MONEY AND PRICES IN BANGLADESH: SOME PRELIMINARY ANALYSIS

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ABSTRACT

This paper conducts an investigation of the long run relationship and short run dynamics between money supply and aggregate prices level in Bangladesh employing the unit root tests and the Engle-Granger co-integration test and error correction methodologies. The co-integration tests suggest that there is a long run equilibrium relationship money supply and prices, with the relationship being stronger for broad money (M2) than its narrower counterpart M1 money. The short-run dynamic analysis shows similar strong and stable relationship between M2 money and prices but not with M1 money. Further, the modified Granger causality tests within the error-correction framework show that there is unidirectional causality flowing form M2 money to prices, but short-run independence between M1 money and prices.

INTRODUCTION

Inflation is a major macroeconomic issue for every country in the world and is of serious concern for general public, businesses, academics and researchers, development partners, international organizations, and policy makers. Given that controlling inflation (keeping inflation low and stable) is a major macroeconomic policy objective of any country, understanding inflation and predicting its future course and taking appropriate steps ahead of time to control are major challenges for policy makers in both rich and poor countries including Bangladesh. Controlling inflation is important not only to preserve the internal (purchasing power) and external (currency depreciation) value of money, but also because high inflation has many adverse effects on society including hidden redistribution of income and wealth, uncertainty in decision making, output fluctuations, export competitiveness, and even political and social instability in a high inflation country, among others. Further, once a country enters into a phase of persistent high inflation and falls into a high inflation trap (Hooker, 2002), it becomes very difficult and also costly on society to bring down the inflation to a long-run sustainable level.

The literature on this topic at both theoretical and empirical levels, particularly with reference to the relationship between money supply and inflation is enormous, and often filled with heated debates and controversies. On the theoretical front, the classical quantity theory of money in terms of the well-known Fisher's (1911) equation of exchange as posits not only a unidirectional causal linkage flowing from money supply to prices, but also the relationship is hypothesized to be proportional under assumed conditions of full employment and constant velocity of money circulation (money changing hands over a given period of time). The modern quantity theory of money a-la Milton Friedman (1956) retains the causality aspect of the relationship of the classical formulation with slight modification in the nature of the relationship by hypothesizing a strong and stable, if not proportional, relationship between money supply and inflation. In this view, money matters strongly and inflation is viewed essentially and purely as a monetary phenomenon.

Bangladesh is a densely populated poor developing country in South Asia. The relationship money and inflation is of utmost importance for the country's population in general and of policy makers in particular. While some other studies have been conducted on this topic in the context of Bangladesh, but sophisticated research with long-time series data using advanced econometric techniques has been lacking. This paper proposes to empirically examine the relationship between money supply and inflation for this country focusing on the empirically testing the monetarist hypothesis in terms of money supply's role in explaining historical inflation in Bangladesh. The paper will conduct empirical tests to examine the existence of any long-run co-integration relationship along with its corresponding short-run dynamics using the error-correction method based on the existence of any co-integrated relationship. The paper will use for the first time the most elaborate quarterly time series data hitherto undertaken spanning from the early years of the country's independence to the present and utilizing more advanced econometric techniques. The quarterly time-series data would cover the period from 1972 to 2011 covering the entire monetary history of the country and would be collected from various sources such as Economic Trends of the Bangladesh Bank and International Financial Statistics of the International Monetary Fund.

ENGLE-GRANGER COINTEGRATION METHODOLOGY

The long run relationship between oil price and general price level can be described by the following equation:

$$P_t = \alpha_0 + \alpha_1 M_{it} + u_t \qquad (1)$$

Following Engle-Granger (1987) methodology, the short-term dynamics of the relationship between them can be represented by the following dynamic short-run dynamic error correction model (ECM).

$$\Delta P_t = \beta_0 + \sum \beta_{1s} \Delta M_{it-s} + \sum \beta_{2s} \Delta P_{t-s} + \beta_3 U_{t-1} + v_t \qquad (2)$$

where P_t is the quarterly Consumer Price Index (CPI); M_{it} represents money supply (i= M1I or i=M2I both in index form), u and v are random disturbance terms and Δ is the first difference operator.

