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A Cointegration-Based Error Correction Approach to Money Demand: The Case of Bangladesh

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A cointegration-based error-correction mechanism is employed in this paper to estimate a dynamic money demand function for the Bangladesh economy using quarterly data from 1975 to 1988. The long-run income elasticity of money demand has been found to be lower than what is generally obtained in partial adjustment models, and higher than unity, the value assumed in the conventional error correction model. The result suggest that a dynamic money demand model incorporating a CI-ECM is more stable than its partial adjustment counterpart and hence has a better predictive power. From policy perspective, this result has important implications.

I. Introduction

There is a vast amount of literature on demand for money in the context of developed countries but the number of studies that deals with the developing countries appear to be few and far between. A major reason for the imbalance is that, until recently, there was a widely held view that monetary policy was not effective in achieving stability and promoting economic growth in developing countries. Several, closely interwoven, features of the undeveloped financial markets of LDCs contributed to this view. One such feature which is often mentioned in the literature is the government control of the financial sector, often using inappropriate regulations. In most developing countries interest rates are set by decree and do not reflect the underlying market forces. Another feature of an undeveloped financial market is the lack of competition among financial institutions, and a very limited choice of financial instruments which make it difficult for the monetary authorities to conduct any meaningful monetary policy. The most commonly used instrument of monetary policy

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in developed countries, namely the open market operations, has very little relevance in the developing world for lack of open financial markets on which trading can take place. The governments of LDCs have not only been blamed for inappropriate regulations, but they have also been blamed for not having the political will to adopt appropriate regulations and enforce them uniformly.

In recent years, analytical work of Shaw (1973) and McKinnon (1973) have stressed the role of financial policies in developing countries in mobilizing domestic savings and allocating them in productive investments. These authors have argued that monetary policy can contribute not only to short term price stability but also to long term growth. On the practical side, the positive results of financial liberalization which has been experienced by a few South-East Asian developing countries has encouraged policy-making elsewhere to consider liberalizing the financial sector of their own countries.[1] Financial liberalization, which increases competition among financial institutions and restores to the price system its allocative functions, has been promoted by many international agencies like the IMF and the World Bank, sometimes requiring liberalization measures as a precondition for a country's access to the resources of these agencies.

Whether the liberalization measures will succeed in achieving the desired goals depend on several factors, an important factor being the general macroeconomic stability. McKinnon (1973, pp. 77-79) and Shaw (1973, pp. 119-120), among others, have emphasized macroeconomic stability, especially the price stability, as a prerequisite for successful financial liberalization. Price stability has always been a prime objective of monetary policy. Thus, the need to design an effective monetary policy in a developing country which is striving to liberalize its financial sector can hardly be over-emphasized.

Successful implementation of monetary policy requires, among other things, a comprehensive understanding of the factors that determine the demand for money. The present paper, which deals with the estimation of a money demand function in Bangladesh, is motivated by the recent attempts in Bangladesh to liberalize its financial sector.

[1] Although a large number of Latin American and South-East Asian countries have experimented with monetary and financial reforms, only the latter group is cited to have benefited from these reforms. For more on the positive effects of financial development, see Fry, M.J. (1988), especially Chapter 9. Dornbusch, R. and A. Reynoso (1989), although agrees that financial factors play an important role in economic development, provides a skeptical assessment of the Asian and Latin American experiences.

The Bangladesh government has taken several measures in recent years to move towards a greater market orientation in the financial sector. First, to allow increased competition, private banks have been allowed to operate since 1984, marking a reversal of the nationalization policy adopted in 1972 at the inception of the country. In 1972, there were six nationalized commercial banks with 1,078 branches, three foreign banks with 14 branches, and two specialized banks with 82 branches. In 1989, there were four nationalized banks with 3,486 branches, ten foreign banks with 22 branches, nine private banks with 733 branches, and four specialized banks with 1,228 branches. Total number of branches increased five folds between 1972 and 1988.[2] Based on the recommendation of the National Banking commission, a new interest rate policy was implemented in 1989 in which the central bank has been assigned responsibility to establish a band — rather than a single rate — for each specified category of loans and deposits. Each bank will have its own centralized mechanism to determine its rates within the prescribed bands. Other measures that would affect credit creation by commercial banks have also been taken. Many economists see the changes as a step toward more flexibility in the monetary sector whereby the market signals will now be taken into consideration in designing the monetary policy.

Money demand functions for Bangladesh have been studied by Ahmed (1977), Murty and Murty (1978), Taslim (1983, 1984) and Hossain (1988). These studies, like many other studies on the demand for money in developing countries, is based on a partial adjustment framework. But existing evidence indicates that partial adjustment models are potentially misspecified.

