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ANTICIPATED MONEY, INFLATION UNCERTAINTY AND REAL ECONOMIC ACTIVITY

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ABSTRACT

ANTICIPATED MONEY, INFLATION UNCERTAINTY AND REAL ECONOMIC ACTIVITY

This paper critically examines a number of maintained hypotheses that are necessarily being tested along with the basic notion derived from the rational expectations (RE) formulation of Lucas (1972) (1973) that "only unanticipated money matters." The trend stationary representation of secular real output of Lucas and others is replaced by a difference stationary representation found by Nelson and Plosser (1980) to be consistent with U. S. historical data. The impact of inflation uncertainty on real activity is considered. Attention is paid to possible mis-measurement of agents' *ex ante* anticipated money growth. It is found that three alternative measures of anticipated money growth produce a stable impact on growth of output and employment. Contemporaneous and lagged values of unanticipated money growth have no significant additional explanatory power in the presence of any one of the three measures of anticipated money growth. Beyond this, it is impossible to reject the hypothesis that the initial positive real impact of anticipated money is *not* temporary. Inflation uncertainty is found to act as a significant depressant of real economic activity in the presence of all tested combinations of anticipated and unanticipated money growth.

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ANTICIPATED MONEY, INFLATION UNCERTAINTY AND REAL ECONOMIC ACTIVITY

Summary

The prevailing view in neoclassical macroeconomics propounded by Lucas (1973) and others, termed the RE hypothesis here, holds that only a current monetary surprise will elevate the current level of real economic activity. If the Lucas specification is modified, following Nelson and Plosser (1980) so that real output or employment is assumed to follow difference stationary process rather than a trend stationary process, the main implication of the RE hypothesis becomes that a current monetary surprise should produce an impact on the current rate of change of real economic activity that is completely reversed after a lag of one period.

This study finds that three alternative measures of ex post anticipated money growth produce a stable impact on employment growth and output growth in the United States over a 1953-75 sample period.[11] Beyond this, it is impossible to reject the hypothesis that the initial, positive real impact of anticipated money is not temporary.

The impact of anticipated money growth on employment growth and output growth also dominates the impact of contemporaneous and lagged "surprises" in money growth. In the presence of anticipated money growth and inflation uncertainty, contemporaneous and lagged "surprises" persistently failed F-tests for joint significance. A contemporaneous monetary surprise by itself also proved insignificant in the presence of anticipated money growth and inflation uncertainty.

The discussion in Section 1 of possible bias arising from an investigator's mismeasurement of true anticipated money growth as seen by economic agents within a given sample period reveals that non-neutrality discovered in Section 2 cannot be fully explained by appeal to such mismeasurement. If anything, implications of possibly biased measures of anticipated (and thereby of unanticipated) money only enhance damage to the RE hypothesis implicit in empirical findings reported in Section 2. In no case where RE holds, with either omitted or redundant variables in the investigator's measure of anticipated money growth should, as in findings reported here, the estimated coefficient on anticipated money be significantly larger than that on unanticipated money.

To the conclusions reported here regarding real effects of anticipated money, which must be termed highly improbable under the RE hypothesis, can be added the finding that a rise in inflation uncertainty as measured by Livingston survey data significantly depresses real economic activity. This result is robust, appearing in virtually all formulations of tests of the RE hypothesis conducted for this study. While suggested by earlier writers including Keynes and Friedman, the precise manner in which inflation uncertainty acts to depress economic activity is not at present well understood. Considerable research remains to be done in order to develop a fuller understanding of this phenomenon.

In sum, results presented here force one to consider rejection of the core of RE that only surprises matter. Some investigators including Poole (1976), Gordon (1979) and Friedman (1979) have suggested that costly information may provide some basis for this alternative. More careful measurement and testing will be required to resolve the issue.

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This paper critically examines a number of maintained hypotheses that are necessarily being tested along with the basic notion derived from the rational expectations (RE) formulation of Lucas (1972, 1973) that "only unanticipated money matters." The need for further investigation of RE along these lines is suggested by results obtained by Small (1979), Mishkin (1980) and Darby (1980) in empirical investigations of RE stimulated by the pioneering work of Lucas, Barro (1977, 1979), Sargent and Wallace (1976) and others.

