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Money and Output in Mexico, Colombia, and Brazil*

This chapter investigates the effects of changes in the quantity of money on economic activity in Mexico, Colombia, and Brazil. On a theoretical level, the impact of monetary shocks on economic activity has been analyzed in modern theories of the Phillips curve by Friedman (1968), Phelps (1970), Lucas (1973), and Barro (1976). In these models cyclical movements in output are generated by shifts in prices relative to expected values of prices, where these expectations refer either to future periods or to alternative markets. Increases in wages or prices above their expected or normal values lead to increases in factor supplies and to corresponding increases in employment and output.

Monetary shocks can increase output in this type of framework because these shocks may not immediately and fully be recognized as nominal in origin. A fully perceived nominal disturbance to aggregate demand—that is, "anticipated money growth"—will raise actual and expected prices by equal amounts. Since this type of disturbance does not produce a gap between actual and expected prices, it does not stimulate factor supplies, and it therefore has no impact on output. On the other hand, the aggregate demand shift implied by

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"unanticipated money growth" will appear to market participants as partly a change in relative prices—that is, as partly a real shock to excess demand for particular products or services. Expected prices—either over time or across markets—will lag behind actual prices when this underlying demand shift is not fully perceived as an aggregate, purely nominal disturbance. In this circumstance factor supplies will respond positively to the (incorrectly) perceived improvement in relative prices, and there will be a cyclical boom in output. Negative values of unanticipated money growth imply a corresponding contractionary effect on economic activity.

A key element in the theory is the extent to which money movements are anticipated or unanticipated. Hence, the completion of the theoretical model requires an approach to expectation formation. Individual expectations will depend in part on the information available at the current date. Notably, the confusion between nominal and real shocks that is central to modern theories of the Phillips curve requires some lag in the transmission of information about the values of nominal shocks. Given incomplete knowledge of the absolute price level, money stock, and so on, it is natural (because of the lack of a serious alternative) to assume rational formation of expectations. That is, individuals are assumed to forecast prices, and so on, in an optimal manner subject to their limited information. Accordingly, the present study identifies anticipated money growth as the value that is predictable for the future (one year ahead) based on experiences with money and other variables that influence the money supply process. The implicit one-year lag in information transmittal is an empirical construct that worked well in my previous investigations of the U.S. economy (Barro, 1977). As in that study, an important test of the underlying theory is whether money growth influences economic activity only when it differs from the anticipated value of money growth.

For the United States I was able to isolate three types of predictable influences on money—first, a positive response of money to a rise in government spending above its "normal" level (as measured by a distributed lag of past values of government spending); second, a countercyclical response of money to the level of economic activity; and third, a positive correlation with previous growth rates of money. For the three Latin American cases that I consider in this chapter I have been unable to find a systematic relation between money growth and the first two types of variables. However, in the Mexican and Colombian cases there are some effects on money growth of a measure of the departure of prices from purchasing power parity and of the behavior of money growth in the United States. In addition,

these two cases show a time pattern of negative serial correlation in money growth rates. For the Brazilian case the only money predictor that I have isolated is based on a positive correlation with the previous year's money growth rate.

The estimated money growth relations for the three cases are used to form time series for anticipated money growth. The differences between actual and anticipated growth are then measures of unanticipated money growth—the monetary variable that is supposed to influence real variables like output and employment.

In the Mexican case I have found some important effects of money on output as well as effects that involve the level of output in the United States, the value of Mexican prices relative to purchasing power parity, and an index of the terms of trade. Since the model performed well in its (ex ante) prediction for 1974, there should be some interest in its predictions for 1975 and beyond. These (ex ante) forecasts indicated a period of substantial output contraction for 1975-1976. One notable implication of the results is that a devaluation of about 25 percent, which would restore approximate purchasing power parity (and which turned out, ex post, to be the actual order of magnitude for the first devaluation made in late 1976), would be a substantial stimulant to Mexican output for 1976.

A less cheerful aspect of the Mexican results is that they do not provide supporting evidence for the underlying hypothesis that only the unanticipated portion of money growth affects output—that is, the actual and unexpected money growth variables had about the same explanatory power for output. In this respect the results for Mexico contrast sharply with those found elsewhere for the United States.

For Colombia I have been unable to find any link from money (unanticipated or otherwise) to output, whereas in the Brazilian case there is only a weak indication of a contemporaneous link from unanticipated money growth to output. Hence, these two experiences look very different from both Mexico and the United States.

1. MEXICO

1.1 Behavior of Money Growth

The money growth equation for Mexico involves three types of variables: first, the past history of money growth (up to three annual lags); second, the behavior of money growth in the United States; and third, a lagged index of the departure of prices from purchasing power parity. This index is measured by the Mexican exchange rate times the ratio of U.S. prices (the implicit price deflator for gross

national product) to Mexican prices (the implicit price deflator for gross domestic product).

Because the Mexico/U.S. exchange rate was fixed from 1955 to the end of the sample period at 12.5 pesos per U.S. dollar, the expectation over this period is that a change in U.S. money growth would lead—through actual or anticipated movements in the balance of payments—to a corresponding change in Mexican money growth. Since the money growth equation is used to generate a forecast, $\hat{DM}_t$, for date t based on information available in the previous year, it is desirable to measure U.S. monetary behavior from the standpoint of date $t - 1$ information. From my previous study (Barro, 1977, Table 3), I have available the forecasted values of U.S. money growth for date t, $\hat{DM}_{US_t}$, based on date $t - 1$ information.[1] These values are reproduced in Table 6-1, column 7. The expectation is that in the "long run," under a fixed exchange rate regime and with the appropriate other variables held fixed, a one percentage point increase in $\hat{DM}_{US}$ would lead to a one percentage point increase in the Mexican money growth rate.

During the 1948 to 1955 period in Mexico there were devaluations in 1948, 1949, 1950, 1954, and 1955. The impact of $\hat{DM}_{US}$ on Mexican DM over this period is less apparent, although the effect would still be positive to the extent that Mexico was attempting to maintain a fixed exchange rate during this period.

The index of departure from purchasing power parity (PP) is measured by the exchange rate (constant since 1955) times the ratio of U.S. to Mexican prices (Table 6-1, column 9). (The variable has been normalized so that its average value over 1948 to 1974 is equal to zero.) The price measures used in this calculation were GNP and GDP deflators, respectively, although "traded goods" price indices (perhaps proxied by wholesale prices) are typically used to construct this type of index. Particularly because of the prominence of "invisible" trade between the United States and Mexico, it seemed that the concept of traded goods should be broadened to encompass the entire spectrum of economic transactions. It is also implicit in the calculation that the underlying price ratio that corresponds to purchasing power parity remained constant over the sample period.