One alternative to the partial adjustment approach is the Error Correction Mechanism (ECM) which was originally introduced by Sargan (1964) and later developed by, among others, Davidson, Hendry, Sbra and Yeo (1978). Hendry, Pagan, and Sargan (1984) provides a comprehensive discussion of error correction mechanism covering both theoretical, as well as, empirical issues. Error correction models have become quite popular in applied macroeconomic work in recent years.[3] A study by Domowitz and Elbadawi (1987) is of special interest to us because it uses ECM to estimate money demand function for the Sudanese economy. Their results show quite a contrast with that obtained from a partial adjustment framework.

In our study, we use an error correction mechanism but unlike

[2] Bangladesh Bank, *Bangladesh Bank Bulletin*, various issues.

[3] A number of studies have been published in recent years employing error-correction mechanism. A recent paper by Hendry and Ericsson (1991) deals with the U.K. money demand and employs the same methodology.

Domowitz and Elbadawi who use a conventional ECM, we use a cointegration-based ECM (CI-ECM). An important difference between the conventional ECM and CI-ECM is that in the conventional form unit income and price elasticities of demand for money are imposed as restrictions on the model, whereas in the CI-ECM the long-run elasticities are estimated from the data and then imposed as restrictions.

Our results suggest that a dynamic money demand model incorporating a CI-ECM is more stable than its partial adjustment counterpart and hence has a better predictive power. The estimated long-run income elasticity of money demand in our study is 1.84 which is lower than what is normally found in the partial adjustment models but much higher than what is assumed in the conventional error-correction models.

The result of the paper is organized as following: in the second section a model of demand for money is specified. In the third section cointegration approach to error correction is discussed. In the fourth section the two-stage tests for cointegration are presented. In the fifth section the estimated money demand relationships are presented which is followed by the concluding comments.

II. A Model of Demand for Money

The existing literature on the demand for money in developing countries suggests that the desired long-run real balance (M^*) is a function of real income (Y), the price level (P), the rate of inflation ($\dot{P}$) and in some cases, the rate of interest (i). The interest rate variable has been found to be statistically insignificant in many developing countries including Bangladesh and thus it will not be included in the following model. Hence the equilibrium money demand relationship for Bangladesh can be specified as following:

$$(1) \qquad m_t^* = \alpha_0 + \alpha_1 y_t + \alpha_2 p_t + \alpha_3 \dot{p}_t + u_t$$

where the lower case letters represent the logarithm of the respective upper case variables.

In most previous studies, including the studies using Bangladesh data, a partial adjustment framework has been used to replace the desired money stock (m_t^*) with observable variables. However, in recent years, various error correction mechanisms are increasingly being used to capture the dynamic adjustment behaviour.

Davidson et. al (1978), Salmon (1982), and Nickell (1985), among others, have shown that error correction models are more general than the partial adjustment models and that the latter models are just a subset of the former. Nickell (1985) examines several circumstances where the error correction models represent optimal response of the relevant economic agents in a dynamic environment. However, it must be recognized that both theory and data play a role in determining the final shape of a dynamic adjustment equation incorporating an ECM.

The equation (1) can be transformed into the following dynamic equation, where k is number of lagged first differences of the exogenous variable and the dependent variable, and an Error Correction Mechanism (ECM) has been introduced to capture the dynamics of adjustment of the desired money stock variable to its equilibrium values. The inflation rate does not appear in this equation separately because the variables are in logarithmic form and the first difference of the price variable itself is the inflation rate.

$$(2) \qquad \Delta m_t = c + \sum_{i=0}^{k} \alpha_i \Delta y_{t-i} + \sum_{i=0}^{k} \beta_i \Delta p_{t-i} + \sum_{i=0}^{k} \lambda_i \Delta m_{t-i-1} + \Sigma\, \alpha EC + u_t$$

Where EC is an error correction mechanism. In conventional error correction mechanism the EC term is $(m-p-y)_{t-1}$, whereas in cointegration-based error correction approach the EC term is estimated from the data; the estimation procedure will be discussed in the next section. Once the EC term has been computed, one can estimate equation (2) first and then engage in a general to specific search for a more parsimonious equation.

