Money, Income, and Prices in Bangladesh: A Cointegration and Causality Analysis

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Abstract

This paper re-examines the causal relationship between money, income and prices in Bangladesh during the period 1972/73 to 2009/10. Cointegration analysis indicates a long-run relationship among the variables. Based on the Error Correction Model (ECM), a bidirectional causality between money and income has been observed. Therefore, monetary policy should be formulated by taking into account the feedback effects of output on money. Money supply can be considered as an effective control variable as causality is found to run from money to prices supporting the Monetarists.

Key Words: Cointegration, Error Correction Model, Bivariate Causality, Trivariate Causality, Bangladesh.

1. Introduction

The relationship between money, income, and prices has been a matter of debate among different economists particularly between the Monetarists and Keynesians. The Monetarists consider money supply to be the important factor leading to changes in income and prices. Thus, the direction of causation runs from money to income and prices without any feedback. On the contrary, the Keynesians asserts that changes in income leads to changes in the stock of money through the demand for money. Therefore, the direction of causation runs from income to money without any feedback.

The causal relationship between money and the other two variables, i.e., income and prices has been an issue argued by economists particularly after the seminal paper by Sims (1972). Using post-war quarterly data for U.S. in a bivariate framework, he found evidence of unidirectional causality from money to income as claimed by the monetarists. However, this result was not obtained by subsequent studies. Replicating Sims' test in the Canadian economy, Barth & Bannett (1974) showed bidirectional causality between money and income. Williams *et al.* (1976) employing a similar approach found evidence of unidirectional causality from income to money in case of U.K., opposite to Sims' findings. However, Dyreyes *et al.* (1980) showed evidence of bidirectional and unidirectional causality between money and income in U.S. and Canada respectively. Concerning the relationship between money and prices, the studies undertaken by Bengali *et al.* (1999), Husain & Rashid (2006) found evidence of unidirectional causality running from money to prices in Pakistan. Lee & Li (1983) showed unidirectional causality from money to price in Singapore. Causality is also found to run from money supply to price movements in Malaysia as observed by Ghazali *et al.* (2006). The results obtained by these studies confirm the claim made by the Monetarists. On the contrary, Jarrah (1996) found money to be Granger caused by prices in Saudi Arabia. Mishra *et al.* (2010) also found unidirectional causality from price level to money supply in India.

Regarding Bangladesh, Jones & Sattar (1988) examined the causal relationship between money-income and money-inflation. They found evidence of unidirectional causality from money to output. Similar result was also obtained regarding the relationship between money and prices. Therefore, monetary expansion could have a significant impact on output growth while there might be inflation in the economy. Shams *et al.* (2010) found unidirectional causality from money to income in Bangladesh. Ahmed (2003) while investigating multivariate causality among money, interest rates, prices and output, identified bidirectional causality between money and prices in Bangladesh.

The objective of this paper is to re-examine the causal relationship between money-income and money- prices in Bangladesh. The study concentrates on Cointegration and Error Correction Model (ECM) to look into the bivariate causal relationship by taking care of the stochastic properties of the variables. The major drawback of bivariate analysis is the exclusion of relevant variable(s). Such omission may lead to erroneous conclusions.

Therefore, this study also attempts to investigate the causal relationship through trivariate causality. The rest of the paper is arranged as follows. Section 2 provides the data sources. The methodology and empirical results are presented in section 3. The final section contains the conclusions and policy recommendations.

2. Data

This study is based on annual data covering the period from 1972/73 to 2009/10. Gross Domestic Product (GDP) has been considered to represent income (I). Data on Gross Domestic Product (GDP) and Broad Money (M) which includes time deposits along with narrow money have been obtained from various publications of Economic Trends, published by the Bangladesh Bank. GDP and M are expressed in terms of Taka (Domestic Currency of Bangladesh) in Millions. To measure prices (P), the Consumer Price Index (CPI) is used which has been collected from different issues of Statistical Yearbook of Bangladesh. Econometric estimations have been done by using STATA 9.2.

