Cointegration, Error Correction and the Demand for Money in Bangladesh

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Abstract

The demand for money is a critical component in the formulation of and implementation of monetary policy. A well-defined and stable money demand function is a necessary condition for monetary policy to have predictable effect on the macroeconomic variables. This paper applies the advanced technique of cointegration to estimate the demand for money balances in the case of Bangladesh and evaluates stability of the equations. The analysis shows that there exist a long-run relationship between real money, real income, inflation, and interest rate that remains stable over time. The long-run properties emphasize that both inflation and interest rate have negative effects on real money demand, whereas real income has positive effects. The long-run relationship is finally embedded in a dynamic equilibrium correction model. The short-run dynamic parsimonious error correction models for both money demand functions were estimated and these were free from the conventional econometric problem faced by other studies. The stability of the equations and coefficients were highly encouraging.

Key Words: Money Demand, Unit Root Test, ECM.

I. Introduction:

The demand for money is a critical component in the formulation of and implementation of monetary policy. A well-defined and stable money demand function is a necessary condition for monetary policy to have predictable effect on the macroeconomic variables. Therefore the demand for money has been studied extensively both in the developed and developing countries. Among these studies Friedman (1959), Chow (1966), Goldfeld (1973), Heller and Khan (1979), Laidler (1985), and Friedman and Kuttner (1992), Bhattacharya (1995) and Obben (1998) are well cited. In developed countries demand for money is usually explained by income, inflation, and interest and yield rates on financial assets. The stable and predictable money demand functions in developed countries are in most cases supported by well managed dataset and institutional settings. The scenery is almost opposite in developing countries where datasets and institutional settings are poor. Demand for money has also received some attention in

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Bangladesh. A large number of studies dealt with the demand for money in the context of Bangladesh economy. These include Ahmed (1977), Murti and Murti (1979), Taslim (1984); Hossain (1992),and Islam (2000).Whilst Ahmed and Murti and Murti studied money demand function using the same annual data for 1959/60-1975/76 (excluding two years-1970/71 and 1971/72) thus comprising both the pre and post-liberation periods, others have considered the post-liberation period only.

Ahmed (1977) estimated the money demand function adopting a straightforward textbook function using real income and nominal interest rate. He found coefficients that were statistically significant at respectable levels and of the expected signs. He concluded that there existed a stable money demand function in Bangladesh. Murti and Murti (1978) focused on the appropriate functional form of money demand function using the generalized Box-Cox Transformations. By applying log-likelihood test it was found that the conventional linear form was appropriate version of the money demand function. The results found by them were similar to those of Ahmed's results as they adopted the whole data set of Ahmed and estimated the same variables and functions. Taslim (1984) introduced expected inflation rate as a measure of opportunity cost of holding money instead of using nominal interest rate that was significant. He criticized using of nominal interest rate as an explanatory variable as it was determined by institutional settings rather than market forces. Hossain (1992) studied the stability of money demand function in Bangladesh. He found real income, interest rate and the expected rate of inflation were major determinants of money demand in Bangladesh. Using both Chow and CUSUM and CUSUMS'Q test, and he found a stable broad money function while he identified the instability of narrow money demand function, which might have been caused by financial reforms in Bangladesh since the early 1980s. To the best of our knowledge the latest attempt in studying money demand is Islam (2000) who employed sophisticated econometric techniques, Johansen-Juselius Co-integration tests, in estimation of money demand function in Bangladesh using quarterly data set only for 1974Q1-1996Q4. He found a stable single co-integrating vector exists in the long-run equilibrium money demand relation ship in Bangladesh for both the narrow and broad money categories. However, the study has taken weighted average of nominal interest rates which were administratively set.

Although, the empirical studies in the context of Bangladesh provide conclusive evidence that real income and expected inflation rate are the determinants of money demand but they provide inconclusive evidence regarding the significance of interest rate in money demand determination. These studies covered a limited time period. However, the most important problem associated with the previous studies is that these regression analyses are based on the assumption that time series data that are being used are stationary. A time series is stationary when its mean, variance and auto-covariance's are time invariant. By now there is compelling evidence that many of macroeconomic time series are non-stationary as a result the results from standard Ordinary Least Squares (OLS) regression analysis might be 'spurious'[†] . If the data are non-stationary the OLS estimates are inconsistent and inefficient and a valid long-run relationship may not be found.