III. Cointegration Approach to Error Correction

The conintegration based error correction approach exploits the long-run relationship between two or more time series. Individual economic variable may fluctuate violently but a collection of them may be tied together by economic forces and thus may fluctuate only moderately. Engle and Granger (1987) show that if each element of a vector of time series x_t becomes stationary after differencing k times, but a linear combination $\alpha' x_t$ becomes stationary after differencing k' times, then the vector of time series are cointegrated if $k' < k$. If a vector of variables are cointegrated, then there exists a valid error correction representation of the data which is not subject to "spurious regression."[4]

[4] See Granger and Newbold (1974) for a discussion of the spurious regression issue.

Engle and Granger suggest a two-step procedure for the construction of an ECM. First, each of the variables hypothesized to form a cointegrating set (say M_t, P_t, and Y_t), is checked for the order of integration. If they have the same order of integration (say k), then the following regression is run; this is the second stage of the two-stage procedure.

$$(3) \qquad M_t = \alpha_0 + \alpha_1 P_t + \alpha_2 Y_t + u_t$$

The second-stage regression is called the cointegrating regression. The residual from the cointegrating regression is checked for the order of integration. If the set of variables are cointegrated, then u_t from the above equation will achieve stationarity after differencing k' times, where $k' < k$.

Most economic variables achieve stationarity after differencing once (i.e. I(1)). If the above set of variables (M_t, P_t, and Y_t) are all I(1), and if a linear combination of them is I(0), then they form a cointegrating set. The final step in cointegration analysis is to use the residual from the cointegrating equation as error correction mechanism in a general dynamic error-correction model.

IV. Testing for Cointegration

For empirical analysis, first each of the variables hypothesized to form a cointegrating set was tested for order of integration. We selected broad money (M2), real permanent income (Y) and price level (P) for this analysis. Broad money (M2) has been used because of the ease with which savings and time deposits can be converted into demand deposits or cash in Bangladesh. Permanent income is considered to be a more appropriate scale variable in money demand functions. Fry (1978), Mangla (1979) and Trivedi (1980), among others, have found permanent income to be a better scale variable than measured income in developing countries. Hossain (1988) has also convincingly argued in favour of using permanent income as a scale variable in his money demand estimation using Bangladeshi data.

There is no unique method of estimation of permanent income although most researchers use an average of past incomes, sometimes a weighted average, as an estimate of permanent income. Friedman (1959) defined permanent income as a weighted average of past incomes, where the weights on the past incomes exponentially decline. In our study, we have used a weighted average, where the weights were determined by an Almon polynomial lag; the lags extended to four periods and the polynomial was of degree two.

Both M2 and Y were first expressed in constant monetary units and then all the variables including the price level were transformed into logarithm. These transformations should stabilize to some extent the inter-temporal variance in the series. Nominal stock of money and nominal GDP are expected to rise quite a bit because of inflation. The real GDP and real money stock may also grow substantially if a long sample period is considered. Thus, the variance in data and the error variance in the regression residual (heteroscedasticity) should be moderated because of these transformations.

As a prelude to more formal testing for stationarity, correlograms of each of the three variables (both level and first-difference) were examined. For all three variables, the autocorrelation function (ACF) of the first difference approached zero quite quickly, whereas the ACFs of the levels started from a value close to one and slowly declined to half the starting value at about tenth lag. Thus, the correlograms were indicative of first-difference stationarity in each variable.

Next, four formal tests of stationarity were applied to the data: the Cointegrating-Regression Durbin-Watson (CRDW) test, the Dickey-Fuller (DF) test, the Augmented Dickey-Fuller (ADF) test, and the Phillips-Perron test. According to the CRDW test, to test a series X_t for stationarity, the regression $X_t = a_0 + u_t$ is run and the computed Durbin-Watson from the regression is compared with the critical values. The null hypothesis of non-stationarity is rejected if the computed CRDW exceeds the relevant critical value.

According to the Dickey-Fuller test, the following regression is run

$$(4) \qquad \Delta x_t = \beta x_{t-1} + v_t, \qquad v_t \sim \text{i.i.d. } (0, \sigma_v^2)$$

and the t-statistic for β is the relevant test statistic. If this test statistic is negative and the absolute value of it exceeds the relevant critical value provided by Dickey and Fuller (1981), the null of non-stationarity is rejected and it is concluded that x_t is stationary. However, if the null is accepted then we need to check if Δx_t is stationary and that is done by repeating the above procedure.

This time the relevant test statistic is obtained from the following regression

$$(5) \qquad \Delta^2 x_t = \beta \Delta x_{t-1} + v_t$$

Now the null hypothesis is that Δx_t is non-stationary and if it is rejected the alternative hypothesis of Δx_t being stationary is accepted. One problem with the above two tests is that these tests are sensitive to the underlying data generation process. The ADF test and the Phillips-Perron test overcome this.