A high (lagged) value of the PP index signifies that the Mexican currency is undervalued, which implies upward pressure on the Mexican money stock. In the present context there is assumed to be symmetric downward pressure on Mexican money when the PP index is low. Again, the impact of the PP variable on Mexican DM is clearer during the fixed rate period since 1955 than in the earlier period.

Table 6-1. Mexico Independent Variables and Predictions of Monetary and Real Growth

	(1) DM	(2) $\hat{DM}$	(3) DMR	(4) $\tilde{y}$	(5) $\hat{\tilde{y}}$	(6) $\tilde{y} - \hat{\tilde{y}}$	(7) $\hat{DM}_{US}$	(8) $\tilde{y}_{US}$	(9) PP	(10) TT	(11) $\hat{X}$
1948	0.056	0.033	0.023	0.047			0.014	-0.003	-0.17	100.7	-0.18
9	0.108	0.119	-0.011	0.038			0.005	-0.039	0.13	85.5	0.08
1950	0.202	0.165	0.037	0.061			0.005	0.015	0.12	100.0	0.16
1	0.258	0.158	0.100	0.066			0.038	0.053	0.00	98.5	0.13
2	0.040	0.075	-0.035	0.040			0.046	0.046	-0.05	103.4	0.06
3	0.073	0.017	0.056	-0.023			0.047	0.052	-0.03	86.3	-0.08
4	0.101	0.081	0.020	0.011	0.026	-0.015	0.023	0.001	0.17	93.7	0.16
1955	0.192	0.180	0.012	0.028	0.020	0.007	0.026	0.036	0.15	92.0	0.29
6	0.116	0.154	-0.038	0.026	0.030	-0.004	0.029	0.017	0.12	91.4	0.25
7	0.088	0.082	0.006	0.031	0.018	0.013	0.020	-0.006	0.09	82.6	0.03
8	0.065	0.091	-0.026	0.018	0.004	0.014	0.021	-0.055	0.06	83.9	-0.06
9	0.117	0.131	-0.014	-0.019	-0.008	-0.011	0.032	-0.031	0.04	82.5	-0.10
1960	0.113	0.151	-0.039	-0.013	-0.028	0.015	0.039	-0.044	0.04	68.2	-0.13
1	0.062	0.107	-0.045	-0.037	-0.027	-0.010	0.022	-0.062	-0.01	68.3	-0.15
2	0.077	0.109	-0.032	-0.056	-0.055	-0.001	0.039	-0.036	-0.03	64.4	-0.09
3	0.134	0.122	0.012	-0.042	-0.024	-0.018	0.034	-0.035	-0.01	65.1	-0.08
4	0.181	0.134	0.047	0.005	-0.010	0.016	0.037	-0.019	-0.02	62.0	-0.06
1965	0.087	0.104	-0.017	-0.002	0.000	-0.002	0.040	0.005	-0.02	62.4	-0.04
6	0.080	0.073	0.007	-0.001	0.009	-0.010	0.044	0.030	-0.04	61.3	-0.04
7	0.085	0.105	-0.020	-0.007	-0.004	-0.003	0.045	0.018	-0.06	60.8	-0.18
8	0.103	0.122	-0.019	0.005	0.000	0.005	0.042	0.026	-0.06	65.6	-0.15
9	0.095	0.135	-0.040	-0.001	-0.006	0.005	0.052	0.015	-0.05	64.3	-0.08
1970	0.100	0.120	-0.021	0.000	0.002	-0.003	0.047	-0.027	-0.04	70.1	-0.19
1	0.073	0.119	-0.046	-0.033	-0.033	0.000	0.044	-0.032	-0.03	66.9	-0.19
2	0.144	0.144	-0.001	-0.030	-0.032	0.002	0.061	-0.009	-0.06	69.4	-0.06
3	0.223	0.141	0.082	-0.023	-0.023	0.000	0.057	0.010	-0.12	69.4	0.14
4	0.189	0.092	0.097	[-0.032]	-0.028	[-0.004]	0.058	-0.049	-0.24		0.19
1975		-0.006		[-0.057]	-0.059	[0.002]	0.052	-0.086			
6		0.000			-0.093		0.053				

Table 6-1 continued

Notes to Table 6-1

$DM_t \equiv \log(M_t) - \log(M_{t-1})$, where M is an annual average of the money stock in billions of pesos (obtained from Manuel Cavazos of the Mexican Central Bank). $\hat{DM}_t$ is an estimated value from Equation (6-1). $DMR_t \equiv DM_t - \hat{DM}_t$.

$\tilde{y}_t \equiv \log(y_t) - 3.161 - 0.0666 \cdot t$ is output relative to trend, where y is real gross domestic product (billions of pesos at 1960 prices) from *International Financial Statistics* (henceforth, *IFS*). $\tilde{y}$ is an estimated value from Equation (6-4).

$\hat{DM}_{USt}$ is the predicted value of DM in the United States for year t from Barro, 1977. $\tilde{y}_{US}$ is U.S. output (real gross national product in 1958 prices) relative to trend from Barro, 1977.

PP, the index of departure from purchasing power parity, is the peso-U.S. dollar exchange rate (*IFS*) times a ratio of the GNP deflator in the United States (1958 base) to the GDP deflator in Mexico (*IFS*, 1960 base). This variable is measured relative to its mean value over the 1948 to 1974 period.

TT is an index of the terms of trade (ratio of U.S. dollar export prices to U.S. dollar import prices with a base of 1950 = 100) from Griffiths, 1972, Appendix Table 4, p. 141, up to 1967, and from *Economic Survey of Latin America*, 1975, Table 17, p. 42, since 1967.

$\tilde{X}_t \equiv \log(X_t) - 1.510 - 0.0314 \cdot t$ is real exports relative to trend, where X is the peso value of exports (*IFS*) divided by the Mexican GDP deflator.

Finally, the money growth equation also includes some lagged values of the dependent variable. Since lagged values of four or more years were unimportant to the fit, the equation incorporates the first three annual lags: DM_{t-1}, DM_{t-2}, and DM_{t-3}.

For the United States I found some important money supply influences from the level of government spending relative to "normal" and from a lagged value of the level of economic activity (a countercyclical response of money). I have been unable to detect any influences of this sort for Mexico. However, the failure of the government expenditure variable may reflect a data problem—the available series involve ambiguities over which types of expenditure to classify as governmental and they also contain changes in coverage over time.