Although by now there exist well developed techniques of handling non-stationary time series data, by our best knowledge, no attempt has been made to study the money demand behavior using these methods and considering the changes in the financial system of Bangladesh. The significant changes in the financial market are the establishment of floating exchange rate, liberalization of interest rates, abolition of most of the restrictions on current accounts etc. In this backdrop, the present article examines the money demand behavior for Bangladesh using wider data period than previously used and by applying the co-integration techniques. Basic objective of this paper is to find out whether there exists a valid long-run relationship among monetary aggregates, income, interest rate and expected inflation rate. If such relationship exists it is possible to estimate the nature of this relationship and formulate a short-run error-correction model to capture the dynamics of short-run deviation from the long-run path. Engle-Granger two stage procedure of cointegration technique has been applied. We avoided Johansen-Juselius approach as it is unlikely to use this method when number of observation is low.

This paper is organized as follows: following this introduction, the theoretical framework is given in section II. Whilst section III presents the analysis of data issue and variable selection criteria, section IV deals with the time series properties of the variables. In section V, technique of cointegration has been employed to test the validity of long-run relationship and formulate the

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[†] The regression result is spurious when non-stationary variables produce highly significant non-sense correlation among variables although in reality there may not any such relationship.

short-run error correction models and stability of the regression and parameters have been presented. Finally, section VI deals with concluding remarks.

II. The Demand for Money: Theory and Specification

The consensus account of the theory of the demand for money has changed little in the last forty years (Cooley & LeRoy, 1981). Keynes diagnosed three possible motives for holding money: the *transaction motive*, the *precautionary motive* and the *speculative motive*. To the extent that volume of transactions rises with income, both transactions and precautionary demand for real balances rise with an increase in income. The speculative demand for real balances reduces with the rise in the opportunity costs of holding money. The variables normally included in the money demand function include a scale variable such as real GDP to capture the transactions and precautionary motives for holding money, and an interest rate to capture the speculative motive.

With respect to opportunity cost variable, interest rate is a perfect opportunity cost variable for a well-developed and organized financial market. But in Bangladesh, there are some arguments that the use nominal interest rate may be problematic (see Taslim, 1984) at least on two grounds. Firstly, interest rates are determined institutionally instead of competition and remain unchanged for long time for the absence of well-developed and organized capital markets. Secondly, the interest rate used in various empirical studies is the weighted average of rates on time deposits; the prime component of M2.For M2, interest rate represents the return instead of reflecting the opportunity cost of holding alternative assets. In countries, like Bangladesh non-financial assets are used as money substitutes. When inflation is expected, money becomes less attractive, making non-financial assets attractive. So expected inflation rate is included as a proxy for the opportunity cost of holding money. We also include nominal interest rate as proxy for opportunity cost of holding money as the financial markets are developing with increased deregulation and financial liberalization in the country since 1980s.

Based on the above discussion, the general long-run function of the demand for real money balances in Bangladesh can be specified as follows:

$$m_t^d = f(RGDP_t, I_t, P_t) \ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \ (1)$$

Where m_t^d = the demand for real money balances at time t, $RGDP_t$= Real Gross Domestic Product at time t, I_t= Nominal interest rate at time t, P_t= Consumer price index at time t.

We use double-log form of money demand function so that we can measure income, interest and price elasticity of money directly from the coefficient of income variable, interest rate variable and CPI variable. Equation (1) can be written-

$$Lm_t^d = \alpha + \beta LRGDP_t + \delta LI_t + \phi LP_t \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (2)$$

Where L stands for natural log

This is the long run specification of real money balances. Our priori sign expectation on the basis of theoretical considerations for each variable are: the real income variable (RGDP) is expected to have a positive effect on money demand. To the extent that, nominal interest rate and CPI reflects the opportunity cost of holding money as a substitute for holding financial and non-financial assets, the coefficients are expected to have negative sign.

III. Data Issues and Variable Selection

Annual data for narrow money balances, broad money balances, GDP, nominal interest rate and inflation rate during 1980-2006 are used in the investigation. All of narrow money balances, broad money balances and GDP were obtained at current prices in crore taka. The GDP deflator was used to convert them into real terms. The data needed for this study were compiled from various issues of Economic Trends of Bangladesh Bank and World Economic Outlook-2006. The all data sets used in this article are available in the Appendix. Furthermore, all of the series were transformed into log form. Log transformation can reduce the problem of heteroskedasticity because it compresses the scale in which the variables are measured, thereby reducing a tenfold difference between two values to a twofold difference (Gujarati, 1995).

Some researchers prefer the use of permanent income to current income. But in view of Adekunle's finding that income and price expectations are static in Least Develop Countries (LDCs) (Adekunle, 1968). So it might not be inappropriate that the demand for real balances should be related to current income and current inflation rate, so we use nominal GDP measure as a proxy for current income and current inflation rate, as a proxy for expected inflation rate.

We use CPI to find real variables for adjustment and to measure the inflation as the inflation measure should also include changes in the prices of imported goods and excludes prices of the exported goods. Weighted average of different interest rates of scheduled banks on deposits is used as interest rate variable in our country.