In ADF test, the DF regression is augmented to allow for a higher order autoregressive model of the form:

$$(6) \qquad \Delta x_t = \beta x_{t-1} + \sum_{j=i}^{p} d_j \Delta x_{t-j} + v_t; \quad v_t \sim \text{i.i.d.}$$

The OLS estimate of β and its t-statistic is examined for the negative sign and significance. The power of the ADF test declines as more nuisance parameters are estimated.

The Phillips-Perron test is a non-parametric test and is robust to the underlying data generation process. Its main advantage over the ADF test is that it does not require the estimation of additional nuisance parameters. The particular Phillips-Perron test used in our study is the following:

$$(7) \qquad Z = T(\hat{\beta}_1 - 1) - \text{CORR}(u)$$

where $(\hat{\beta}_1)$ is estimated from

$$(8) \qquad x_t = \beta_0 + \beta_1 x_{t-1} + u_t$$

and CORR(u) is an additive correction term derived from the estimated residual ($\hat{u}$) as detailed in Phillips and Perron (1988, pp. 340-41).

The CRDW, DF, ADF, and Phillips-Perron tests reported in Table 1 confirm what was indicative of the correlograms — that is the variables are first difference stationary. Therefore, we conclude that the Y_t, P_t and M_t are integrated of order one. The inflation variable, as mentioned earlier, was excluded from the cointegration analysis because the first difference of $\ln P_t$ itself is the inflation rate.

Having established that each of the three variables is I(1), we can now test whether collectively they form a cointegrating set. For this purpose the cointegrating regression was run and the residual from this regression was tested for stationarity. The residuals were found to be I(0) and the relevant test statistics are reported below along with the cointegrating equation.

$$(9) \qquad \underset{(282)}{M_t = -6.051} + \underset{(2.63)}{0.284 P_t} + \underset{(6.27)}{1.841 Y_t}$$

Table 1

TESTS OF STATIONARITY

Variables	CRDW	DF	ADF	Z
$\Delta M2$	2.34	−6.18	−4.01	−81.75
ΔY	3.06	−13.66	−8.48	−52.72
ΔP	1.207	−3.61	−1.29	−48.29
C.V.(5%)[a]	0.39	−2.89	−2.79	−13.70

[a]Sources of critical values: CRDW's from Sargan and Bhargava (1988), DF and Z from Fuller (1976), and ADF from Dickey and Fuller (1981). The critical values are for a nominal sample size of 100 rather than our sample of 56. Use of critical values for a larger sample size biases the tests towards rejection of the null.

$$R^2 = .96 \quad \sigma = .083 \quad F(2,54) = 699.93 \quad DW = .708$$
$$DF = 3.40, \quad CRDW = .742 \quad ADF_4 = 3.07, \quad Z = 24.28$$

The test statistics reported above establish that M_t, P_t, and Y_t collectively form a cointegrating set. We can now use the lagged error from the above equation in our dynamic money demand equation, which is done in the next section.

V. Estimated Money Demand Relationship

The lagged residual series from the cointegrating regression is used as an error correcting variable in a general dynamic money demand equation. The error correcting term EC is $\hat{e}_{t-1}$ from equation (9), where $\hat{e}_t = (M_t + 6.051 - 0.284P_t - 1.841Y_t)$.

$$\begin{aligned} (10) \qquad \Delta m_t = {} & \underset{(3.88)}{0.029} + \underset{(2.94)}{0.384}\Delta m_{t-3} - \underset{(2.99)}{0.532}\Delta p_t - \underset{(2.57)}{0.398}\Delta p_{t-1} \\ & + \underset{(3.25)}{0.487}\Delta p_{t-3} - \underset{(2.43)}{0.301}\Delta p_{t-4} + \underset{(6.38)}{0.659}\Delta y_t - \underset{(2.59)}{0.157}EC \end{aligned}$$

