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Inflation in a Low-income Country Tests Based on the Quantity Theory of Money

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Abstract: An inflation-rate equation derived from a money-demand model is tested using annual time-series data for the Philippines. A conventional econometric approach shows that money has a positive and significant effect. The result seems confirmed by some time-series techniques, which indicate that money growth Granger-causes inflation.

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I. Introduction

This paper empirically studies the effect of money growth on inflation in a low-income country. In recent years, several less-developed countries with serious external-debt problems have been advised by multilateral lending institutions to tighten money in a bid to stop inflation. Adjusting money to the proper degree, however, is generally hampered by lack of quantitative information on the links between inflation and money growth. This paper attempts to narrow down this information gap.

To interpret inflation-rate figures, the methodology starts with conventional econometric modeling. The underlying theoretical model is based on the quantity theory of money, which suggests a one-for-one impact of money on the price level.[1] An inflation equation, derived from a money-demand model, is implemented empirically.[2]

The theoretical model, however, offers no guide to the monetary aggregate that is appropriate for statistical analysis. Moreover, money may affect inflation with a lag, but theory is silent on what the appropriate lag length is. To guide the search

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[1]This paper has in mind Friedman's (1956) restatement of the quantity theory of money.

[2]To illustrate this approach, see, for example, Barro (1978). But for a skeptical view of interpreting money-demand as a price equation, see Mackinnon and Milbourne (1988).

for possible extensions of the basic econometric model, some time-series techniques are put to work. First, the variables used in the analysis are each tested for stationarity. Those that need to be transformed are subjected to first differencing. Tests of optimal lag length and Granger causality are then undertaken.

The inflation model is tested using annual time-series data for the Philippines, which seems sufficiently monetized to render tests based on a monetary approach to inflation promising. For the period 1973-90, for example, the average annual inflation rate of the Philippines was 14 percent, while the average reserve money growth rate was 16 percent each year. All figures used in the empirical work are taken from the IMF's **International Financial Statistics Yearbook**.

The paper is organized as follows. Section II discusses the relationship between money and inflation implied by the quantity theory of money. Section III presents the time-series techniques. Section IV concludes the paper.

II. Money and Inflation: Theory and Tests

To establish the link between money and inflation, consider a demand for real money balances of the form:

$$M_d = kPY \tag{1}$$

where M_d is nominal money demand, P is the price level, Y is real income, and k is the ratio of nominal money to nominal income, which in the short run, as is done here, may be assumed fixed.[1]

Taking logarithms of (1) and differentiating yields the following:

$$m_d = p + y \tag{2}$$

where the lower-case symbols indicate rate of change of the upper-case variables. If the money market is in equilibrium such that money supply, M_s, is equal to M_d, and solving for p in (2) above, then:

$$p = m_s - y. \tag{3}$$

According to (3), a positive inflation rate means that the growth of nominal money supply exceeds the growth of real income.

It is not explicit from the theory what monetary aggregate can be considered exogenous for statistical purposes. It has been argued that reserve money is exogenous, but that a broader definition like M1 is endogenous. The point has been made that M1 is a function of variables that depend on the decisions of banks and the public regarding their respective demand for reserves and currency. In approximation of exogeneity, reserve money is used here.

Using (3) above, a parsimonious model of inflation which includes reserve money and real income as explanatory variables is formulated. The dependent variable is the inflation rate, p,

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[1]Viewed, however, as the reciprocal of the income velocity of money, k may vary in the long run, a function of the variables affecting the demand for real cash balances.

which is measured as the annual rate of change in the GDP price deflator. The independent variables are annual rate of change of reserve money, m, and annual rate of change of real GDP, y. Applying ordinary least squares with a Cochrane-Orcutt correction for serial correlation to annual data for 1962-88, the following regression estimate is obtained:

$$p_t = 4.081 + .634\ m_t - .639\ y_t \qquad (4)$$
$$(1.13) \quad (4.80) \quad (-1.44)$$
$$\bar{R}^2 = .56 \quad F = 11.5 \quad D\text{-}W = 1.93$$

As expected, the rate of change in reserve money is positively related to the inflation rate. Note, however, that the coefficient is less than unity. Though the rate of change in real income yields the expected negative sign on inflation, the coefficent is insignificant. The absolute values of the coefficients of money growth and real income are about the same.

In conventional empirical models of money demand, the nominal interest rate is typically included, along with real income, as a regressor. The nominal interest rate, which is intended to capture the opportunity cost of holding money, is hypothesized to be negatively related to the demand for money, and hence, positively related to the inflation rate. In the Philippines, ceilings on interest rates were imposed in the mid-1950s in line with the provisions of an anti-usury law. In 1974, interest rates were raised to a new level where they remained fixed up to 1980. In 1981, under a financial-market liberalization program, interest rates on loans and deposits of varying maturities were freed, a policy that with some modifications still holds. In view of these varied interest-rate regimes equation (4) is re-estimated with a dummy variable that takes the values 0, 1, and 2 for the periods 1962-73, 1974-80, and 1981-88, respectively. The dummy variable, it turns out, has no explanatory power, and henceforth, is dropped from the analysis.

It is widely held that money affects inflation with a lag.[4] But again, the quantity theory, provides no guide to what the appropriate lag length is. For this purpose, the paper harnesses some time-series techniques.

III. A Time-Series Analysis

The past few years have seen the use of time-series techniques as an atheoretical way to establish relationships among macroeconomic variables. In this paper, some time-series methods are used to test for stationarity of the variables that matter theoretically, and to determine appropriate lag lengths and Granger causality. The path that Darrat and Lopez (1988) have taken is essentially followed here.