3. Methodology and Empirical Results

The causal relationship between two variables is tested through the standard Granger (1969) causality framework by estimating the following equations:

$$(1-L)Y_t = \alpha_0 + \sum_{i=1}^{m} \alpha_i (1-L)Y_{t-i} + \sum_{j=1}^{n} \beta_j (1-L)X_{t-j} + \varepsilon_t \tag{1}$$

$$(1-L)X_t = \delta_0 + \sum_{i=1}^{m} \delta_i (1-L)X_{t-i} + \sum_{j=1}^{n} \gamma_j (1-L)Y_{t-j} + \omega_t \tag{2}$$

where L is the lag operator, ε and ω are mutually uncorrelated white noise series and t denotes time period. Causality may be determined by estimating equations (1) and (2) by testing the null hypothesis that $\beta_j = \gamma_j = 0$ for all j's against the alternative hypothesis that $\beta_j \neq 0$ and $\gamma_j \neq 0$ for at least some j's. If the coefficients β_j's are statistically significant but γ_j's are not, then Y is said to have been caused by X. The reverse causality holds if γ_j's are statistically significant while β_j's are not. If both β_j and γ_j are significant then causality runs both way.

In addition to bivariate causality, this paper also attempts to examine the causal relationship through trivariate causality i.e., the causal relationship between money and income conditional on the presence of prices. Similarly, it tests the causal relationship between money and prices conditional on the presence of income. In order to test the joint influence of two variables on the third variable, the joint trivariate causality model is specified as:

$$(1-L)Y_t = \chi_0 + \sum_{i=1}^{m} \chi_i (1-L)Y_{t-i} + \sum_{j=1}^{n} \varphi_j (1-L)X_{t-j} + \sum_{k=1}^{p} \lambda_k (1-L)Z_{t-k} + u_t \tag{3}$$

$$(1-L)X_t = \lambda_0 + \sum_{i=1}^{m} \lambda_i (1-L)X_{t-i} + \sum_{j=1}^{n} \psi_j (1-L)Y_{t-j} + \sum_{k=1}^{p} \phi_k (1-L)Z_{t-k} + v_t \tag{4}$$

In the trivariate specification, (i) X and Z Granger-cause Y if $\varphi_j = \lambda_k = 0$ is not true i.e., $\varphi_j = \lambda_k = 0$ is rejected, (ii) if $\psi_j = \phi_k = 0$ is rejected, Y and Z Granger-cause X. A feedback system exists if (i) – (ii) hold simultaneously. Finally, X, Y, and Z are causally independent if all the coefficients of X and Z in equation (3), Y and Z in equation (4) are not statistically different from zero.

The causality tests involving money, income, and prices are carried out in the following three steps. Step I consists of identifying the order of integration of the variables under consideration. Cointegration is determined through the maximum likelihood procedure established by Johansen (1991) in step II. In step III, we perform the causality tests.

3.1 Testing for the Order of Integration

The econometric methodology first examines the stationarity properties of univariate time series. This is necessary to avoid the potential problem of estimating spurious relationships. The Augmented Dickey-Fuller

(ADF) (Dickey & Fuller, 1981) test is used for this purpose. The ADF test is derived from the regression equation:

$$(1-L)X_t = \pi_0 + \pi_1 X_{t-1} + \sum_{i=1}^{n} \pi_2 (1-L) X_{t-i} + e_t \tag{5}$$

where L is the lag operator and n is the number of lags on the dependent variable. The null hypothesis is that X is generated by a unit root process i.e. $\pi_1 = 0$. The ADF test statistic is obtained by dividing the estimate of π_1 by its standard error. If the calculated ADF test statistic is less than the critical value (in absolute terms), the null hypothesis of a unit root can not be rejected and the series is said to be non-stationary. The order of integration of X is determined by conducting the ADF test on its first difference. The series will be integrated of order 1 if its first difference does not possess a unit root. The ADF test is carried out by replacing X_t with I_t, M_t and P_t in equation (5) respectively. The results of the unit-root tests are reported in Table 1. The results indicate that in all cases money (*M*), income (*I*), and prices (*P*) are nonstationary at their levels. Therefore to achieve stationarity, the variables must be first-differenced. The ADF statistics are significant only for the first-differenced series. Thus, *M*, *I* and *P* all appear to be *I(1)*.

3.2 Testing for Cointegration

Cointegration test helps to identify the long-run relationship among nonstationary time series. Two or more variables are said to be cointegrated if they are integrated of the same order. Having determined that the variables are stationary at first differences, the Johansen cointegration test (1991) is used to examine whether the variables in question have common trend. The, Johansen procedure assumes that W_t has a vector autoregressive (VAR) representation such that:

$$W_t = \delta + \Pi_1 W_{t-1} + \Pi_2 W_{t-2} + \ldots + \Pi_k W_{t-k} + \varepsilon_t \tag{6}$$

where δ is the intercept and ε_t are the disturbance terms. Equation (7) also yields:

$$\Delta W_t = \delta + \Gamma_1 \Delta W_{t-1} + \Gamma_2 \Delta W_{t-2} + \ldots + \Gamma_k \Delta W_{t-k} + \varepsilon_t \tag{7}$$