Equation (2) is the dynamic error correction model that captures the short run response of the change in the inflation rate to the change in money supply. The coefficients of ΔM_i and ΔP represent the short run responses to the change in money supply and lagged changes in CPI over different lags, respectively. In the Engle-Granger (1987) two-step approach, the order of integration for each variable in Equation (1) is determined before conducting the co-integration test. In the first step of the Engle-Granger approach, the long run equilibrium relationship between money supply and prices as specified by Equation (1) is estimated using ordinary least squares method. In the second step, the short run relationship is estimated with v_t replaced by the one-period lagged residuals from estimated Equation (1), i.e. estimated u_{t-1}. All equations were estimated using natural logarithmic transformations of original variables: $p = \log (P_t = \log \text{CPI})$ and $m_{it} = \log (M_{it})$ and M_{it} with respect to both M1 and M2 are converted into index form with the same base as CPI, thus all variables being index numbers with 1985=100 as the base period.

We have conducted a battery of unit root tests to determine non-stationarity of consumer price index and two money supply variables. Although the ADF test (Dickey and Fuller, 1979) is more commonly used as unit root tests, this test assumes that errors are statistically independent and have a constant variance (Enders, 1995). Phillips and Perron (1988) developed a generalization of the Dickey-Fuller procedure that does not require the restrictive assumptions of ADF tests. PP tests can be applied even in situations where the disturbance is weakly dependent and heterogeneously distributed. We have also reported the results from the moiré powerful KPSS tests. The justification of KPSS test is found in Kwiatkowski et al. (1992). Kwiatkowski et al. (1992) argues that traditional unit root tests (ADF and PP tests) fail to reject a unit root because they have low power against relevant alternatives and propose instead a more powerful test known as the KPSS test, which tests the null hypothesis of stationarity against the alternative of a unit root.

PRELIMINARY EMPIRICAL RESULTS

The preliminary empirical results are presented below under several sub-headings as follows. The figures and tables referred to in this section are placed at the end of the paper immediately before the reference section.

Testing for Non-Stationarity in the Variables

Figure 1 shows the quarterly time trend of the three level variables, CPI, M1I, and M2I from 1972.Q2 to 2011.Q1. The three lines show that there is some trending (co-integrating) relationship between M1I and CPI on the one hand and the M2I and CPI on the other hand as the two bi-variate series seem to move together with a common trend and all three variables seem to be non-stationary as individual series. This non-stationarity needs to be confirmed by formal unit root tests as discussed below.

As outlined earlier, all three unit root tests have been conducted with intercept (C) and trend (T) terms as appropriate along with the associated optimal lag structure. The results are reported in Table 1. The unit root test results is somewhat mixed in terms of alternative unit root tests. The ADF test shows CPI to be stationary but M1I and M2I are non-stationary. The Philips-Perron test shows that CPI and M1I are stationary while M2I is non-stationary. But the most powerful of the three tests, the KPSS test shows that all three relevant variables, CPI, M1I, and M2I, are non-stationary. Although the test results are mixed, but we will rely more on the KPSS tests and accept that the three variables are non-stationary (having unit roots or being integrated of order one I(1)) in their level forms.

Engle-Granger Co-integration Test Results

Based on the above-reported graphical trend and more formal unit root test results, long-run equation (1) needs has to be estimated using any co-integration methodology. Since the relationship is bi-variate in nature, we would be able to use the Engle-Granger two-step method to find the co-integrating relationship. In the Engle-Granger method step 1, equation (1) has been estimated using the OLS method with quarterly data from 1972.Q2 to 2011.Q1. The estimated coefficients of the Engle-Granger long-run co-integrating equations are reported in Table 2 for alternative money supply M1I or M2I variables in second and third columns respectively. The long run elasticity coefficient of M1I is found to be 0.59 while that of M2I is 0.48, both being positive but less than unity. In terms of conventional statistical criterion, these two elasticity coefficients are found to be statistically highly significant at better than 1% level as shown by very high t-values. In addition, the adjusted R^2 values were very high for both equations showing high explanatory power for the two alternative money supply models in explaining prices in Bangladesh. Further, the F-statistic representing significance of the overall regression was found to be highly significant at better than 1% level. However, given that the R^2 values are larger than the corresponding D-W statics in both models, the regression results could be representing a spurious relationship (Granger and Newbold 1974).

However, since the variables were found to be non-stationary, the above-mentioned conventional criteria are not appropriate in evaluating the price and money supply relationships. We need to conduct step 2 of the Engle-Granger method to determine the existence of co-integration based on whether the residuals from these two long-run equations are stationary or not. If the residuals are stationary, then the long-run equation would indicate the presence of co-integration between the variables in that equation. Accordingly, three alternative unit root tests were now applied on the residuals RESM1 derived from the M1 money equation and RESM2 derived from the M2 money equation and these unit rot tests are depicted in Table 3.