$R^2 = .65 \quad \sigma = .026 \quad F(7,44) = 11.86, \quad DW = 1.92$

Stability: $\chi^2(8)/8 = 1.99$; Chow $(8,36) = 1.58$

LM-Autocorrelation: $F(4,40) = .64$; $\chi^2(14) = 3.12$

LM-Heteroscedasticity: $F(14,29) = .87$; $\chi^2(14) = 15.44$

LM-ARCH: $F(4,36) = .23$; $\chi^2(4) = 1.18$

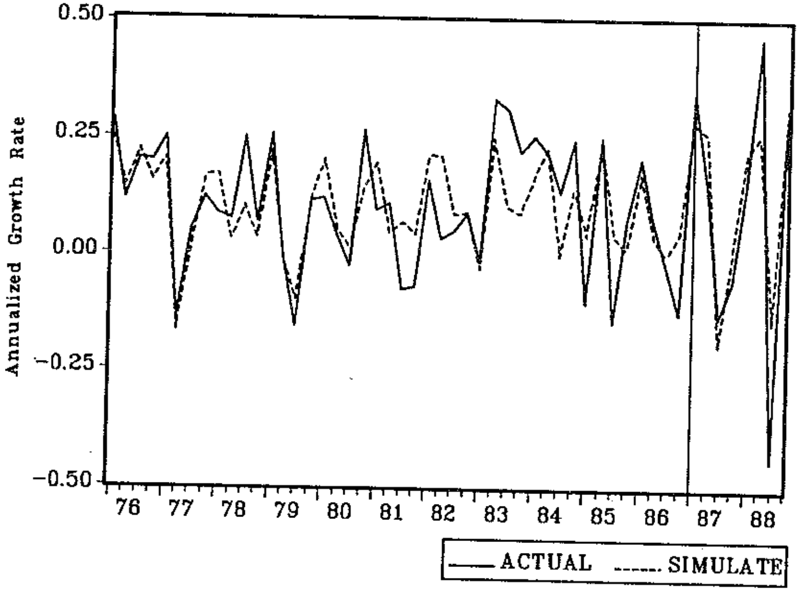
The dynamic money demand model reported above is a parsimonious specification of the money demand function. The error correction term has the expected sign and it is statistically significant. Since we are dealing with quarterly data, we started with up to four period lags for each variable to be included in the model. The general to specific simplification search was then employed and the above parsimonious version was reached. It is not uncommon to include up to eight lags in quarterly models if the sample size is very large. In our case this temptation was resisted primarily because of the sample size. In our general to specific simplification search all the lagged variables for ΔY_t(e.g. ΔY_{t-1}, ΔY_{t-2}, ΔY_{t-3}, ΔY_{t-4}) came out statistically insignificant, as did ΔM_{t-1}, ΔM_{t-2}, ΔM_{t-4}, and ΔP_{t-2}.

The equation passes various important statistical tests; the tests and test results are briefly described here. Two stability tests are reported here; Chow's predictive test for stability and Hendry's forecasting test. Chow test has an F-distribution with n_2 and (n_1-k-1) degrees of freedom, where n_1 is the number of observations in the estimation period, n_2 is the number of post sample periods, and k is the number of explanatory variables. In order to apply the Chow test to our model, the sample was broken into two sub-samples, one including data up to 1986IV and the other including the rest of the observations, i.e. 1987.I to 1988IV. The reason for choosing this specific point to split the sample is that it allows some time for the effects of liberalization measures, such as privatization of banks, to be felt by the entire economy. Earlier breaking points were tried and the resulting Chow-test statistic provided stronger evidence in favour of parameter stability. The relevant F-value from the F-table exceeds our calculated F-value and thus we can accept the null of parameter stability. The Hendry's forecasting (Hendry 1979) test is an asymptotically valid test for parameter stability, and is a good indicator of the equation's *ex ante* forecasting performance. The test was used to evaluate forecasting accuracy for eight periods beyond the estimation period. The F-form of the test is reported and the model passes this test, validating what was indicative of the Chow test.

The Lagrange Multiplier (LM) test for serial correlation in the residuals of lags up to four periods has been reported. This is a useful test when the equation contains lagged dependent variable. Both χ^2 and F-form of the test are reported above, although the F-form suggested by Harvey (1981) is the preferred diagnostic test. The computed F-value is lower than the F-value reported in the F-table at 1% level and thus we accept the null of no autocorrelation. The χ^2 form of the test reinforces the conclusion reached by using the F-form.

Figure 1

Actual and Simulated Growth Rate of Real M2



LM tests for heteroscedasticity and Autoregressive Conditional Heteroscedasticity (LM-ARCH) are reported in both F-form and χ^2–form and the null of no heteroscedasticity cannot be rejected based on these tests.

Based on the diagnostic tests, we can accept the above model as a well specified model. The long run income elasticity obtained in the cointegration regression is 1.84 which is some what lower than what is typically obtained for developing countries using a partial adjustment framework.[5] In fact a partial adjustment model was estimated using the same data set that was used for the above CI-ECM model; the results are reported in Appendix A. The long run elasticity obtained from the partial adjustment model is 2.5 which appears to be unreasonably high.[6]

5 Since Equation (9) is estimated in double-log form, the estimated coefficients are the elasticities.

6 The long-run income elasticity is obtained by dividing the coefficient of the income variable by one minus the coefficient of the lagged dependent variable. Thus the income elasticity of 2.5 is obtained by dividing 0.44 by (1–0.824).