The principal money growth equation that I have used for the Mexican case, estimated from annual observations over 1948 to 1973, is (with standard errors of the coefficients in parentheses)[2]

$$DM_t = \underset{}{0.14} - \underset{(0.03)}{0.03}\, DM_{t-1} - \underset{(0.21)}{0.49}\, DM_{t-2} - \underset{(0.19)}{0.24}\, DM_{t-3} + \underset{(0.73)}{1.41}\, \hat{DM}_{US_t} + \underset{(0.11)}{0.29}\, PP_{t-1}, \qquad (6\text{-}1)$$

$$R^2 = 0.49,\ DW = 1.59,\ \hat{o} = 0.044$$

where DM_t ($\equiv \log [M_t] - \log [M_{t-1}]$) is an annual average of the money growth rate with M_t measured as an annual average of the money stock in year t. (The mean value of Mexican money growth over 1948 to 1973 is 0.114 per year with a standard deviation of 0.055.) The fit of the equation is indicated by the $\hat{o}$ value of 0.044, which signifies an estimation error of about ± four and one-half percentage points per year in the money growth rate. By contrast, the value of $\hat{o}$ for the United States over the 1946 to 1973 period is about 0.015, but the mean value of U.S. money growth for that period is only about 3.4 percent per year.

The estimated form of Equation (6-1) implies a tendency for Mexican money growth to return to a normal or long-run rate, $\overline{DM}$, that is determined by the values of the constant term and $\hat{DM}_{US}$ (assuming a long-run average value of PP equal to zero). The relation for this long-run money growth rate can be determined by setting $DM_t = DM_{t-1} = DM_{t-2} = DM_{t-3} = \overline{DM}$ and $PP = 0$ in Equation (6-1) to obtain

$$\overline{DM} = 0.080 + 0.80\, \hat{DM}_{US} \qquad (6\text{-}2)$$

For example, at $\hat{DM}_{US} = 0.03$ per year (a typical value for the 1948 to 1963 period), the value of $\overline{DM}$ is 10 percent per year. At $\hat{DM}_{US} = 0.058$ per year—the value applicable to 1974—the result is $\overline{DM} = 13$ percent per year. Since the estimated coefficient on $\hat{DM}_{US}$ in Equation (6-2) does not differ significantly from one, there is support for the theoretical idea that the long-run effect of $\hat{DM}_{US}$ on Mexican DM is one to one.

The negative coefficients on DM_{t-2} and DM_{t-3} in Equation (6-1) (only the DM_{t-2} coefficient is individually significantly different from zero) indicate that years in which DM is above $\overline{DM}$ tend to be followed by years in which DM is below $\overline{DM}$. This type of behavior would be expected from the pressure generated by a fixed exchange rate system to restore a particular relationship between the *levels* of Mexican and U.S. money stocks.

The estimated coefficient of 0.29 on PP_{t-1} (t-value relative to zero of 2.6) reflects the hypothesized positive response of DM to an undervaluation of the currency. An undervaluation by 10 percent produces an increase of about three percentage points in next year's money growth rate.

It is of interest to compare the results from the overall 1948 to 1973 sample with those obtained solely from the fixed-rate period from 1955 to 1973. Over the latter period the estimated equation is

$$\begin{aligned} DM_t = {} & 0.091 + 0.10\,DM_{t-1} - 0.52\,DM_{t-2} - 0.26\,DM_{t-3} \\ & (0.075)\ (0.28)\qquad (0.27)\qquad (0.27) \\ & + 2.23\,DM_{US_t} + 0.32\,PP_{t-1} \\ & (1.26)\qquad (0.21) \end{aligned} \tag{6-3}$$

$$R^2 = 0.50,\ DW = 1.64,\ \hat{\sigma} = 0.037$$

Statistically, one cannot reject the hypothesis that the observations from 1948 to 1954 are generated by the same model (with the same coefficients) that generated the data over the fixed rate period from 1955 to 1973 (though there is little power in this test). Comparison of Equation (6-3) with Equation (6-1) indicates that the main difference is a higher coefficient for $\hat{DM}_{US}$ over the fixed rate period. Although this behavior is consistent with the view that Mexican money was more closely related to U.S. money during the fixed-rate period than during the devaluation period from 1948 to 1954, the high standard errors make it impossible to obtain any firm statistical evidence on this point. In any event there is no empirical evidence that would invalidate the use of Equation (6-1) over the entire period from 1948 to 1973.

The estimated values from Equation (6-1), denoted by $\hat{DM}_t$, are contained in Table 6-1, column 2. The residuals from this equation, $DMR_t \equiv DM_t - \hat{DM}_t$ (Table 6-1, column 3), are used in the subsequent analysis of Mexican output.

1.2 Behavior of Output

The equation for output (real gross domestic product in 1960 prices) includes the following variables:

1. Current and lagged values of money growth rates. One type of equation involves only the unanticipated part of money growth, $DMR \equiv DM - \hat{DM}$, as calculated from Equation (6-1). Another type includes the actual money growth rate, DM. In both cases values of money growth up to two annual lags turn out to be important.
2. A direct effect from the level of economic activity in the United States. This influence is measured by the (lagged) value of U.S. output (real gross national product in 1958 prices) relative to a time trend, $\tilde{y}_{US}$, as tabulated in Table 6-1, column 8. This variable captures effects of U.S. demand for Mexican output—particularly for invisible exports[3]—and would also proxy for influences that work through international capital markets. Empirically, only a one-year lag of $\tilde{y}_{US}$ was significant in the Mexican output equation. The inclusion of U.S. (unanticipated) money growth rates (with $\tilde{y}_{US}$ excluded) has effects that are similar though somewhat inferior in terms of fit, to those produced by $\tilde{y}_{US}$. This result suggests that the $\tilde{y}_{US}$ variable proxies partly for the effects of U.S. money on Mexican output and partly for the effects of other U.S. output influences on Mexican output.
3. The magnitude of departure from purchasing power parity, $|PP_t|$. The idea here is that these departures in either direction constitute relative price distortions[4] that would tend to depress output. The algebraic value of the departure, PP_t, turns out to be insignificant in the output equation.
4. A measure of Mexican terms of trade, (TT_t), (Table 6-1, column 10), which should have a positive effect on output.
5. A time trend variable, intended to hold constant the growth of "normal" output.