IV. Time Series properties of the variables:

The model in equation (2) postulates a static long-run relationship. However, as mentioned earlier, if the variables in the models are non-stationary, the OLS estimates may lead to spurious regression and the standard t and F tests become misleading. Figure 1 gives us a first hand impression that the variables except rate of interest may be non-stationary on their levels. The problem is that the non-stationary series can be generated either by a Difference Stationary Process (DSP) or by a Trend Stationary Process (TSP). The TSP series contains a deterministic trend and for stationary we need to detrend the series. On the other, to make a DSP series stationary needs to be differenced until it become stationary. Indeed, one can employ formal tests to differ between TSP and DSP. These tests are known as the Unit Root tests.

Figure 1: Standardized values of natural log of narrow money, broad money, GDP, inflation and interest rate
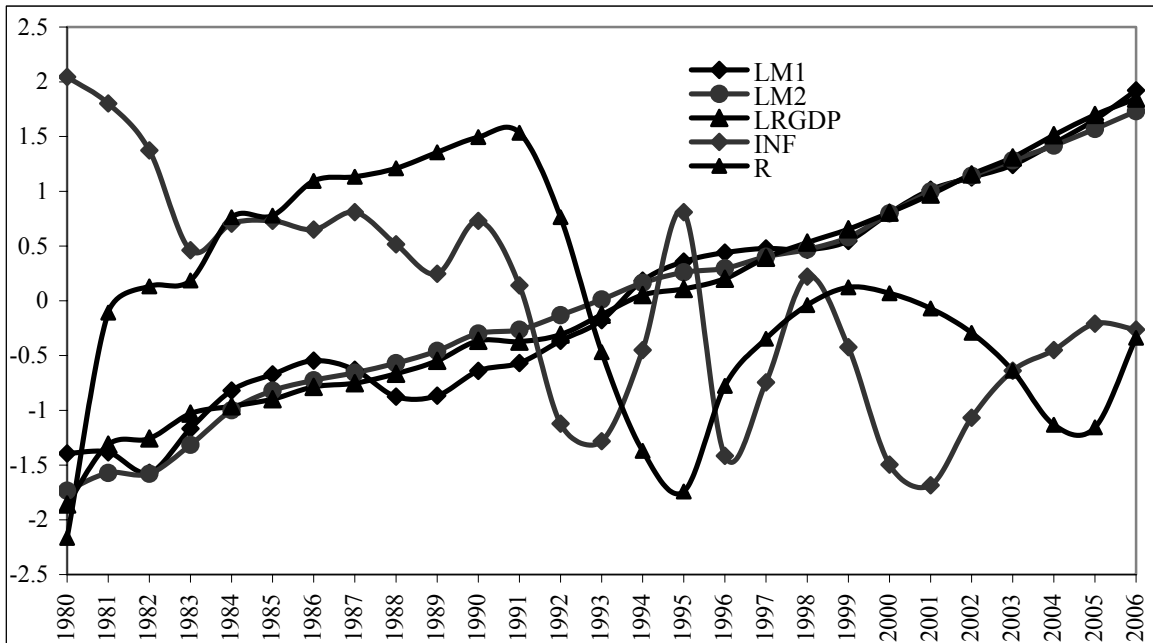
Source: Reproduced from Economic Trend, Bangladesh Bank, Various Issues.

Testing the variables for Unit Root

First, the Dickey-Fuller (DF) and the Augmented Dickey-Fuller (ADF) tests, the popular tests for unit roots, have been performed for variables based on the following two equations:

$$\Delta Y_t = \alpha + (\psi - 1)Y_{t-1} + \eta T + e_t \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots(3)$$

$$\Delta Y_t = \alpha + (\psi - 1)Y_{t-1} + \eta T + \gamma \Delta Y_{t-1} + e_t \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots(4)$$

The DF test for unit root is based on equation (3) with the null hypothesis of (Ψ-1)=0 (i.e. the Y_t is non-stationary) against the alternative of (Ψ-1)<0 (i.e. Y_t is stationary).The t-test on the estimated coefficient of Y_{t-1} provides the DF test for the presence of a unit root. The Augmented Dickey-Fuller (ADF) is based on the equation (4) which is a modification of the DF test and involves augmentation of equation (3) by lagged values of dependant variables. Since the data are annual in nature, following the usual practice of unit root test we have used only one lag in equation. This is done to ensure that the error process in the estimating equation is residually uncorrelated. The t-ratio on (Ψ-1) provides the ADF statistics.