Turning to our own estimated long-run elasticity of 1.84, we find that this value is much higher than unity — the value assumed in the conventional error correction models. However, in view of the much higher elasticity values obtained in other studies using partial adjustment framework, we find our estimated elasticity to be a more realistic estimate. A higher income elasticity is not unreasonable for developing countries. It is well known that a limited scope for financial asset substitution in developing countries lead to a higher income elasticity of demand for money as an asset. Another reason for a higher elasticity is the political and economic uncertainties, and the resulting shorter economic time horizon, that persuade many economic agents to demand more money than usual for precautionary purposes. Yet another reason is a gradual movement away from subsistence farming and bartering towards specialization and monetization, a process which is still taking place in remote rural areas.

Has the process of financial liberalization changed the relationship between the money demand variable and its determinants? To answer this question both Equation (9) and Equation (10) were estimated for a shorter sample period ending in 1986.IV (See Equations (9′) and (10′) in Appendix A.) The purpose was to compare the results obtained from the pre-financial-liberalization period with the results obtained from the full-sample estimates which includes more recent post-liberalization data. The post liberalization period is not long enough to enable us to estimate the equations just using data from that period alone. However, the aforementioned exercise shows some changes in the results, such as changes in the long-run income and price elasticities. As data points relating to the more recent periods are added to the estimation period, income elasticity goes down from 1.99 to 1.84 and the price elasticity increases from 0.24 to 0.28. The decline in income elasticity is expected as the financial sector develops, the elasticity should drop to what is found in economies with developed financial sector, that is close to unity. Increase in price elasticity is perhaps due to the increase in the proportion of economic activity and trade that is coming under the monetized sector. As the number of financial institutions increases and the population, specially in the rural areas get into the habit of using money, the response of money demand to changes in the price level may increase in the beginning.

VI. Policy Issues and Concluding Comments

The policy relevance of the present study is quite significant. As Bangladesh continues to implement financial liberalization measures that began in the mid-eighties with the chartering of private banks, the question of maintaining macroeconomic stability assumes greater importance. Financial liberalization is just one aspect of the broader structural changes the country has been undergoing since the mid-eighties. A large number of factors, such as an increasing degree of monetization, a liberalized trade policy, a competitive interest rates policy, devaluation of the currency, offering of foreign currency denominated bank deposits by the commercial banks, a fluctuating foreign exchange reserve, and a move towards privatization of the manufacturing and the services sector, are some of the important changes that have been taking place in the country during the last several years. Whether, these changes have created any significant macroeconomic instability is an important policy issue and the estimation and especially the stability tests of the money demand function presented in this paper indicate that nothing of that sort has yet happened. This result indicates that the implementation of liberalization measures have a better chance of succeeding in Bangladash; this should be reassuring to the policy makers.

It should however be mentioned here that the fact that the money demand function remained stable during the sample period is no guarnatee that it will remain stable in the face of a more intensive liberalization policy. The fact still remains that the stability issue has to be addressed on a regular basis as the country moves ahead with the above changes.

Turning now to the quantitative estimates of the demand for real balance and its systematic relationship to the price level (see equation (9)), we see important policy implications for the designing and conducting monetary policy. As price level increases demand for nominal balance increases more than proportionately; for a one percent increase in price level, demand for real balance increases by 0.28 percent and hence the nominal balance increases by 1.28 percent. Viewed from the money supply side, one can argue that other things remaining the same a 1.28% increase in money supply will result into a one percent increase in price level. Equally important implications can be derived from the error correction model (equation 10)) that shows that present and past inflation rates affect the rate of growth of real balance. These results can be used to design and implement anti-inflationary policies.

The interest rate variable which is a very important variable in the money demand function estimated for developed countries came out to be insignificant in the present study. Although this result is consistent with what has been found for many developing countries, including Bangladesh, still deserves some elaboration. Interest rates in Bangladesh showed very little variation until the late eighties and the conditions in the monetary sector was, and still to a large extent is, such that money demand has been largely determined by income and inflation rate. However, this is not to suggest that interest rates as determinants of money demand will not become important in future. In fact, as the monetary sector is liberalized interest rates will become more and more relevant in the money demand function, as it is the case in most developed and many developing countries. It is the presence of the interest rate variables in the money demand function, and hence in the monetary sector, that provides the connection and the transmission mechanism between the monetary and the real sector. Thus, it appears that, in order for the financial liberalization to have any major impact on the economy, the interest rate variable should come out as significant both in the monetary sector (i.e. in the money demand function) as well as in the real sector.