Implications of three maintained hypotheses implicit in most existing empirical tests of RE are considered. First examined is the assumption that the natural level of output is a trend stationary process as represented by Lucas (1973). The implicit assumption that the effect of a monetary surprise can be measured without holding constant the degree of *ex ante* uncertainty about future prices is examined next. Work by Levi and Makin (1979, 1980) and by Mullineaux (1980) strongly suggests the importance of controlling for inflation uncertainty when estimating "real" effects of monetary surprises.

The third, and perhaps most troublesome assumption employed in empirical investigation of the RE hypothesis, requires that the investigator's measure of anticipated money, usually derived employing data from the *entire* sample period under investigation, be equal to that actually employed by decision makers *within* the sample period under investigation.[1] Failure to satisfy this condition can produce biased estimates of coefficients on anticipated and unanticipated money growth terms employed in an equation which properly tests the RE hypothesis. The corollary is that "anticipated" money properly specified ought to leave residuals which "matter" in a properly formulated test of the RE hypothesis. However, failure of numerous "anticipated" money filters to leave residuals which dominate the real effects of anticipated money would constitute evidence damaging to the RE hypothesis if an investigator were willing ex ante to grant that the filters had been carefully constructed so as to leave residuals which displayed no systematically predictable behavior.

Formulation and execution of empirical tests of the RE hypothesis based upon attention to maintained hypotheses embodied in earlier studies occupies most of this paper. Section 1 examines further the hypotheses which must be maintained jointly along with the RE hypothesis if empirical tests are to be implemented. This examination suggests a modified formulation for tests of the RE hypothesis presented in Section 2. The tests reveal that, in the presence of "anticipated" money, "unanticipated" money has no additional explanatory power in equations describing growth of employment and real output. Possible reasons for this result are explored. Section 3 presents some concluding remarks.

1. Maintained Hypotheses in Empirical Tests of the RE Hypothesis

RE is usually represented as:[2]

$$y_t = y_{nt} + \gamma[p_t - p_t^e] + u_t \tag{1}$$

$$y_{nt} = \alpha + \beta t \tag{2}$$

where

y_t = log of actual real output or employment at time t.

y_{nt} = log of the natural level of output as a deterministic trend where t = "time," α = a constant.

p_t = log of the "price level."

p_t^e = log of expected price level at time t, conditional on information at time t-1.

u_t = error term.

Formulations by Lucas (1973), Cukierman and Wachtel (1979) and Froyen and Waud (1980) identify a cyclical component of real output, y_{c_t}, as the residual from the trend line $y_t = \tilde{\alpha} + \tilde{\beta}t$ fit by least squares for the relevant sample period. Identification of the cyclical component of real output under this view requires the assumption that estimation of a real output equation, where real output is represented as a deterministic trend line leaves stationary residuals which measure the cyclical component of real output. Discussion below considers implications which may arise if, as suggested by empirical investigation of U.S. macroeconomic time series data, this assumption is not correct.

Real Output as a Trend Stationary Process

Equations (1) and (2) suggest that real output can be written as a trend stationary process (TSP)

$$y_t = \alpha + \beta t + e_t \tag{1'}$$

where $\alpha + \beta t$ measures the stable mean of the long term forecast of y_t and the error term e_t captures the cyclical component of real output ($e_t = y_{c_t} = (p_t - p_t^e) + e_{1_t}$). Nelson and Plosser (1980) have shown that if a variable like y_t actually follows a difference stationary process (DSP), the simplest example being a random walk, instead of the TSP indicated by (1'), a misspecifiaation results which has important implications for tests of RE.

Writing y_t as a DSP:

$$(1 - L)y_t = \beta + d_t; \; \delta(L)d_t = \lambda(L)v_t; \tag{3}$$

where (1 - L) is the difference operator, v_t is distributed normally with zero mean and finite variance δ_v^2 and $\delta(L)$ and $\lambda(L)$ are polynomials satisfying stationarity and invertibility conditions. Taking the simplest formulation of (3), the random walk suggested by empirical evidence of Nelson and Plosser, the rate of change of output becomes stochastic $[(y_t - y_{t-1}) = \beta + d_t]$ and:

$$y_t = y_o + \beta t + \sum_{j=1}^{t} d_j \tag{4}$$

Suppose now that (1'), the usual output representation, is employed in place of (4). It is true that both formulations represent y_t as a linear function of time plus the deviation from it. But y_o, the intercept in (4) depends on historical events and the deviations from trend are nonstationary rather than stationary as in (1').