With respect to RESM1, it is shown to be non-stationary by the ADF test, but was found to be stationary based on other test unit root tests, i.e. the Philips-Perron test and the more powerful KPSS test. Since two out of three unit root tests shows stationary, we are inclined to conclude that RESM1 is stationary and hence concluding that there exists a long-run co-integration between M1 money supply and CPI. With respect to RESM2 residuals, all three unit root tests indicate stationarity and hence strong evidence for the existence of long-run co-integration between M2 money supply and CPI. These results confirm that both M1 and M2 money supply has a long-run co-integrating relationship with each other in the sense of having common trends and co-movements, the results being stronger for the M2 equation than the M1 equation. The co-integration results thus indicate the elasticity coefficients reported from the long-run equation are reliable indicator of the long-run impact of M1 and M2 money supply on the CPI variable.

Short-Run Dynamics and Error-Correction Model Estimates

To capture the shorts term dynamics of the model and the speed of the adjustment to long run equilibrium, we estimated the error correction model as specified in equation (2) earlier. In estimating this ECM model, the optimal lag length of eight (k*=8) is used for the M1 equation and five lags (k*=5) for the M2 equation, which were determined by a number of leg-length criterion selections statistics such as AIC (Akaike Information criterion), FPE (Final prediction error), LIR (sequential modified LR test statistic), SC (Schwartz criterion), and HQ (Hannan-Quinn) information criterion. The error correction term in Equation (2) is given by the coefficient of lagged residual derived from estimated equation (1). Since lagged residuals are included in equation (2), this short-run dynamic error-correction model can be estimated by the OLS method.

The results of the ECM model estimates are shown in Table 4. The short-run dynamic model for M1 performed very poorly with most lagged coefficients being statistically insignificant (except the intercept and $\Delta p(-7)$

term), low adjusted R^2 value (only 0.03), and low and statistically insignificant F-statistic to judge the overall regression. Further, the D-W statistics of course shows no autocorrelation in the data. The coefficient of the lagged residual variable RESM1(-1) is of utmost interest and came out with the expected negative sign indicating stability, but the coefficient value is small and statistically insignificant with a value of only 0.02. In contrast, the short-run dynamic model for M2 money performed much better than M1 model. Although most lagged coefficients are statistically insignificant (except the $\Delta p(-4)$), this estimates are more acceptable with a reasonable adjusted R^2 value 0.08 and a statistically highly significant F-statistic to judge the overall regression to be significant. Further, the D-W statistic shows no autocorrelation in the data. Most importantly, the coefficient of the lagged residual variable RESM2(-1) is of expected negative sign to indicate stability, and is statistically significant at better than 1% level, giving further confirmation of the existence of long-run co-integration between M2 money supply and consumer prices. The coefficient value of RESM2(-1) at -0.10 for this error-correction term shows that any short-run deviation of the consumer prices adjusts to its long-run equilibrium with a speed of adjustment at the rate of 10% per quarter (or about 40% per year). In other words, the results suggest that when CPI is disturbed by an external shock and deviates from its long-run path, the M2 money supply will adjust at the above speed to bring prices back to its long-run equilibrium path. Given the above result, it becomes clear that the Short-run dynamic model corresponding to M2 model performed much better than the M1 model, indicating that M2 money supply is more important and significant in explaining both long-run co-integration and short-run dynamics for Bangladesh.

CONCLUSION

In this paper, we have explored the long run relationship and short run dynamics between money supply and consumer price index employing the unit root tests for non-stationarity followed by the Engle-Granger methodology of co-integration and error-correction methodology for the short-run dynamics. The empirical results suggest that all three variables non-stationary (I(1)) in their level forms. Engle-Granger co-integration tests suggest that there is a long run equilibrium relationship between M1 money and M2 money with consumer price level, albeit a bit weaker test result for M1 money than M2 money model. The results from the error correction model suggest that the long run relationship is stable, that is, in the presence of a shock, the system moves back to the equilibrium. However, the coefficient of the lagged error correction term being insignificant for the M1 money equation, the M1 and Price long-run relationship reported earlier cannot be confirmed by the error-correction model results. In contrast, the coefficient of the lagged error correction term in the M2 equation was statistically highly significant with the expected negative sign, thus giving further confirmation of the long-run relation reported earlier between M2 money and prices. The estimated speed of adjustment with respect to the M2 equation was found to be 0.10, or about 10% per quarter (about 40% per year) which appears to be reasonable.