The estimated equation that includes DMR values from Equation (6-1) is, when estimated from annual observations for 1954 to 1973,

$$\log(y_t) = \underset{(0.22)}{2.70} + \underset{(0.12)}{0.23}\, DMR_t + \underset{(0.13)}{0.18}\, DMR_{t-1} \qquad (6\text{-}4)$$
$$+ \underset{(0.11)}{0.28}\, DMR_{t-2} + \underset{(0.14)}{0.57}\, \tilde{y}_{US_{t-1}} - \underset{(0.16)}{0.39}\, |PP_t|$$
$$+ \underset{(0.05)}{0.11}\log(TT_t) + \underset{(0.0009)}{0.0666} \cdot t,$$
$$R^2 = 0.9993,\ DW = 2.68,\ \hat{\sigma} = 0.0125,\ SSE^5 = 0.00188$$

A test for joint influence of the three *DMR* variables in Equation (6-4) yields the statistic, $F^3_{12} = 4.1$, which is significant at the 5 percent level (critical value = 3.5). Hence, there is evidence of a positive effect of Mexican money growth on Mexican output. The magnitude of the effect of an increase in unexpected money growth (*DMR*) by one percentage point per year that is sustained over a three-year period is determined by the sum of the three lag coefficients to be an increase in output by 0.7 percent.

There is also a strong positive effect on Mexican output from the lagged value of U.S. output relative to trend, $\tilde{y}_{US}$ (coefficient of 0.57, standard error = 0.14). Since my previous results for the United States (Barro, 1977, section III) indicated an effect of U.S. *DMR* values on $\tilde{y}_{US}$ with a sum of coefficients equal to 3.0, the implication is that U.S. unanticipated money growth affects Mexican output with a total coefficient of 1.7 (3.0 × 0.57). Hence, the effect of all unanticipated money growth (both U.S. and Mexican) on Mexican output involves a total coefficient of 2.4—that is, a sustained increase by one percentage point per year in all *DMR* values would raise output by 2.4 percent. This total value is similar to the magnitude found for the United States, although in the Mexican case only about 30 percent of the total effect of money on output is attributable to Mexican money.

Equation (6-4) indicates an important effect of the purchasing power parity variable in the hypothesized negative direction. The coefficient implies that a 10 percent deviation of Mexican prices from par value (or, equivalently, a 10 percent "error" in the exchange rate) reduces output by 4 percent. The symmetry of the |*PP*| variable should be stressed—that is, the undervaluation of the peso by 12 percent in 1956 is estimated to have the same depressing effect on output as the overvaulation by 12 percent in 1973. The effect of this variable is especially important for predictions (see below), since the 1974 value of the *PP* variable (Table 6-1, column 9) shows an overvaluation by 24 percent.

If the algebraic value of *PP* is added to Equation (6-4), it enters insignificantly although the |*PP*| variable remains significant. Hence, there is support for the view that the relative price distortions associated with exchange rate "errors" reduce output, but no support for the Keynesian notion that the aggregate demand influence of these errors—which would distinguish under- from overvaluation—is the important consideration.

Finally, Equation (6-4) also indicates a positive, though relatively minor, effect of the terms-of-trade variable on output. A 10 percent improvement in the terms of trade is estimated to produce a 1 percent increase in output.[6]

The fit of Equation (6-4) can be indicated by the value of $\hat{\sigma}$, which shows an estimation error for output of about ± 1-1/4 percent.[7] Values of output relative to the time trend are shown in Table 6-1, column 4, together with estimated values (column 5) and residuals (column 6) from Equation (6-4).

Equation (6-4), which was estimated through 1973, can be used to generate predictions for 1974 and beyond. For 1974 the predicted value of output relative to the time trend[8] is -0.028 (about three percentage points below trend)—as compared with an actual value of -0.032 relative to trend. Hence, the estimated equation performs well for 1974. The role of the |*PP*| variable in this prediction should be stressed: the value *PP* = -0.24 for 1974 implies a negative contribution of -9 percent to output (which more than offsets the direct positive contribution of the *DMR* variables[9] from 1973 and 1974). In other words the model implies on this count that a 25 percent devaluation—which would restore approximate purchasing power parity—would raise Mexican output by about 9 percent over what would have otherwise occurred.

For 1975 and 1976—assuming no change in the purchasing power parity and terms-of-trade variables and using *DMR* values of zero for 1975 and 1976—the predicted output values relative to trend are -0.059 and -0.093, respectively. Hence, the model predicts a period of strong contraction in the absence of a devaluation or major changes in money or the terms of trade. (The actual value of output relative to trend in 1975 turned out to be -0.057, which is remarkably close to the [ex ante] prediction. The results for 1976 probably were affected by the sharp devaluation of the peso and perhaps also by a shift in underlying purchasing power parity associated with an increased risk of political confiscation.)

An output equation based on actual money growth rates, *DM*, rather than on the unanticipated portion, *DMR*, is the following:

$$\log(y_t) = \underset{(0.19)}{2.84} + \underset{(0.10)}{0.29}\, DM_t + \underset{(0.09)}{0.5}\, DM_{t-1} + \underset{(0.09)}{0.20}\, DM_{t-2} \qquad (6\text{-}5)$$
$$+ \underset{(0.15)}{0.74}\, \tilde{y}_{US_{t-1}} - \underset{(0.16)}{0.35}\, |PP_t| + \underset{(0.04)}{0.08} \log(TT_t)$$
$$+ \underset{(0.0008)}{0.653} \cdot t,$$
$$R^2 = 0.9994, DW = 2.26, \hat{\sigma} = 0.0120, SSE = 0.00173$$

The fit of this output equation, based on the *DM*s, is slightly better than that based on the *DMR*s—although the main observation is that Equations (6-4) and (6-5) appear similar.[10] Hence, unlike the situation in the United States (Barro, 1977, section II.E), the calculation and use of the *DMR* variables is not important for the analysis of the link between money and output. However, it can be noted that Equation (6-5), which is based on *DM* values, does not perform as well for predicting 1974 output relative to trend—this predicted value is -0.019, as compared with the actual value of -0.032 and the predicted value from Equation (6-4) of -0.028.[11] It can also be observed that Equation (6-5) is similar to Equation (6-4) in respect to the effects of the $|PP|$ and TT variables although Equation (6-5) does suggest a somewhat larger impact of the $\tilde{y}_{US}$ variable.