Now-a-days, Phillips-Perron (PP) test for Unit root has widely been used in light of the fact that often economic time series exhibit heteroscedasticity and non-normality in raw data, which the DF and ADF tests do not consider. The PP test is, in fact, an adjusted t-ratio on (Ψ-1) in equation (4). There seems to be a consensus in the cointegration literature that the ADF test is preferable to DF test and the PP test is preferable to ADF. In Table 1 we report the DF, ADF and PP test results to see the order of integration of the related variables. A time series is integrated of order d [usually denoted as ~I(d)] with d is the number of times the series needs to be differenced in order to become stationary. The econometric softwares Eviews3.0, STATA 9 and Microfit 4.0 version were used for the respective tests.

Table 1: DF, ADF and PP Tests for Unit Root

Variables	DF	ADF	PP
LM1	-1.707	-2.709	-2.083
LM2	-1.852	-2.402	-2.052
LRGDP	-2.147	-0.113	-2.476
INF	-2.690	-2.717	-2.621
R	-2.529	-2.132	-2.726
ΔLM1	-3.395*	-4.098*	-3.357*
ΔLM2	-3.863*	-3.997*	-3.838*
ΔLRGDP	-8.958*	-2.927*	-8.467*
ΔINF	-5.360*	-6.018*	-5.678*
ΔR	-4.319*	-3.488*	-4.248*

Note: 1. Δ implies first difference of the respective variables. 2. * implies significant at 5 percent level.

3. The DF and ADF tests for LM1, LM2, and LRGDP are based on the inclusion of an intercept as well as a linear time trend However, since no clear trend was found for the INF, R, ΔLM1, ΔLM2, ΔLRGDP, ΔINF and ΔR in figure 1, 2 and 3 , the DF and ADF tests are performed without the trend term.

In Table 1 the absolute values of ADF statistics on the level of variables, except LM2, smaller than that of the critical values implying that these variables are considered non-stationary. When first differences of these variables are considered, the test statistics on ΔLM1, ΔLM2, ΔLRGDP and ΔINF exceed the critical values. Thus, LM1, LRGDP and LINF are integrated of order one. In the case of LM2, ADF statistics exceed the critical values implying that the variable is stationary in its level. On the other hand, in case of ΔR, ADF statistics fails to exceed critical values. In general, as most unit-root tests are known to have low power when the sample size is small, some subjective judgment is made to interpret the results. This requires a visual inspection of the data set and the autocorrelation function for each of the time series. For small data set, it seems to be wiser to examine Ljung-Box statistics and the correlogram of the variables. The autocorrelation function of each of these series on their levels dies out slowly; implying that these series are non-stationary. The autocorrelation function is random and dies out speedily for each of the variables in their first difference form. The Ljung-Box statistics and correlograms confirm that all of our variables are non-stationary in their levels but stationary in the first difference forms. Thus the main findings of the above discussion and of Figure (1) and (2) is that all the variables of the model are I(1) on their levels and are I(0) on their first difference form.

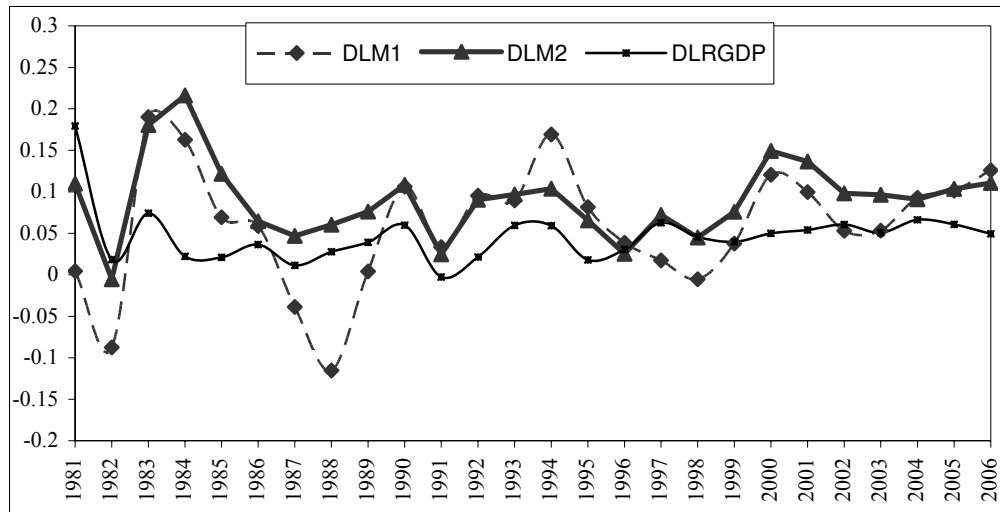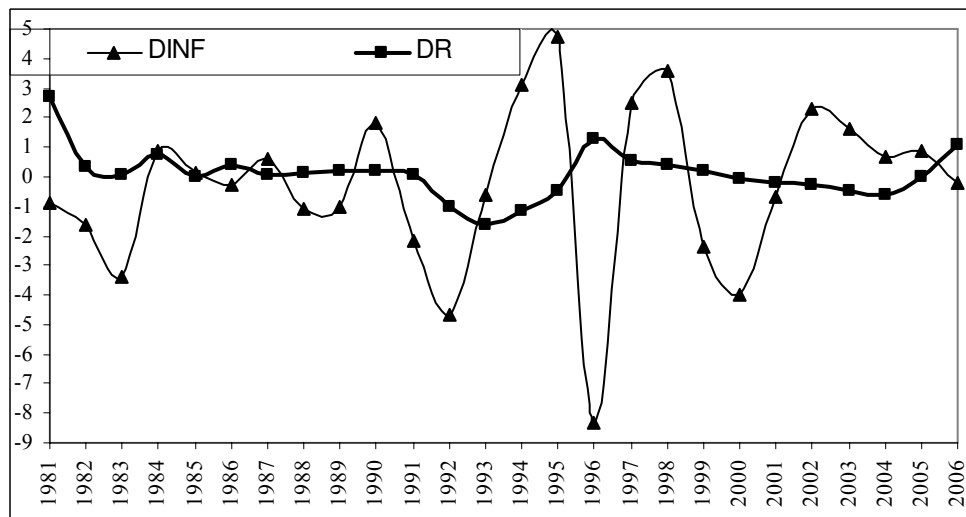**Figure 2: First Difference of natural log of narrow money, broad money, and GDP.**