Figure 1: Quarterly Time Trend in M1I, M2I, and CPI: 1972.Q2 – 2011.Q1

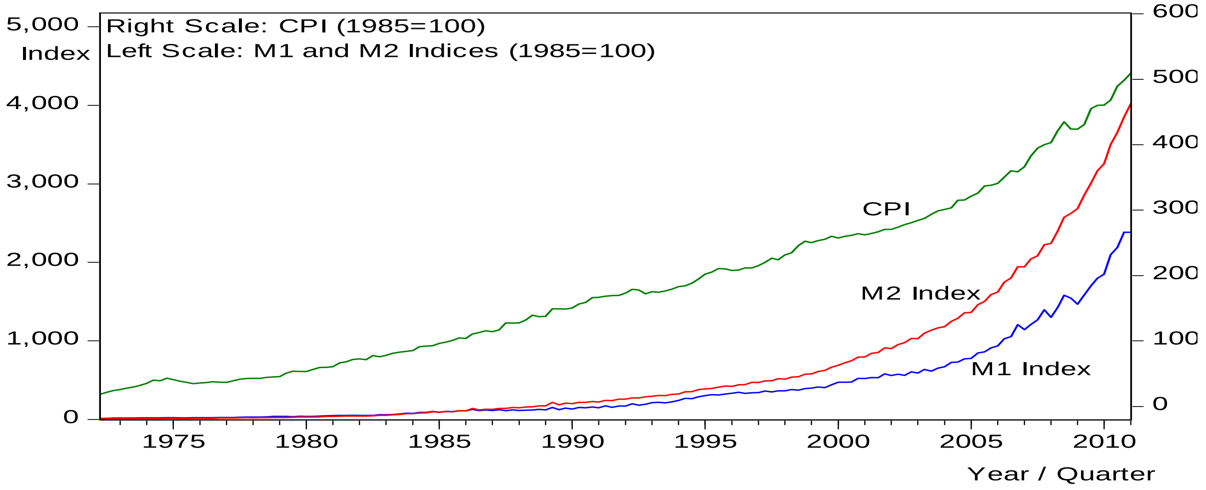

Table 1: Results of three Alternative Unit Root Tests

A. Augmented Dickey-Fuller Test: Null of Unit Root ($\Delta y_t = a + b_0 y_{t-1} + \sum_{j=1}^{k} b_j \Delta y_{t-j} + e_{tk}$)

Variables	**Lags**	**Level**	**First Difference**
ln CPI	8	-4.21***(C,T)	-------
ln M1I	8	-2.25 (C,T)	-5.09***(C)
ln M2I	5	-0.58 (C)	-5.63***(C)

B. Phillips-Perron Test: Null of Unit Root ($\Delta y_t = \mu_0 + \mu_1 y_{t-1} + \sum_{j=1}^{k} \mu_j \Delta y_{t-j} + \beta D + e'_{tk}$ ***with D dummy)***

Variables	**Lags**	**Level**	**First Difference**
ln CPI	8	-3.85** (C,T)	-------
ln M1I	8	-4.15* (C,T)	-------
ln M2I	5	-2.49 (C,T)	-20.02***(C)

C. KPSS (Kwiatkowski-Phillips-Schmidt-Shin) Test: Null of No Unit Root (Stationarity)

ln CPI	8	0.36***(C,T)	0.50 (N)
ln M1I	8	0.16** (C,T)	0.11 (C)
ln M2I	5	0.32***(C,T)	0.39 (C)

Notes: (1) The McKinnon critical values for ADF and PP Tests: (With both intercept and trend) are: (a) 1% = -4.07; (b) 5% = -3.46; and (c) 10% = -3.16 respectively; (With only intercept) are: (a) 1% = -3.48; (b) 5% = -2.88; and (c) 10% = -2.58; (without intercept and trend) are: (a) 1% = -2.59; (b) 5% = -1.94; and (c) 10% = -1.62 respectively. (2) Critical values for KPSS Test: (with both intercept and trend: (a) 1% = 0.22; (b) 5%=0.15; and (c) 10% = 0.12; respectively; (with intercept only): (a) 1%=0.74; (b) 5%=0.46; and (c) 10% = 0.35 respectively; (without intercept and trend) (a) 1%=0.73; (b) 5% = 0.46; and (c) 10% = 0.35 respectively. (3) (a) *** = significant at 1% level; (b) ** = significant at 5% level; and (c) * = significant at 10% level. (4) Letters in parentheses after the coefficients represent the following characteristic included during the unit root tests and in determining the critical values as appropriate: C = Intercept; T = Trend; and N = None (No Intercept ; No Trend).