The slightly poorer performance of the *DMR* output equation can be attributed to the presence of the PP_{t-1} variable in the *DM* relation, Equation (6-1).[12] If this variable is omitted, the *DM* equation over 1948 to 1973 becomes

$$DM_t = \underset{(0.034)}{0.129} + \underset{(0.21)}{0.20}\, DM_{t-1} - \underset{(0.20)}{0.30}\, DM_{t-2} - \underset{(0.19)}{0.32}\, DM_{t-3} \qquad (6\text{-}6)$$
$$+ \underset{(0.78)}{0.76}\, \hat{DM}_{US_t},$$
$$R^2 = 0.32, DW = 1.92, \hat{\sigma} = 0.049$$

With the *DMR* values based on the residuals from Equation (6-6), the output equation over 1954 to 1973 becomes

$$\log(y_t) = \underset{(0.16)}{2.85} + \underset{(0.09)}{0.27}\, DMR_t + \underset{(0.09)}{0.23}\, DMR_{t-1} \qquad (6\text{-}7)$$
$$+ \underset{(0.07)}{0.28}\, DMR_{t-2} + \underset{(0.11)}{0.67}\, \tilde{y}_{US_{t-1}} - \underset{(0.13)}{0.37}\, |PP_t|$$
$$+ \underset{(0.04)}{0.08} \log(TT_t) + \underset{(0.0007)}{0.0670} \cdot t,$$
$$R^2 = 0.9996, DW = 2.83, \hat{\sigma} = 0.0098, SSE = 0.00115$$

Although this equation fits better than Equation (6-5), which was based on *DM* values, this result does not provide much support to the idea that only the unanticipated part of money expansion, *DMR*, is relevant for output. If a readily available and apparently important money predictor such as a measure of departure from purchasing power parity is not incorporated into anticipated money growth, then there is not much content in the distinction between anticipated and unanticipated money movements. My conjecture is that a better procedure would be to look for some additional money growth predictors that were omitted from Equation (6-1), rather than deleting the PP_{t-1} variable. One candidate for an omitted variable is domestic holdings of international reserves relative to a target level of these reserves, which could reflect a policy response of the monetary authority. I have not yet explored this possibility.

2. COLOMBIA

2.1 Behavior of Money Growth

For the Colombian case the period since 1957 has been characterized by a flexible exchange rate at least in the sense that the rate has depreciated more or less continuously with the increases in the domestic price level relative to that in the United States. For the entire 1951 to 1972 period, an estimated money growth equation is[13]

$$DM_t = \underset{}{0.307} - \underset{(0.078)}{0.65}\, DM_{t-1} - \underset{(0.22)}{0.38}\, DM_{t-2} + \underset{(1.00)}{0.62}\, \hat{DM}_{US_t} + \underset{(0.037)}{0.64}\, PP_{t-1}, \qquad (6\text{-}8)$$

$$R^2 = 0.39,\ DW = 2.18,\ \hat{\sigma} = 0.043$$

This equation is similar to that estimated for Mexico in Equation (6-1) although in the Colombian case the negative lag pattern appears sooner and the $\hat{DM}_{US}$ and PP_{t-1} (Table 6-2, column 7) variables are quantitatively less important. The value of $\hat{\sigma}$ for Colombia is almost identical to that for Mexico.

Equation (6-8) implies that money growth in Colombia tends to return to a normal rate of about 16 percent per year ($\hat{DM}_{US}$ does not significantly affect this normal rate). The mean value of *DM* over 1949 to 1973 was, in fact, 0.160 per year with a standard deviation of 0.057. Values of *DM*, together with estimated values and residuals from Equation (6-8), are indicated in Table 6-2, columns 1 to 3.

A money growth equation for Colombia that is limited to the flexible exchange rate period from 1957 to 1972 is

Table 6-2. Colombia: Independent Variables and Predictions of Monetary and Real Growth

	(1) DM	(2) $\hat{DM}$	(3) DMR	(4) $\tilde{y}$	(5) $\hat{\tilde{y}}$	(6) $\tilde{y} - \hat{\tilde{y}}$	(7) PP	(8) P_x	(9) $\tilde{X}$
1949	0.202						-0.75	121	0.13
1950	0.042			0.020			-0.86	158	0.30
1	0.153	0.172	-0.019	0.023			-0.62	162	0.36
2	0.155	0.181	-0.026	0.061			-0.58	153	0.34
3	0.161	0.140	0.020	0.074	0.076	-0.002	-0.61	160	0.53
4	0.172	0.119	0.053	0.089	0.084	0.005	-0.70	205	0.59
1955	0.037	0.106	-0.068	0.073	0.068	0.005	-0.68	164	0.42
6	0.220	0.192	0.028	0.056	0.057	-0.001	-0.73	182	0.40
7	0.126	0.115	0.011	0.028	0.026	0.002	-0.31	156	0.18
8	0.118	0.135	0.054	-0.001	0.007	-0.008	0.01	129	0.02
9	0.108	0.157	-0.050	0.015	0.014	0.001	-0.02	110	0.01
1960	0.095	0.189	-0.094	-0.002	0.000	0.002	-0.09	108	-0.05
1	0.218	0.213	0.005	-0.001	-0.014	0.013	-0.15	103	-0.16
2	0.192	0.144	0.048	-0.002	-0.006	0.004	-0.12	97	-0.13
3	0.109	0.113	-0.004	-0.021	-0.023	0.003	-0.10	93	-0.21
4	0.186	0.180	0.006	-0.015	0.002	-0.017	-0.24	108	-0.05
1965	0.146	0.154	-0.008	-0.034	-0.010	-0.023	-0.15	105	-0.10
6	0.131	0.159	-0.028	-0.033	-0.033	-0.001	-0.01	98	-0.22
7	0.208	0.193	0.014	-0.048	-0.046	-0.003	0.02	85	-0.27
8	0.135	0.149	-0.014	-0.041	-0.040	-0.001	0.08	84	-0.24
9	0.199	0.178	0.021	-0.031	-0.039	0.008	0.11	83	-0.23
1970	0.202	0.163	0.039	-0.020	-0.021	0.001	0.13	96	-0.13
1	0.112	0.136	-0.023	-0.020	-0.032	0.012	0.14	82	-0.26
2	0.240	0.205	0.035	-0.005	-0.005	0.000	0.15	89	-0.09
3	0.268	0.149	0.119	0.011	0.026	-0.015	0.08	110	0.14
4		0.084							
1975		0.188							

$DM_t \equiv \log (M_t) - \log (M_{t-1})$, where M is annual money stock end of year—see the text-billions of pesos, from *IFS*. DM is an estimated value from Equation (6-8). $DMR \equiv DM - \hat{DM}$.

$\tilde{y}_t \equiv \log (y_t) - 2.445 - 0.0533 \cdot t$, where y is real gross domestic product in 1958 prices (*IFS*). $\hat{\tilde{y}}$ is an estimated value from Equation (6-12).

PP is the official exchange rate (*IFS*) times a ratio of the U.S. GNP deflator (1958 base) to the Colombian GDP deflator (*IFS*, 1958 base). The variable is measured relative to its mean value from 1958 to 1973.

P_x is a U.S. dollar index of export prices (*IFS*, 1963 base) divided by the United States GNP deflator.