Figure 3: First Difference of inflation and interest rate.

Source: Reproduced from Economic Trend, Bangladesh Bank, Various Issues.

V. Estimating the Money Demand Function

5.1. Test for Co-integration: The Engle-Granger Procedure

The finding that many macro time series may contain a unit root has spurred the development of the theory of non-stationary time series analysis. Engle and Granger (1987) pointed out that a linear combination of two or more non-stationary series may be stationary. If such a stationary linear combination exists, the non-stationary time series are said to be cointegrated. The stationary linear combination is called the cointegrating equation and usually interpreted as a

long-run equilibrium relationship among the variables. Cointegartion is shown to be an exception to the general rule. The general rule is that suppose, Y_t and X_t are both I(1) then any linear combination of the two series will yield a series which is also I(1). Thus, if we poist the long-run relationship as:

$$Y_t = \tau + \mu X_t + e_t$$

The linear combination given by: $e_t = Y_t - \tau - \mu X_t$ will also be I(1).The exception to this general rule is when the linear combination of two or more series is integrated of lower order. In this case the common stochastic trend will cancel out providing a series which is stationary. Under such circumstances the OLS involving the variables on their levels will produce a valid long-run relationship. Since pre-testing suggests all variables in our model are to be I(1), we compute what is known as the first step of Engle–Granger procedure:

LM1 = -4.744+1.330 LRGDP -0.0032 INF-0.0418 R ………………………. (5)

LM2 = -8.375+ 1.950 LRGDP -0.014 INF -0.0014 R …………………….. (6)

These estimates in equation (5) and (6) are 'super consistent'[‡] and estimated standard errors are not reported given that they do not provide the basis for valid inferences. To check whether there valid long-run/cointegrating relationship among the variables, we need to test the stationarity of residuals (i.e. linear combination of variables) employing the ADF test, which is given in (7). The ADF test statistics is the t-ratio on the term .The critical values for the test is given by McKinnon (1991).

$\Delta U_t = \rho U_{t-1} + \gamma \Delta U_{t-1} + v_t$ ……………………………………………………… (7)

Where Δ is the first difference operator, U_t is the residual from cointegrating regression and v_t is the white noise.

$\Delta U_{1,t} = -0.73\ U_{1,t-1} + 0.75\ \Delta U_{1,t-1}$ .... (8)
t-ratio (-5.90)   (5.66)

$\Delta U_{2,t} = -0.434\ U_{2,t-1} + 0.323 \Delta U_{2,t-1}$ ………………………………………….. (9)
t-ratio (-5.46)   (2.26)

[‡] It has been shown that the application of OLS to I(1) variables yields super consistent estimates that is, they converge on their true values at a faster rate than it would be the case if all stationary variables are used in regression

Equation (8) and (9) give the estimate of equation (7) for narrow money and broad money demand respectively. It can be seen that the t-ratios of our interest are -4.98 and -5.46 against the McKinnon critical value of -4.56. Thus residuals from both money demand functions pass the cointegration test implying the stationarity of the residuals. However, the visual inspection of the residual plots (Figure 3) also revealed that they were unlikely to be non-stationary.