where Δ being the first difference operator, W is the vector of variables, δ is a drift parameter, and $\Gamma_1 \ldots\ldots\ldots \Gamma_k$ are the coefficient matrices. The number of cointegrating vectors is equal to the rank of Γ_k, denoted by r. Johansen (1991) suggests two test statistics to determine the cointegration rank. The first of these is the trace statistic:

$$\lambda_{trace\ (r)} = -T \sum_{i=r+1}^{n} \ln(1-\hat{\lambda}_i) \tag{8}$$

The second test, known as the maximum eigen value test, is computed as:

$$\lambda_{\max(r,r+1)} = -T \ln(1-\hat{\lambda}_{r+1}) \tag{9}$$

where λ_i 's are the ordered (estimated) eigen values of the matrix Γ and T is the available observations. The null hypothesis of no cointegration i.e., $r = 0$ is tested against the alternative of $r+1$ cointegrating vectors in trace and maximum eigen values tests.

The results of the Johansen's maximum likelihood method for determining the number of cointegrating vectors are summarized in Table 2. The number of lags (i.e., two) is chosen by Akaike information criterion (AIC). Concerning the relationship between money-income and money-prices, the null hypothesis of no cointegration is rejected using either statistics. However, the null hypothesis of at most one cointegrating vector cannot be rejected in favour of $r = 2$. Besides, the null hypothesis of no cointegration is also rejected whereas the null hypothesis of at most two cointegrating vectors cannot be rejected in favour of $r = 3$ regarding the relationship among money, income, and prices. Thus, the empirical support for one and two cointegrating vectors implies that the variables money- income, money-prices and money-income- prices are cointegrated and have a long-run relationship.

3.3 The Causality Tests

As the variables turn out to be cointegrated, the lagged values of the residuals ($\eta_{t-1}, \eta'_{t-1}, \mu_{t-1}, \mu'_{t-1}$) obtained from the cointegrating regressions are used as error correction terms to amend the standard Granger test. The bivariate and trivariate tests are specified as generalized extensions of the standard case (Granger, 1969) as follows:

$$(1-L)Y_t = \alpha_0 + \rho_1\eta_{t-1} + \sum_{i=1}^{m}\alpha_i(1-L)Y_{t-i} + \sum_{j=1}^{n}\beta_j(1-L)X_{t-j} + \varepsilon_t \quad (10)$$

$$(1-L)X_t = \delta_0 + \rho_2\eta'_{t-1} + \sum_{i=1}^{m}\delta_i(1-L)X_{t-i} + \sum_{j=1}^{n}\gamma_j(1-L)Y_{t-j} + \omega_t \quad (11)$$

$$(1-L)Y_t = \chi_0 + \sigma_1\mu_{t-1} + \sum_{i=1}^{m}\chi_i(1-L)Y_{t-i} + \sum_{j=1}^{n}\varphi_j(1-L)X_{t-j} + \sum_{k=1}^{p}\lambda_k(1-L)Z_{t-k} + u_t \quad (12)$$

$$(1-L)X_t = \lambda_0 + \sigma_2\mu'_{t-1} + \sum_{i=1}^{m}\lambda_i(1-L)X_{t-i} + \sum_{j=1}^{n}\psi_j(1-L)Y_{t-j} + \sum_{k=1}^{p}\phi_k(1-L)Z_{t-k} + v'_t \quad (13)$$

For the bivariate as well as the trivariate analysis, the F- value is calculated as:

$$F = \frac{(R^2_{UR} - R^2_R)/l}{(1-R^2_{UR})/(n-q)} \quad (14)$$

where R^2_{UR} and R^2_R are obtained from the unrestricted and restricted causality regressions respectively, *n* is the total number of observations, *l* is the number of lagged terms of the variables which are chosen by Akaike's Information Criterion (AIC), and *q* is the number of parameters estimated in the unrestricted regression.

The findings of the bivariate analysis are presented in Table 3(a). These results show bidirectional causality between money and income. Thus, due to the mixed direction of causation found between money and income, it is difficult either to accept or reject the Keynesians or the Monetarists view in Bangladesh. Regarding, money-price relationship, the results suggest a unidirectional causality from money to price supporting the Monetarists. An increase in the money supply increases the price level which does not in turn cause the money supply to increase. This implies that monetary expansion increase inflation in Bangladesh. Finally, the causal relationship is also examined on the basis of trivariate causality. In view of the presence of a long-run relationship among money, income, and prices, Table 3(b) shows the causal relationship between money and income conditional on the presence of prices. Similarly, it shows the causal relationship between money and prices conditional on the presence of income. The results are similar to those found in the bivariate case, i.e., bidirectional causality between money and income and a unidirectional causality from money to prices conditional on the presence of prices and income respectively.