$\tilde{X}_t \equiv \log (X_t) - 5.829 - 0.0256 \cdot t$, where X is exports in millions of U.S. dollars (*IFS*) divided by the United States GNP deflator.

$$DM_t = \underset{(0.092)}{0.264} - \underset{(0.29)}{0.64}\, DM_{t-1} - \underset{(0.27)}{0.38}\, DM_{t-2} + \underset{(1.47)}{1.56}\, \hat{DM}_{US_t} + \underset{(0.081)}{0.006}\, PP_{t-1}, \tag{6-9}$$

$$R^2 = 0.37,\ DW = 2.07,\ \hat{\sigma} = 0.043$$

Not surprisingly, the effect of PP_{t-1}—which appeared weakly in Equation (6-8)—vanishes when the fixed exchange rate years are removed from the sample. (Although the $\hat{DM}_{US}$ coefficient is actually higher in Equation (6-9) than in equation (6-8), the large standard errors suggest that nothing can be inferred from this result.) The negative coefficients on DM_{t-1} and DM_{t-2} remain even when the sample is limited to the flexible exchange rate period.

2.2 Behavior of Output

For the purpose of explaining output in Colombia, it turns out to make little difference whether Equation (6-8) or Equation (6-9) is used to generate unanticipated money growth, *DMR*. In fact, I have been unable to isolate any monetary effects on output for Colombia. A typical result for output, using Equation (6-8) to calculate *DMR*s and including $\tilde{y}_{US}$ and a measure of real exports relative to a time trend, $\tilde{X}$, (Table 6-2, column 9) as explanatory variables, is (for the 1953 to 1972 period)[14]

$$\log(y_t) = \underset{(0.01)}{2.44} - \underset{(0.07)}{0.06}\, DMR_t - \underset{(0.06)}{0.03}\, DMR_{t-1} - \underset{(0.07)}{0.09}\, DMR_{t-2} - \underset{(0.08)}{0.20}\, \tilde{y}_{US_{t-1}} + \underset{(0.02)}{0.17}\, \tilde{X}_t + \underset{(0.0008)}{0.0538} \cdot t, \tag{6-10}$$

$$R^2 = 0.9992,\ DW = 1.51,\ \hat{\sigma} = 0.0095,\ SSE = 0.00118$$

The *DMR* variables are insignificant with the wrong sign and the $\tilde{y}_{US}$ variable also appears with the "wrong" sign. My expectation in regard to the U.S. output variable was that its effect on Colombian output would be smaller than in the case of Mexico because of the weaker direct connection between the Colombian and U.S. economies. However, the negative sign on $\tilde{y}_{US}$ is difficult to understand. Otherwise, the only variable other than the time trend that shows up strongly is the export variable—the exogeneity of which can be questioned.[15]

The output results are similar when *DM* is substituted for *DMR*:

$$\log(y_t) = \underset{(0.02)}{2.45} - \underset{(0.06)}{0.01}\, DM_t + \underset{(0.07)}{0.01}\, DM_{t-1} + \underset{(0.06)}{0.01}\, DM_{t-2} \qquad (6\text{-}11)$$
$$- \underset{(0.08)}{0.20}\, \tilde{y}_{US_{t-1}} + \underset{(0.02)}{0.16}\, \tilde{X}_t + \underset{(0.0009)}{0.533} \cdot t,$$
$$R^2 = 0.9991,\ DW = 1.26,\ \hat{\sigma} = 0.0102,\ SSE = 0.00135$$

When the monetary variables are excluded entirely the output equation becomes

$$\log(y_t) = \underset{(0.01)}{2.45} - \underset{(0.08)}{0.20}\, \tilde{y}_{US_{t-1}} + \underset{(0.02)}{0.16}\, \tilde{X}_t + \underset{(0.0007)}{0.0533} \cdot t, \qquad (6\text{-}12)$$
$$R^2 = 0.9991,\ DW = 1.32,\ \hat{\sigma} = 0.0092,\ SSE = 0.00136$$

Actual and estimated values of output relative to the time trend from Equation (6-12) are shown in Table 6-2, columns 4 to 6. Although this equation has a low value of $\hat{\sigma}$—indicating an estimation error for output of only about ± 1 percent—the sign of $\tilde{y}_{US}$ is peculiar and most of the "explanatory" power comes from the export variable.

I have very little useful to say about the Colombian output results. One possibility is that there really is no Phillips curve type of relation between money and output in Colombia. Another, and more probable, explanation is that such a relation exists, but I have not been able to isolate it. One excuse is the quality of the data. Anecdotal evidence supports the view that measured real output in Colombia has little to do with actual output.[16] Of course, it is always convenient to blame the data when empirical results are unsuccessful. Another possibility is that the monetary data refer to the end of each year rather than, as perhaps would be more appropriate, annual averages. Hanson (1976) reports somewhat better results when annual average figures are used.

3. BRAZIL

The Brazilian case is much more extreme than the previous two in terms of the mean and variability of money growth (the average value of *DM* over 1949 to 1973 is 0.295 per year with a standard deviation of 0.129). Furthermore, except for 1949 to 1951, the period is characterized by continuous and rapid devaluation of the exchange rate. Not surprisingly, the U.S. money behavior and an index of departure from purchasing power parity have no impact on Brazilian money growth. There is also no indication of the negative

serial correlation in the *DM* series that characterized the money processes for Mexico and Colombia.[17] In fact, the only useful predictor for Brazilian money growth that I have been able to isolate is the previous year's money growth rate. The equation for the 1950 to 1972 period is

$$DM_t = \underset{(0.14)}{0.08} + \underset{(0.13)}{0.76}\, DM_{t-1}, \qquad (6\text{-}13)$$

$$R^2 = 0.62, DW = 1.79, \hat{\sigma} = 0.081$$

Equation (6-13) implies a normal money growth rate of about 32 percent per year. The positive coefficient of DM_{t-1} implies that values of *DM* above the norm tend to be followed by additional above-normal years—that is, there is no tendency for the money stock to return to a normal level relative to trend. The value of $\hat{\sigma}$ for Brazil is about twice as high as those estimated for Mexico and Colombia. Values of *DM* for Brazil, together with estimated values and residuals from Equation (6-13), are indicated in Table 6-3, columns 1 to 3. Since the money growth equation contains only a lagged value of *DM*, there is little distinction that can be made between using *DMR* and *DM* values to explain fluctuations in output.[18]

An output equation for Brazil is the following:[19]

$$\log(y_t) = \underset{(0.03)}{5.22} + \underset{(0.09)}{0.11}\, DMR_t - \underset{(0.23)}{1.16}\, \tilde{y}_{US_{t-1}} + \underset{(0.04)}{0.18}\, \tilde{X}_t + \underset{(0.0013)}{0.0569} \cdot t, \qquad (6\text{-}14)$$

$$R^2 = 0.996, DW = 1.44, \hat{\sigma} = 0.027, SSE = 0.0119$$

where $\tilde{X}$ is a measure of real exports relative to a time trend (Table 6-3, column 9). Additional lagged values of *DMR* are insignificant. The results are similar to those found for Colombia in Equation (6-10) in terms of the unexpected negative sign on the $\tilde{y}_{US}$ coefficient (though the Brazilian coefficient is much higher in magnitude) and the highly significant positive effect of $\tilde{X}$. However, DMR_t does appear weakly with a positive sign for Brazil,[20] and the value of $\hat{\sigma}$ is almost three times as high as that for Colombia. In a sense the higher value of $\hat{\sigma}$ for Brazil makes it more plausible that the measured real output series is reflecting some real phenomena unlike the situation in the Colombian case.