Figure 4: Residuals Plot
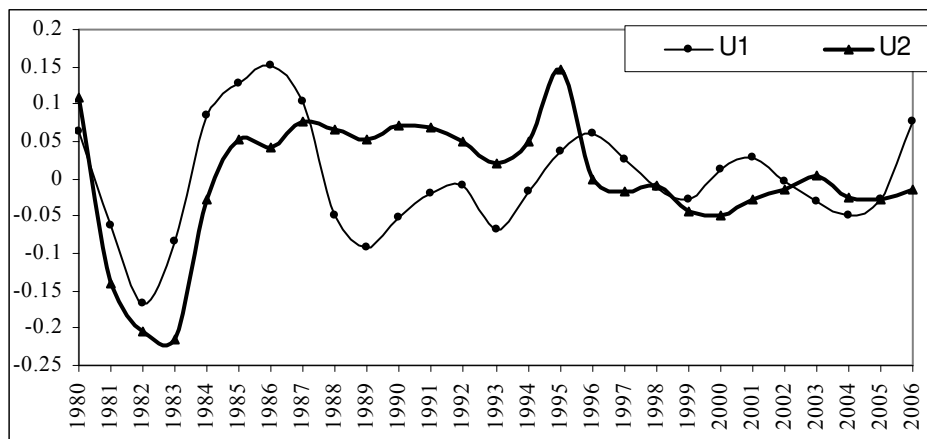
As low power of the ADF test is unavoidable fact, which was also recognised by Engle and Granger (1987). The low power of the ADF test arises because it often fails to reject the null hypothesis of non-cointegration even when it is false (Type II error).apart from this low power, the test for cointegration is often problematic in small sample. Thus, Hall (1986) suggests that in case of small sample the inspection of autocorrelation function and correlogram should be an important tool. Thus before final conclusion about the cointegration, it was decided to inspect the correlogram of residuals obtained from equations (5) and (6). The sample autocorrelation coefficients along with 95 percent confidence interval (two dotted parallel bars) derived from both functions have been inspected and it was apparent that almost all coefficients lie within the error bars suggesting stationarity. After all these evidence, probably it would not be inappropriate to conclude that the residuals from the cointegration regression in (5) and (6) appear to be stationary which in tern , suggesting valid long-run relationship among the variables.

5.2. Short-Run Dynamics in Engle-Granger Procedure

Since evidence suggests cointegration we proceed to estimate the short run Error-Correction Model (ECM). Now an important question is raised in the dynamic modeling necessary to obtain the appropriate ECM is the approach should be adopted. The choice is usually laid out as one between a 'specific-to-general' and a 'general-to-specific' approach. Here Hendry's (1979, 1995) 'general-to-specific' approach has been followed, which involves inefficient estimation in the early stages but allows the econometricians to test-down to a more parsimonious data coherent model. This approach is viewed as less susceptible to the adoption of an incorrect model.

Using the notion of general to specific modeling firstly two lags of all variables and one lags of the residuals from the cointegrating regressions were included. As our sample size is small and data frequency is annual in nature, this was a very general model to start with. Subsequently, the insignificant variables were dropped based on the Akaike Information Criterion (AIC) in order to get the parsimonious model. It needs to be mentioned here that in ECM it is possible that first-difference of a variable as well as its own different order of lags are significant. Under such circumstances, it is necessary to add these coefficients to obtain the total short run effect emanating from that particular variable. Table 2 shows the final parsimonious model which is generated after testing down a general model.

Table 2: Regression Results

Dependant variable	ΔLM1	ΔLM2
Intercept	-0.031(-1.16)	.072* (5.44)
ΔLRGDP	1.485*(2.94)	1.49*** (1.84)
ΔINF	-0.005(-1.55)	-0.0037** (-2.12)
ΔR		-.015 **(-2.18)
ΔR_{t-1}	-0.021***(-1.81)	
$\Delta LM1_{t-1}$	0.50*(3.60)	
U1_1	-0.51*(-4.07)	
U2_1		-0.44*(-4.02)
Adjusted R^2	0.69	0.61
Overall significance of the model	F (5, 19)= 11.50*	F (5, 16)= 9.10*
Akaike Info. Criterion	41.715	52.083
Durbin's h-statistic	0.422	
Serial Correlation	F (1, 18)= 0.0095	F (1, 15)= 0.317
Functional Form	F (1, 18)= 0.068	F (1, 15)= 0.0416
Normality	$\chi^2(2)$= 0.745	$\chi^2(2)$= 0.204
Heteroscedasticity	F (1, 23)= 0.314	F (1, 20)= 0.202
Sample size	25	22

Notes: 1. The figures in parentheses beside coefficients are t-ratios.2. *, **, *** are
indicating the significance of the coefficients at 1%, 5% & 10% level respectively.