4. Conclusions and Policy Recommendations

The objective of this paper has been to examine the causal relationship between money-income and money-prices in Bangladesh over the period 1972/73 to 2009/10. Cointegration analysis suggests a long-run relationship between money and the other variables i.e., income and prices. Based on the Error Correction Model (ECM), the bivariate analysis indicates a bidirectional causality between money and income and a unidirectional causality from money to prices. This implies that an increase in money supply raises the general price level. Therefore, it is money that takes lead in increasing inflation in Bangladesh. The absence of bidirectional causality between money and prices indicate that money supply can be considered as exogenous which can be taken as an effective control variable. However, these results may be inaccurate if relevant variable(s) are omitted. The trivariate analysis also confirms the results obtained from the bivariate case.

In view of the causal effect of money over income and prices, a number of policy implications can be inferred. An increase in money supply leads to an increase in income which ultimately increases the demand for money to finance higher level of economic activity. However, this also increases the price level resulting in inflation. A higher level of income without inflation may be achieved if the growth rate of money supply is fixed roughly at a rate equal to the growth rate of the economy. Thus, if a policy objective is to achieve a high rate of economic growth as well as restrain inflation, money supply should be considered as the most suitable target. Moreover, in view of the bidirectional causal relationship between money and income, monetary policy should be devised by considering the feedback effects of output on money (Mehrara & Musai, 2011).

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Table 1

Unit Root Test with ADF for the period 1972/73 to 2009/10

Variables	ADF		ADF	
	C	First Difference	C, T	First Difference
I	2.184 (2)	2.681 (2)*	2.676 (2)	4.406 (2)***
M	1.392 (2)	-3.621 (1)**	2.584 (2)	4.831 (2)***
P	3.008 (1)	2.754 (1)*	1.665 (1)	3.658 (1)**

Notes: i) Figures within parentheses indicate lag terms chosen by the Akaike information criterion (AIC); ii) ***, ** and * denote rejection of the null hypothesis of unit root at the 1%, 5% and 10% levels respectively; iii) C = constant term included in the unit root test, C,T = constant and trend term included in unit root test.

Table 2

Johansen's Maximum Likelihood Procedure

Variables	Hypotheses		Test Statistics	
	Null	Alternative	Trace	λ - Max
(M,I)	r = 0	r = 1	15.97**	15.97**
	r ≤ 1	r = 2	2.65	3.16
(M, P)	r = 0	r = 1	19.61**	19.26***
	r ≤ 1	r = 2	0.36	0.36
(M, I, P)	r = 0	r =1	29.68**	25.52***
	r ≤ 1	r = 2	6.61	6.49
	r ≤ 2	r = 3	0.12	0.12

Notes: i) r denotes the number of cointegrating vectors; ii) *** and ** denote rejection of the null hypothesis at the 1% and 5% levels respectively.

Table 3 (a)

Bivariate Analysis of Causal Relationship between Money (M) - Income (I) and Money (M) - Prices (P) for the period 1972/73 to 2009/10

Causation	M→ I	I→ M	M → P	P → M
F – Values	7.54***	7.38***	8.83***	1.57

Notes: (i) Critical F-Values: 1% = 5.34, 5% = 3.29, 10% = 2.48, df = (2, 32); (ii) *** indicates a significant causal relationship at the 1% level; (iii) M→ I: M causes I; (iv) I→ M: I causes M; (v) M→P: M causes P; (vi) P→M: P causes M.

Table 3 (b)

Trivariate Analysis of Causal Relationship among Money (M), Income (I), and Prices (P) for the period 1972/73 to 2009/10

Causation	M(P) → I	I(P) → M	M(I) → P	P(I) → M
F – Values	4.57**	3.16*	5.12**	2.26

Notes: (i) Critical F-Values: 1% = 5.39, 5% = 3.32, 10% = 2.49 , df = (2, 30); (ii) ** and * indicate a significant causal relationship at the 5%, and 10% levels respectively; (iii) M(P) → I: M and P jointly cause I after including P in the unrestricted regression; (iv) I(P) → M: I and P jointly cause M after including P in the unrestricted regression; (v) M(I)→P: M and I jointly cause P after including I in the unrestricted regression; (vi) P(I)→M: P and I jointly cause M after including I in the unrestricted regression.