When the CI-ECM model is compared with the conventional money demand model, we find that the CI-ECM model performs better. This is expected. In the conventional money demand model, a lagged dependent variable is included as an explanatory variable to capture the whole of the complex dynamic mechanism linking money and prices. (Laidler, 1985, p. 161). The CI-ECM model builds the short-run dynamic adjustment process around the long-run relationship and uses information from the data generating process. Thus, for forecasting money demand which is the first step in designing monetary policy, the CI-ECM model should be preferred to models of other varieties.

Finally, it must be noted here that the financial liberalization affects mainly the financial institutions, and the rules and regulations that govern them, but the money demand function examines relationship between variables that are for the entire economy. Thus, the impact of liberalization obviously become diluted as it spreads from the financial institutions to the rest of the economy.

Apendix A

The Partial Adjustment Model

A partial adjustment model was estimated using the same data set for the sake of comparing the results. The results are reported below.

(11) $$m_t = -1.876 + 0.824 m_{t-1} + 0.44 y_t - 0.658 \Delta p_t$$

$R^2 = .99$; $\sigma = .0324$; $F(3, 48) = 2253$; $DW = 1.975$
Stability: $\chi^2(8)/8 = 3.73$; Chow$(8, 40) = 3.35$
LM-Autocorrelation: $F(4, 44) = .91$; $\chi^2 = 3.97$
LM-Heteroscedasticity: $F(6, 51) = 2.27$; $\chi^2 = 12.98$

The Short-Period Estimates

The equations (9) and (10) have been reestimated using data up to 1986.IV to compare with the full-sample estimates and the results are presented below.

(9′) $$M_t = -7.132 + \underset{(2.88)}{} \; \underset{(1.94)}{0.240P_t} + \underset{(5.88)}{1.989Y_t}$$

$R^2 = .95$ $\sigma = .088$ $F(2, 46) = 413.29$ $DW = .758$
$DF = 3.34$, $CRDW = .723$ $ADF_4 = 3.09$, $Z = 23.88$

(10′) $$\Delta m_t = \underset{(4.33)}{0.033} + \underset{(2.29)}{0.313\Delta m_{t-3}} - \underset{(3.28)}{0.635\Delta p_t} - \underset{(1.82)}{0.311\Delta p_{t-1}}$$

$$+ \underset{(2.03)}{0.337\Delta p_{t-3}} - \underset{(1.30)}{0.167\Delta p_{t-4}} + \underset{(4.30)}{0.548\Delta y_t} - \underset{(1.89)}{0.113EC}$$

$R^2 = .54$ $\sigma = .025$ $F(7, 36) = 6.02$, $DW = 1.52$
Stability: $\chi^2(8)/8 = 1.97$; Chow $(8, 28) = 1.63$

Appendix B
Sources of Data

All the data used in this study, except the quarterly GDP Series, were collected from two publications of the central bank of Bangladesh (Bangladesh Bank). The publications are *Bangladesh Bank Bulletin* and *Economic Trend*, the first is a quarterly publication and the second is a monthly publication. These data were compared with the data available in the *International Financial Statistics* published by the International Monetary Fund and the data set was found to be a consistent set.

Quarterly real GDP is not available from any published source. However, quarterly manufacturing production index is available. Using this production index, the annual manufacturing value added was allocated into four quarters.

For the agricultural sector, eleven major agricultural outputs were used to construct a quarterly prodcution index. These eleven outputs accounted for 82.6% of the total value added of the agricultural sector in 1985. The agricultural production index series was used to convert the annual agricultural value added into a quarterly series. The rest of the economy's income was converted into quarterly figures by using Lisman and Sandee (1964) method.

Quarterly GDP and M2 are seasonally adjusted and measured in crores (1 crore = 10 million) of Takas. GDP is expressed in constant (1972-73) taka. The consumer price index (P) has a value of 100.00 in 1975.

The entire data set is available from the author on request.

References

Ahmed, S., "Demand for Money in Bangladesh: Some Preliminary Evidence," *Bangladesh Development Studies,* 5, 2, 1977, 227-237.

Davidson, J., D.F. Hendry, S. Srba, and S. Yeo, "Econometric Modelling of the Aggregate Time Series Relations between Consumption and Income in the U.K.," *Economic Journal,* 88, 1978, 661-692.