5.3. The Empirical Results

Error correction modeling approach has been applied by using first-difference forms of the variables that are confirmed as stationary by different tests. Stationarity of all variables included in the regressions has confirmed the validity of the inferences by means of standard t and F tests. The estimated results of ECM of real narrow and broad money balances are reported in table 2. The coefficients of the short-run money demand presented in table 2 are generally in line with economic theory and reasonably satisfactory. Real GDP is positively and significantly associated with both narrow and broad money demand functions. The short run income elasticity of the demand for narrow money is 1.48 and the short run income elasticity of the demand for broad money 1.49.

Price increases precipitate an initial increase of the demand of nominal balances, but a subsequent decrease associated with the need to economize money balances to avoid the inflation tax which is the reflection of a higher opportunity cost of holding money. The coefficients of the rate of inflation bear expected sign. The short-run coefficient of inflation has been found insignificant in narrow money demand function and significant in broad money demand function at conventional 5 percent level of significance.

The sign of short-run coefficients of interest rate has been found expectedly significant in both narrow money demand equation and broad money demand equation. The short-run interest elasticity of money demand is 0.021 in narrow money demand function and is 0.015 in broad money demand function. Nominal interest rate paid on interest bearing time deposits, which are included in the definition of M2 money. Because of this, the measured nominal interest rate is not a good proxy to reflect the opportunity cost of holding the M2 money and this has been reflected in the short-run interest elasticity of broad money demand which is lower than that of narrow money demand function.

The coefficient of the lagged dependant variable is significant in the narrow money demand function while it has been found insignificant and dropped from the error correction model for broad money demand function. The coefficient is 0.50 in narrow money demand function which indicates that, in the short-run, 1 percent increase in narrow money base generates 0.5 percent increase in the narrow money base in the next period.

Both money demand functions have a negative and highly significant error term confirming the existence of long-run equilibrium relationship. As the value of coefficients of error correction term are less than unity and negative, the short run money demand functions are stable i.e., any deviation of short run money demand from its long run equilibrium path would be corrected within a reasonable time and the long run equilibrium would be restored. The size on this coefficient implies that adjustment to disequilibria via the equilibrium correction term is fast. The coefficient of error correction term is -0.51 in narrow money demand function which implies that any deviation from the long-run equilibrium relationship will be faded away by 50 percent within a year. While disequilibrium will be disappeared by 44 percent within a year in broad money demand function, as the coefficient of error correction term is -0.44.

The equations yield a moderate value for the adjusted R^2. The adjusted R^2 value of 0.69 in narrow money demand function implies that 69 percent of variations in narrow money is explained by the explanatory variables and error correction term. While the adjusted R^2 value of 0.61 in broad money demand function implies that 61 percent of variations in broad money is explained by the explanatory variables and error correction term. After using stationary data, the R^2 value is less than 0.7 in both money demand function which indicates that there may be other factors that are important in determining the money demand in Bangladesh which should be studied.
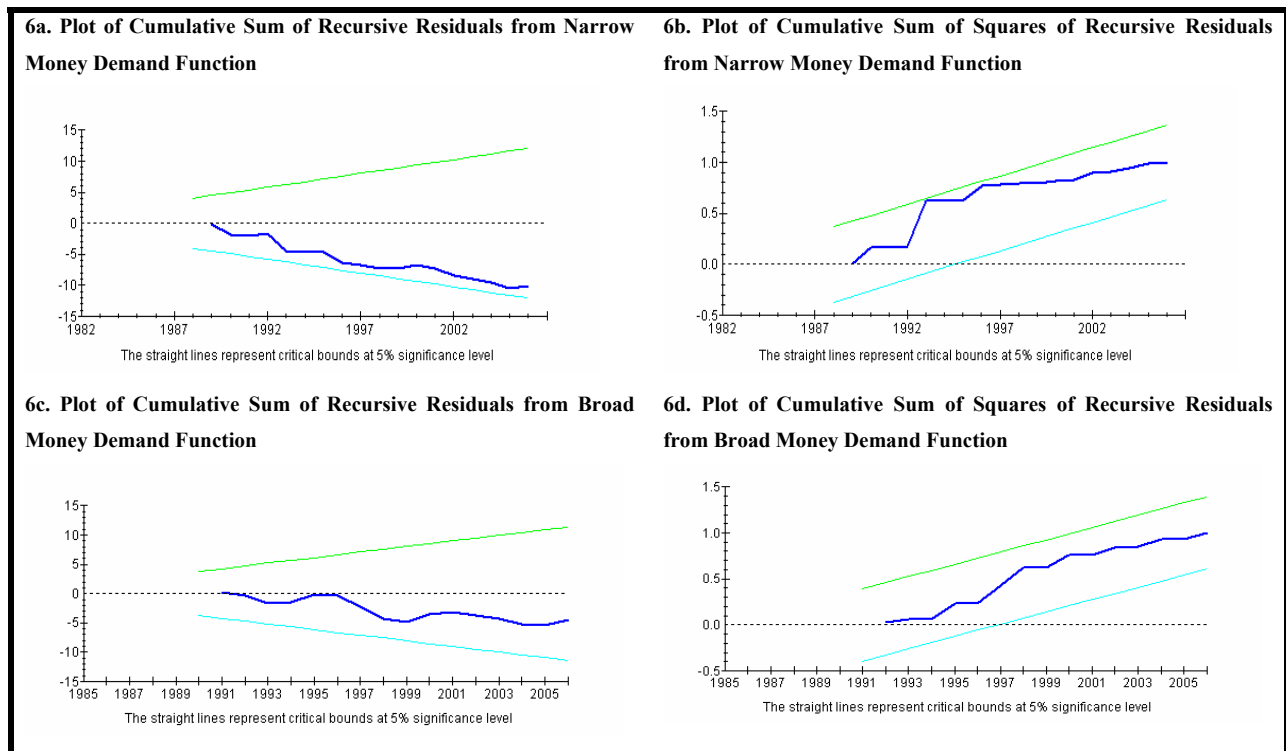
The ρ value of obtaining an F value in both money demand functions are almost zero; leading to the rejection of the null hypothesis that together RGDP, interest rate, inflation rate and the lagged error correction term have no effect on money demand. The Durbin's h (Dh) statistic for narrow money demand function is 0.422. The null hypothesis of no autocorrelation may not be rejected at any of 1% level, 5 % level and 10 % level in both models. The F statistic based on Ramsey's RESET test is highly insignificant, that reject the null hypothesis of model misspecification; indicating that the models are correctly specified. Normality test based on a test of skewness and kurtosis of residuals shows that residuals are normally distributed in both demand functions. Diagnostic test on heteroscedasticity based on the regression of squared residuals on squared fitted values for both models show no evidence of the presence of heteroscedasticity. As both the