The appearance of a weak reduction between money and output in Brazil is not surprising, given the large prediction variance for *DM*

Table 6-3. Brazil: Independent Variables and Predictions of Monetary and Real Growth

	(1) DM	(2) $\hat{DM}$	(3) DMR	(4) $\tilde{y}$	(5) $\hat{\tilde{y}}$	(6) $\tilde{y} - \hat{\tilde{y}}$	(7) PP	(8) P_x	(9) X
1949	0.120			0.044			-0.14	122	0.74
1950	0.216	0.170	0.047	0.038			-0.13	172	0.88
1	0.143	0.242	-0.099	0.027			-0.27	193	1.01
2	0.210	0.187	0.023	0.043	0.027	0.016	-0.19	186	0.71
3	0.169	0.237	-0.068	-0.001	0.027	-0.028	-0.11	178	0.72
4	0.195	0.206	-0.012	0.027	0.015	0.012	0.06	205	0.65
1955	0.175	0.226	-0.051	0.025	0.039	-0.015	0.08	161	0.48
6	0.187	0.211	-0.024	-0.012	-0.008	-0.004	-0.10	149	0.42
7	0.211	0.220	-0.009	-0.003	-0.014	0.011	-0.14	147	0.26
8	0.289	0.238	0.050	0.003	-0.016	0.019	0.26	132	0.05
9	0.240	0.297	-0.057	-0.011	0.020	-0.031	-0.09	110	0.00
1960	0.327	0.260	0.067	0.013	-0.011	0.023	-0.12	106	-0.09
1	0.367	0.326	0.041	0.042	0.006	0.037	0.00	110	-0.07
2	0.433	0.356	0.077	0.025	-0.009	0.034	0.12	95	-0.29
3	0.458	0.406	0.052	-0.028	-0.029	0.001	-0.02	93	-0.22
4	0.622	0.426	0.196	-0.068	-0.026	-0.041	-0.03	110	-0.28
1965	0.606	0.550	0.057	-0.109	-0.055	-0.054	0.15	109	-0.26
6	0.337	0.538	-0.201	-0.128	-0.112	-0.016	0.07	102	-0.26
7	0.278	0.334	-0.056	-0.149	-0.152	0.002	0.02	98	-0.41
8	0.353	0.289	0.064	-0.137	-0.120	-0.017	0.03	96	-0.39
9	0.280	0.346	-0.066	-0.106	-0.127	0.021	0.12	94	-0.29
1970	0.249	0.290	-0.041	-0.085	-0.103	0.018	0.10	91	-0.24
1	0.266	0.267	-0.011	-0.046	-0.059	0.013	0.13	93	-0.30
2	0.292	0.280	0.012	-0.015	-0.013	-0.002	0.12	99	-0.07
3	0.358	0.299	0.059					131	0.25
4		0.349							
1975									

Table 6-3 continued

$DM_t \equiv \log (M_t) - \log (M_{t-1})$, where M is an annual average of the money stock in millions of Cruzeiros (*IFS*). DM is an estimated value from Equation (6-13). $DMR \equiv DM - DM$.

$\tilde{y}_t \equiv \log (y_t) - 5.257 - 0.0684 \cdot t$, where y is real gross domestic product in billions of 1949 Cruzeiros (*IFS*). $\hat{\tilde{y}}$ is an estimated value from Equation (6-14).

PP is the exchange rate (*IFS* trade conversion factor since 1959; earlier figures correspond to estimates of free market rates, as reported in *IFS*) times a ratio of the U.S. GNP deflator (1958 base) to the Brazilian GDP deflator (*IFS*, 1949 base).

P_x is an index of export prices in U.S. dollars (1963 base) divided by the U.S. GNP deflator.

$\tilde{X}_t \equiv \log (X_t) - 6.352 - 0.0654 \cdot t$, where X is exports in billions of U.S. dollars divided by the U.S. GNP deflator.

in Equation (6-13). The analysis of Lucas (1973) and Barro (1976) predicts that the magnitude of a given *DMR* stimulus on output would diminish as the predictability of *DM* increases. In this respect, and aside from the unexplained negative coefficient on $\tilde{y}_{US}$ in Equation (6-14), the Brazilian results are less difficult to understand than those for Colombia.

4. CONCLUSIONS

Although the model has some explanatory power for the money supply processes in Mexico and Colombia, and some predictive value for output in Mexico, the main results of this study are disappointing. The output results for Colombia and Brazil are not very useful and those for Mexico do not support the U.S. finding that the switch from actual to unanticipated money growth is an important empirical concept. In the Mexican case the results may improve by an extension of the money growth equation to include variables like the reserve stock and the behavior of government spending (if useful data on the latter can be constructed). It may also be useful to extend the sample period for output back to 1948. For Colombia and Brazil I am less hopeful that the output results can be improved.

It may be more useful to extend the empirical analysis by considering some additional cases instead of refining the results for the present three. Venezuela would be an interesting case because of the relative stability in its money and price behavior. At the other extreme it would be of interest to see whether the Argentine and Chilean cases appear similar to the Brazilian experience. If a money/output relation were satisfactorily isolated for a number of countries, it would be possible to carry out a test of the Lucas proposition that the magnitude of the Phillips curve slope diminishes when money and prices become less predictable. There was some indication of this effect from a comparison of Mexico and Brazil, but the present results are surely inconclusive in this respect.

NOTES

1. Alternatively, the underlying determinants of $\hat{DM}_{US_t}$—which were lagged money growth in the United States, a measure of the government budget in the United States, and a lagged value of the United States unemployment rate—could have been entered into the Mexican money growth equation. This alternative entails an unnecessary loss of degrees of freedom.

2. *DW* is the Durbin-Watson statistic for serial correlation of the residuals (which is not very useful for an equation that contains a lagged dependent variable) and $\hat{\sigma}$ is the estimated standard error of the disturbance term.