Dickey, D.A. and W.A. Fuller, "The Likelihood Ratio Statistics for Autoregressive Time Series with a Unit Root," *Econometrica,* 49, 1981, 257-275.

Domowitz, I. and I. Elbadawi, "An Error Correction Approach to Money Demand, the Case of Sudan," *Journal of Development Economics,* 26, 1987, 257-275.

Dornbusch, R. and A. Reynoso, "Financial Factors in Economic Development," *American Economic Review,* Papers and Proceedings, May 1989, 1-30.

Engle, R.F. and C.W.J. Granger, "Cointegration and Error Correction: Representation, Estimation and Testing," *Econometrica,* 55, 1987, 251-276.

Fair, R.C., "International Evidence on the Demand for Money," *The Review of Economics and Statistics,"* 69, 1987, 473-480.

Friedman, M., "The Demand for Money: Some Theoretical and Empirical Results," *Journal of Political Economy,* 67, 4, 1959, 327-351.

Fry, M.J., "The Permanent Income Hypothesis in Underdeveloped Economies: Additional Evidence," *Journal of Development Economics,* 5, 4, 1978, 399-402.

———, *Money, Interest Rates and Banking in Economic Development,* Baltimore: Johns Hopkins Press, 1988.

Fuller, W.A., *Introduction to Statistical Times Series,* New York: Wiley, 1976.

Granger, C.W.J. and P. Newbold, "Spurious Regressions in Econometrics," *Journal of Econometrics,* 2, 1974, 111-120.

Hendry, D.F., A.R. Pagan, and J.D. Sargan, "Dynamic Specification," ch. 18 in Z. Griliches and M.D. Intriligator (eds.), *Handbook of Econometrics,* Amsterdam, North-Holland Publishing Co., 2, 1984, 1023-1100.

Hendry, D.F. and N.R. Ericsson, "An Econometric Analysis of U.K.

Money Demand in Monetary Trends in the United States and the United Kingdom by Milton Friedman and Anna J. Schwartz," *American Economic Review*, 81, 1, 1991, 8-38.

Hossain, M.A., "A Quarterly Short-run Money Demand Model for Bangladesh 1974:1-1985:4," *Bangladesh Development Studies*, 16, 3, 1988, 1-30.

Laidler, D.E.W. *The Demand for Money*, 3rd edn, New York: Harper & Row, 1985.

Lisman, J.H.C. and J. Sandee, "Derivation of Quarterly Figures from Annual Data," *Applied Statistics*, 13, 1964, 87-90.

McKinnon, R.I., *Money and Capital in Economic Development*, Washington, DC: The Brookings Institution, 1973.

Mangla, I., "An Annual Money Demand Function for Pakistan: Some Further Results," *Pakistan Development Review*, 18, 1, 1979, 494-499.

Murty, G. and S. Murty, "The Functional Form of the Demand for Money in Bangladesh," *Bangladesh Development Studies*, 6, 3, 1978, 443-460.

Nickell, S.J., "Error Correction, Partial Adjustment and All That: An Expository Note," *Oxford Bulletin of Economics and Statistics*, 47, 2, 1985, 119-129.

Phillips, P.C.B. and P. Perron, "Testing for a Unit Root in Time Series Regression," *Biometrica*, 75, 1988, 335-346.

Salmon, M., "Error Correction Mechanisms," *Economic Journal*, 92, 1982, 615-629.

Sargan, J.D., "Wages and Prices in the United Kingdom: A Study in Econometric Methodology." In *Econometric Analysis for National Economic Planning* (ed. P.E. Hart, G. Mills, and J.K. Whitaker) London: Buttersworth Scientific Publications, 1964.

——— and A. Bhargava, "Testing Residuals from Least Squares Regression for Being Generated by the Gaussian Random Walk," *Econometrica*, 51, 1983, 153-174.

Shaw, E., *Financial Deepening and Economic Development*, New York: Oxford University Press, 1973.

Stock, J.H., "Asymptotic Properties of Least Squares Estimators of Cointegrating Vectors," *Econometrica*, 55, 1987, 1035-1056.

Taslim, M., "Aid-elasticity of Demand for Money in Bangladesh," *Indian Economic Review*, 18, 2, 1983, 285-291.

———, "On Rate of Interest and Demand for Money in LDCs: The Case of Bangladesh," *Bangladesh Development Studies*, 12, 3, 1984, 19-36.

Trivedi, M., "Inflationary Expectations and Demand for Money in India," *Indian Economic Journal*, 28, 1, 1980, 62-76.