'F' value and 't' ratios are significant, we can conclude that there is no multicollinearity among the regressors.

Stability of the Money Demand Functions

The coefficients of the error correction term in both models have the correct positive sign and the absolute value being less than unity indicates stability of the money demand functions. However the plotted cumulative sum of residuals (CUSUM) and cumulative sum of squared residuals (CUSUMSQ) for the narrow money demand function was found closed the defined critical line at the 5% level of significance during the eighties(Figure 6). That might have been caused by financial reforms in Bangladesh since the early 1980s. In the case of broad money demand function, the plotted CUSUM residuals and the CUSUMSQ residuals has remained within the critical lines defined at the 5% level. The plot of CUSUM and CUSUMSQ of both narrow money demand equation and broad money demand equation leads us to infer that the broad money demand function has been more stable than the narrow money demand function.

Figure 6: Stability Test of the Regressions by CUSUM and CUSUMSQ Test

6a. Plot of Cumulative Sum of Recursive Residuals from Narrow Money Demand Function

6b. Plot of Cumulative Sum of Squares of Recursive Residuals from Narrow Money Demand Function

6c. Plot of Cumulative Sum of Recursive Residuals from Broad Money Demand Function

6d. Plot of Cumulative Sum of Squares of Recursive Residuals from Broad Money Demand Function

Parameter Stability

Parameter steadiness is a critical issue for money demand functions. In particular to be able to interpret the estimated equation as a money demand equation, it is necessary to assure that the parameters are stable over the estimation period. The stability of the coefficients can be judged through the recursive estimation of the coefficients. The estimates might vary initially (as the sample size remains small) but should eventually settle down to a constant value, as long as the model is stable. A sudden change in the estimates is evidence of a structural break and should be obvious from the graph. Figure 7 shows the recursively estimated coefficients of all the variables in the model plus/minus twice their recursively estimated standard errors for narrow money demand function as well as broad money demand function. Coefficients vary only slightly and become more accurate with time as more information is accumulated and the standard errors decrease. Only the coefficient of differenced log of real GDP in broad money demand function is exhibiting a slight downward tendency, even though the coefficient remains within its standard error band. The estimated money demand equations seem therefore to satisfy the necessary stability requirements.

VI. Concluding Remarks:

The main objective of this paper has been to estimate the money demand function for Bangladesh for the period 1980-2006 by using Engle-Granger Two-Step Procedure. As a first step, long-run cointegrating relationships between money demand and its determinants have been estimated. The significant long-run relationships were found between real money demand, real GDP, inflation rate and interest rate. The short-run dynamic parsimonious error correction models for both money demand functions were estimated and these were free from the conventional econometric problem faced by other studies. The stability of the equations and coefficients were highly encouraging.

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