Table 2: Estimates for the Engle-Granger Long Run Co-integration for M1 and M2 Models
Long-run co-integration equation: $p_t = a + b\, m_{1it} + e_t$

Alternative Models **Coefficient Estimates**	**M1 Model Estimates Dependent Variable: p_t=ln CPI**	**M2 Model Estimates Dependent Variable: p_t=ln CPI**
Intercept	1.8802*** (45.4238)	2.3942*** (102.7304)
m_{1t} =ln $M1_{It}$	0.5902*** (76.1491)	
m_{2t} = ln M_{2It}		0.4761*** (114.1999)
Adjusted R^2	0.9741	0.9888
F-Statistic	5798.68***	13041.61***
Prob. of F-Statistic	0.0000	0.0000
D-W statistic	0.1196	0.1547

Notes: (1) Values in the parentheses below the coefficients are the relevant t-values; (2) *** = significant at 1%; ** = significant at 5%; and * = significant at 10% level

Table 3: Results of the Unit Root Tests for Engle-Granger Long-run Regression Residual derived from the equation: $\ln P_t = a + b \ln M_{it} + \ln u_t$; i = ln M1I or ln M2I

A. Augmented Dickey-Fuller Test: Null of Unit Root ($\Delta y_t = a + b_0 y_{t-1} + \sum_{j=1}^{k} b_j \Delta y_{t-j} + e_{tk}$ ***)***

Variables	**Lags**	**Level**	**First Difference**
RESM1	8	-0.81 (N)	-4.51***(N)
RESM2	5	-3.19***(N)	-------

B. Phillips-Perron Test: Null of Unit Root $(\Delta y_t = \mu_0 + \mu_1 y_{t-1} + \sum_{j=1}^{k} \mu_j \Delta y_{t-j} + \beta D + e'_{tk}$ ***with D dummy)***

Variables	**Lags**	**Level**	**First Difference**
RESM1	8	-3.05***(N)	-------
RESM2	5	-3.54***(N)	-------

C. KPSS (Kwiatkowski-Phillips-Schmidt-Shin) Test: Null of No Unit Root (Stationarity)

RESM1	8	0.35 (C)	-------
RESM2	5	0.36 (C)	-------

Notes: Notes: (1) The McKinnon critical values for ADF and PP Tests: (without intercept and trend) are: (a) 1% = -2.59; (b) 5% = -1.94; and (c) 10% = -1.62 respectively. (2) Critical values for KPSS Test: (without intercept and trend) (a) 1%=0.73; (b) 5% = 0.46; and (c) 10% = 0.35 respectively. (3) (a) *** = significant at 1% level; (b) ** = significant at 5% level; and (c) * = significant at 10% level. (4) Letters in parentheses after the coefficients represent the following characteristic included during the unit root tests and in determining the critical values as appropriate: C = Intercept; T = Trend; and N = None (No Intercept ; No Trend).

Table 4: Engle Granger Short-run Error-Correction Model Estimates for M1 and M2 Models

M1 and M2 Models **Coefficient Estimates**	**M1 Model Estimates Dependent Variable: Δp_t k* = 8 lags**	**M2 Model Estimates Dependent Variable: Δp_t k*=5 lags**
Intercept	0.016752*** (2.6283)	0.009351 (1.28)
Δp(-1)	-0.036412 (-0.43)	0.077171 (0.90)
Δp(-2)	-0.034330 (-0.42)	0.001971 (0.02)
Δp(-3)	0.047919 (-0.42)	0.083255 (1.00)
Δp(-4)	0.080231 (0.59)	0.142147*** (1.77)
Δp(-5)	0.038035 (0.99)	0.109236 1.37)
Δp(-6)	-0.236575 (0.48)	----------
Δp(-7)	-0.021174*** (-3.04)	----------
Δp(-8)	-0.035304 (-0.27)	----------
Δmi(-1)	0.040771 (-0.47)	-0.004824 (-0.07)
Δmi(-2)	0.032409 (0.78)	0.095709 (1.43)
Δmi(-3)	0.051128 (0.61)	0.054431 (0.83)
Δmi(-4)	-0.018962 (0.99)	-0.037606 (-0.58)
Δmi(-5)	-0.065962 (-0.37)	-0.051320 (-0.78)
Δmi(-6)	0.035285 (-1.25)	-----------
Δmi(-7)	0.031632 (0.67)	----------
Δmi(-8)	0.044659 (0.60)	----------
RESM1(-1)	-0.023603 (-1.10)	-0.102601*** (-3.05)
Adjusted R^2	0.03	0.08
F-Statistic	1.25	2.18***
Prob. of F-Statistic	0.23	0.0186
D-W statistic	1.89	1.96

Notes: (1) Values in the parentheses below the coefficients are the relevant t-values; (2) *** = significant at 1%; ** = significant at 5%; and * = significant at 10% level

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