The first step is to transform each of the variables--inflation rate, money growth, and real income--into a stationary series. Each level of the three variables is regressed on a constant and a time trend; if the time trend is insignificant, the

[4]See, for example, Harberger (1963) and Vogel (1969).

series is stationary. Table 1 shows such regressions and it turns out that only the inflation rate is stationary. Real income and money growth are subjected to first differencing and regressed again on a constant and time trend; both variables, after first differencing, become stationary.

The second step is to determine the optimal own lag length of the inflation rate. Following Hsiao (1981), the optimal lag is based on minimizing Akaike's (1969) final prediction error (FPE), defined as:

$$FPE(n) = \{(T + n + 1)/(T - n - 1)\} \{SSR(n)/T\}$$

where T is the number of observations, n is the length of the lags, and SSR is the sum of squared residuals. Table 2 shows the results of two regressions: in one, the inflation rate is regressed on a constant only; in the other, the inflation rate is regressed on a constant and on the inflation rate lagged one period. Note that FPE(0) < FPE(1), which means that the optimal own lag is of order zero.

After determining optimal own lag length of inflation, n^*, *the* third step is to run a regression containing the optimal own lag length (zero in this case) and one of the remaining explanatory variables, say, money growth. For this explanatory variable, the following is calculated:

$$FPE(k;n^*) = \{(T + n^* + k + 1)/(T - n^* - k - 1)\} \{SRR(k;n^*)/T\}$$

where k is the lag length on money growth. If $FPE(k;n^*) < FPE(n)$, then money growth is said to Granger-cause inflation. Another regression is then run containing optimal own lag length and real income growth. The same FPE-criterion is applied to real income growth to find out if it Granger-causes inflation. From Table 3.1 it is shown that Dm_t and Dm_{t-1} Granger-cause inflation. Meanwhile, it is shown in Table 3.2 that Dy_t Granger-causes inflation.

The final step is to estimate an inflation equation as a function of its optimal own lag length, the causal variable with the lowest FPE(k;n*) in step 3 above (namely, money growth lagged one period), and the remaining explanatory variable. The righthand side of this regression equation involves a constant, Dm_t, Dm_{t-1}, and Dy_t. Table 4 shows the results: Dm_t is positive and significant while Dy_t is negative and significant, in line with the expected signs; Dm_{t-1}, however, is insignificant. Re-estimating the equation without Dm_{t-1} yields significant coefficients for Dm_t and Dy_t, but in absolute-value terms, the coefficient of Dm_t is smaller compared to that of Dy_t. The inflationary impact of a percentage-point increase in money growth is more than offset by an accompanying percentage-point increase in real output growth.

IV. Concluding Remarks

This paper has investigated the effect of money growth on inflation using, initially, conventional econometric methods. The inflation-rate equation is based on the quantity theory of money. Next, some time-series techniques are used to determine lag lengths and Granger causality. The results show causality from money growth to inflation, in support of the quantity theory of money.

Some time-series techniques have been used here to guide further model search, noting that the theoretical model offers no clue as to what monetary aggregate to use, and how long the lags of money growth and the other explanatory variables should be. The time-series approach may be viewed also as an atheoretical attempt to discover the relationship between inflation and money growth. The results confirm the inflationary impact of money, but such impact is offset by an accompanying increase in real output growth.

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Table 1

Regressions to Test for Stationarity

Level

Dependent Variable	constant	time trend
m_t	8.197 (2.02)	.524* (2.18)
p_t	5.771 (1.51)	.381 (1.68)
y_t	6.753 (5.70)	-.165* (-2.31)

First Difference

Dependent Variable	constant	T
Dm_t	.862 (.13)	-.052 (-.14)
Dy_t	-.389 (-.34)	.028 (.41)

Notes: m_t = growth rate of reserve money; p_t = inflation rate or rate of change of real GDP price deflator; y_t = growth rate of real GDP.

The numbers in parentheses are t-ratios.
*significant at 10%

Table 2

Regression of Inflation Rate on Own Lag

Dependent variable (inflation rate)	constant	lagged explanatory variable P_{t-1}	T	SSR	FPE
P_t	11.48 (6.31)		27	2322.39	86.0
P_t	10.52 (3.65)	.085 (.43)	27	2304.87	92.1

Notes: T = number of observations; SSR = sum of squared residuals; FPE = final prediction error. The numbers in parentheses are t-ratios.

Table 3.1

Inflation and money growth: Granger-causality test

Dependent variable	explanatory variable constant	Dm_t	Dm_{t-1}	Dm_{t-1}	FPE(k;n)
P_t	11.39 (6.94)	.324 (2.64)			72.39
P_t	11.49 (7.34)	.436 (3.49)	.272 (2.18)		65.64
P_t	11.57 (7.27)	.504 (3.79)	.372 (2.60)	.169 (1.26)	67.30

Notes: $Dm_t = m_t - m_{t-1}$
The numbers in parentheses are t-ratios.

Table 3.2

Inflation and real income growth: Granger-causality test

Dependent variable	constant	Explanatory variable Dy_t	Dy_{t-1}	FPE(k;n)
P_t	11.535 (7.10)	-1.69 (-2.76)		71.01
P_t	11.77 (6.90)	-1.722 (2.71)	.064 (.101)	78.06

Notes: $Dy_t = y_t - y_{t-1}$
The numbers in parentheses are t-ratios.

Table 4

Regression of Inflation on Money and Output Growth

Dependent variable (inflation rate)	constant	Explanatory variables Dm_t	Dm_{t-1}	Dy_t	$\bar{R}^2$	F
p_t	11.66 (7.90)	.36 (2.93)	.122 (.88)	-1.29 (-.99)	.38	6.27
p_t	11.77 (7.71)	.31 (2.80)		-1.60 (-2.82)	.38	8.64

Note: The numbers in parentheses are t-ratios.