3. The $\tilde{y}_{US}$ variable does not have a significant effect on real Mexican exports as measured—see note 6 below. Furthermore, real exports do not have a significant effect on Mexican output, given the other variables that are included in Equation (6-4) below.

4. Some of these distortions could be the result of government policies associated with maintaining the "wrong" exchange rate.

5. *SSE* is the error sums of squares for the equation.

6. As indicated in note 3 above, a real export variable does not enter significantly when added to Equation (6-4). An equation to "explain" real exports is the following:

$$\log(X_t) = \underset{(2.31)}{-0.82} + \underset{(0.7)}{1.6}\, DMR_t + \underset{(0.9)}{1.1}\, DMR_{t-1} + \underset{(0.7)}{1.2}\, DMR_{t-2} + \underset{(0.79)}{0.06}\, \tilde{y}_{US_{t-1}} - \underset{(1.05)}{0.04}\, PP_t + \underset{(0.30)}{0.54}\log(TT_t) + \underset{(0.010)}{0.031}\, t,$$

$$R^2 = 0.83,\ DW = 1.69,\ \hat{\sigma} = 0.086$$

The three *DMR* variables together appear significantly in this equation ($F^3_{12} = 4.2$, 5 percent critical value = 3.5) although the mechanism by which *DMR* affects exports positively is not apparent.

7. The Durbin-Watson statistic indicates absence of positive serial correlation in the residuals. A lagged value of y is not significant when added to Equation (6-4).

8. Assuming that the terms-of-trade index remains at its 1973 value, but using the 1974 value of *DMR* = 0.097.

9. In a complete model that included price determination, there would also be an effect of cumulated monetary experience on the *PP* variable (assuming the maintenance of a fixed exchange rate).

10. An output equation with the *DMR*s and *DM*s included simultaneously yields an *SSE* of 0.00085. Based on this value, a test that (all three of) the *DMR*s are irrelevant to the determination of output, given the inclusion of the *DM*s, yields the statistic, $F^3_9 = 3.1$, which is less than the 5 percent critical value of 3.9. Similarly, a test that the *DM*s are irrelevant, given the inclusion of the *DMR*s, yields $F^3_9 = 3.6$. The implication is that either the *DMR*s or the *DM*s (but not both sets of variables) can be deleted without significantly affecting the fit.

11. Equation (6-5) also predicts a substantially larger contraction of output relative to trend for 1975 and 1976 if the very low values of $\hat{DM}$ (Table 6-1, column 2) for 1975 and 1976 are used in these calculations. The predicted value for output relative to trend in 1975 is -0.107 and that for 1976 is -0.150. (Recall that the actual value for 1975 is -0.057.)

12. In my earlier study of Mexico (Barro, 1975), the PP_{t-1} variable was not included in the *DM* equation.

13. A measure of government expenditures relative to "normal," the type of

variable that was important in my study for the United States, did not enter significantly when added to Equation (6-8).

14. The $|PP_t|$ variable is insignificant when added to Equation (6-10), as is an export price index, P_x (Table 6-2, column 8). A lagged value of y added to Equation (6-10) has a coefficient of 0.25, standard error = 0.15.

15. When the $\tilde{X}$ variable is omitted the output equation becomes

$$\log(y_t) = \underset{(0.12)}{2.54} + \underset{(0.16)}{0.11}\, DMR_t + \underset{(0.14)}{0.09}\, DMR_{t-1} + \underset{(0.15)}{0.12}\, DMR_{t-2} + \underset{(0.18)}{0.15}\, \tilde{y}_{US_{t-1}} + \underset{(0.0010)}{0.0476} \cdot t$$

$$R^2 = 0.9947, DW = 0.72, \hat{\sigma} = 0.024, SSE = 0.00809$$

Although the DMR and $\tilde{y}_{US}$ variables have the "right" signs here, they are all insignificantly different from zero ($F^3_{14} = 0.3$ for the three DMR variables simultaneously). Furthermore, the deletion of the $\tilde{X}$ variable has a dramatically negative effect on the fit. An equation to "explain" exports is

$$\log(X_t) = \underset{(1.39)}{2.68} + \underset{(0.67)}{0.25}\, DMR_t + \underset{(0.56)}{0.43}\, DMR_{t-1} + \underset{(0.62)}{0.41}\, DMR_{t-2} + \underset{(0.76)}{0.44}\, \tilde{y}_{US_{t-1}} - \underset{(0.18)}{0.25}\, PP_t + \underset{(0.27)}{0.66}\, P_{x_t} + \underset{(0.0096)}{0.0256} \cdot t,$$

$$R^2 = 0.82, DW = 0.93, \hat{\sigma} = 0.089$$

where P_x is an export price index (Table 6-2, column 8). The three DMR variables are jointly insignificant in this equation ($F^3_{12} = 0.3$).

16. One such anecdote is that output predictions and ex post measurements of output are made by the same persons. It turns out that only small modifications are ever required in the measurement stage. This story may also explain the low value of $\hat{\sigma}$ in Equation (6-12).

17. In this respect the monetary behavior in Brazil is similar to that found earlier for the United States. See Barro (1977, section II.B).

18. A form with DMR values would be equivalent to a (restricted) form with DM values that contained one additional lag term. However, the pattern of money growth rate coefficients in the output equation would be affected by the switch from DMR to DM.

19. An export price index, P_x (Table 6-3, column 8), and an index of departure from purchasing power parity, $|PP_t|$ (Table 6-3, column 7), are insignificant, given the inclusion of the export variable, $\tilde{X}$. An estimated equation for exports is

$$\log(X_t) = \underset{(1.5)}{0.2} - \underset{(0.35)}{0.61}\, DMR_t + \underset{(0.36)}{0.01}\, DMR_{t-1} - \underset{(1.26)}{1.52}\, \tilde{y}_{US_{t-1}} - \underset{(0.27)}{0.37}\, PP_t + \underset{(0.29)}{1.52}\, P_{x_t} + \underset{(0.011)}{0.070} \cdot t,$$

$$R^2 = 0.80, DW = 1.34, \hat{\sigma} = 0.110$$

20. With DM_t substituted for DMR_t the output results are

$$\log(y_t) = \underset{(0.04)}{5.26} - \underset{(0.07)}{0.08}\, DM_t - \underset{(0.22)}{1.32}\, \tilde{y}_{US_{t-1}} + \underset{(0.04)}{0.14}\, \tilde{X}_t + \underset{(0.0013)}{0.0577} \cdot t,$$

$$R^2 = 0.996, DW = 1.91, \hat{\sigma} = 0.027, SSE = 0.0120$$

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