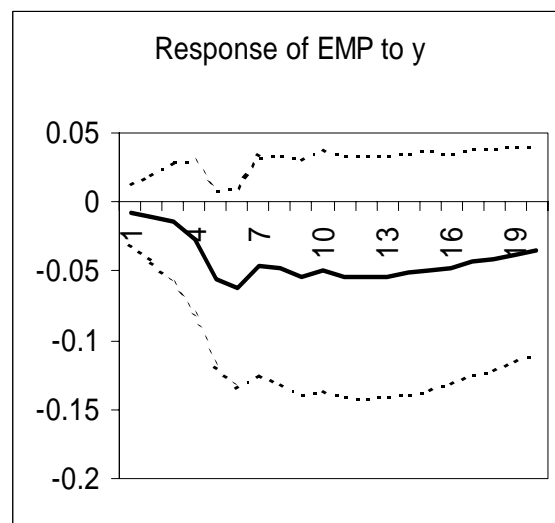
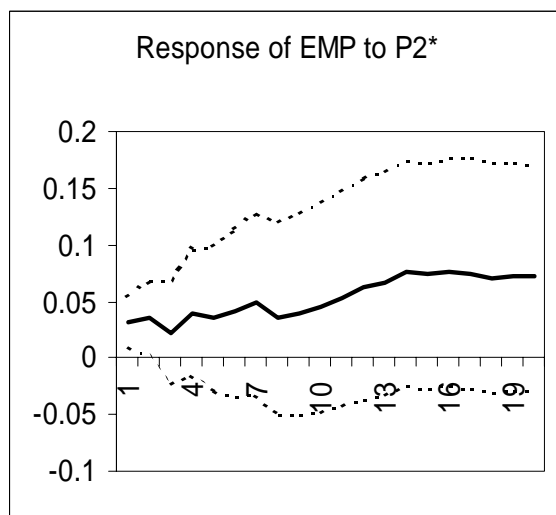
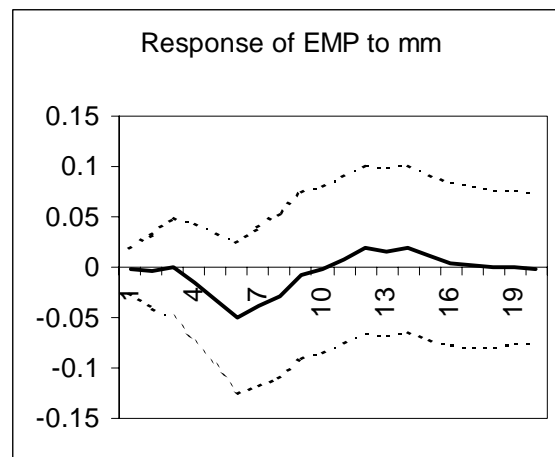
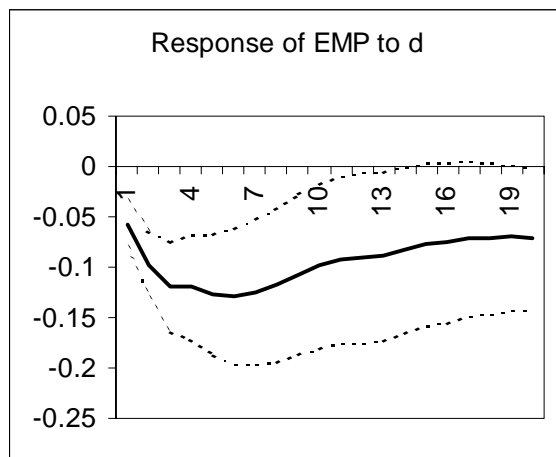
**Figure-10: Responses of EMP due to shocks to d, mm,  $p_1^*$ , and y estimated at lag 8 using BDT/USD exchange rate and Cholesky ordering:  $p_1^*$ , mm, d, y and EMP.**



**Figure-11: Responses of EMP due to shocks to d, mm, p<sub>2</sub><sup>\*</sup>, and y estimated at lag 4 using BDT/INR exchange rate and Cholesky ordering: p<sub>2</sub><sup>\*</sup>, mm, d, y and EMP.**



**Figure-12: Responses of EMP due to shocks to  $d$ ,  $mm$ ,  $p_2^*$ , and  $y$  estimated at lag 8 using BDT/INR exchange rate and Cholesky ordering:  $p_2^*$ ,  $mm$ ,  $d$ ,  $y$  and EMP**



## **Appendix: Variable List**

The data period for this paper is from 1976:2 to 2003:4. The descriptions of the variables used in this paper appear below.

**Foreign Inflation** ( $p_i^*$ ) (1995=100) = the percentage change of foreign (India and the U.S.) consumer price index; the raw data on each consumer price index are seasonally adjusted using the X11 procedure in SAS. Then the percentage change of CPI is used as a foreign inflation variable. The seasonally unadjusted quarterly data on consumer price index are available from IMF CD-ROM.

**Real Income** ( $y$ ) (1995=100) = the percentage change of real income is used as the real income ( $y$ ) variable. Again the data on industrial production has been seasonally adjusted using the X11 method in SAS. Similarly, quarterly data on industrial production are available from international financial statistics (IFS) CD-ROM.

**International Reserves** ( $r$ ) (in Million Taka) =the percentage change of foreign assets ( $r$ ) of the monetary authorities are used as an international reserves variable. The data on the international reserves are seasonally adjusted using the X11 method in SAS. Quarterly data on the international reserves are available from international financial statistics (IFS) CD-ROM.

**Domestic Credit** ( $d$ ) (in Million Taka) =the percentage change in the sum of central bank domestic credit to the government and the private sector is used as a monetary policy variable. The data on domestic credit are seasonally adjusted using the X11 method in SAS. The raw quarterly data on the domestic credit are available from the International Financial Statistics (IFS) CD-ROM.

**Exchange Rate** ( $e$ ) =the percentage change of the nominal exchange rate (BDT/USD and BDT/INR). Here, BDT/INR rate is the cross rate derived from dividing BDT/USD by INR/USD nominal exchange rate. The data of the nominal exchange rate are available from the International Financial Statistics (IFS) CD-ROM.

**Money Multiplier** ( $mm$ ) =the percentage change of the money multiplier ( $mm$ ); the money multiplier is calculated dividing M2 by the monetary base. The seasonally unadjusted data on the M2 and the monetary base are seasonally adjusted using the X11 method in SAS. The seasonally unadjusted data of M2 and the monetary base are available from IMF CD-ROM.

$Q=(e/r) = Q$  is calculated dividing the percentage change of the exchange rate by the percentage change of the international reserves.

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