Nelson and Plosser (1980) are unable to reject the hypothesis that most long-run time series from U.S. macroeconomic variables, including real GNP (1909-1970), industrial production (1860-1970) and employment (1890-1970), are approximated by a random walk. This finding carries implications for existing tests of the RE hypothesis over finite sample periods like the 1953-1967 period investigated by Lucas or the 1940-1975 period investigated by Barro. Since y_o depends on historical events this may account for inclusion of lagged y_c terms to capture persistence effects as in Lucas (1973) or the military conscription, minimum wage and other variables included by Barro (1978). The long distributed lag on money surprises may also be proxying for historical events operating on y_o.

If time series evidence suggests that y is a difference stationary process (specifically, a random walk) empirical tests of (1) ought to be in first-difference form. Then (where $e_{1_t} = e_{1_{t-1}} + u_t$)

$$(y_t - y_{t-1}) = \beta + \gamma(p_t - p_t^e) - \gamma(p_{t-1} - p_{t-1}^e) + u_t \qquad (5)$$

Equation (5) reflects, beyond accommodation of output as a difference stationary process, the fact that a monetary surprise will, according to the RE hypothesis, produce only a temporary rise in output or employment growth above its natural level, β. There is no specific hypothesis about the calendar time actually required to move from "t-1" to "t" in equation (5). This question is investigated empirically in Section 2.

Inflation Uncertainty and Real Economic Activity

There is a growing body of literature on the effect of inflation uncertainty on real economic activity. Evans (1978) cites arguments by Keynes (1924) and Friedman (1977) that volatility of the inflation rate depresses economic activity. Evans' own finding is that his measure of monetary (inflation) uncertainty depresses employment. Empirical studies by Levi and Makin (1979, 1980) and by Mullineaux (1980) have found that inflation uncertainty measured by a high variance of inflationary expectations across Livingston survey respondents is both positively correlated with inflation "surprises" and has a significant negative impact on real variables. These results are tied to earlier works by the finding of Cukierman and Wachtel (1979), employing Livingston and SRC survey data, that large variance in inflation is associated with large variance of inflationary expectations across survey respondents. Taken together, this body of literature suggests that a measure of inflation uncertainty ought to be included in tests of the RE hypothesis and further, that in view of the extant positive correlation between inflation uncertainty and monetary surprises (see Levi and Makin (1980)) omission of inflation uncertainty from tests of the RE hypothesis could introduce bias implicit in an omitted variable problem.

The specific effect of inflation uncertainty hypothesized here is a negative impact on the rate of change of output, represented as:

$$y_t = y_{t-1} + \beta - \phi\sigma_t + d_t \qquad (3')$$

where $\phi > 0$

σ_t = a measure of inflation uncertainty.

$d_t = y_{c_t} - y_{c_{t-1}} + d_{1_t}$.

This formulation implies that more inflation uncertainty and attendant phenomena such as more variability of relative prices, possible reduction in specialization and shortening of optimal duration for contracts written in nominal terms can permanently depress the level of real activity. This result is consistent with the permanent impact of variability of monetary phenomena upon the average level of unemployment suggested by Azariadis (1977). It is also consistent with a negative impact of inflation uncertainty upon investment derived by Cox, Ingersoll and Ross (1977) and with indirect empirical evidence of the same phenomenon reported by Levi and Makin (1979). If investment drops, so does the rate of growth of the capital stock, and thereby output growth would be expected to fall.

The formulation suggested by (3') is investigated empirically in Section 2 employing the exogenous Livingston survey measure of inflation uncertainty.

Implications of Inappropriate Measures of Anticipated Money

Testing of the RE hypothesis that only anticipated money matters requires presence of the investigator's measures of both unanticipated and anticipated money in an equation describing economic activity. It is implicitly assumed that the measure of anticipated money, usually derived employing data from the entire sample period under investigation, is equal to that actually employed within the sample period under investigation by rational decision makers. Failure to satisfy this assumption can lead to spurious inferences regarding the effects of unanticipated and anticipated money growth.

If the investigator erroneously omits a variable actually used to forecast money growth from his own money growth equation, part of the investigator's surprise is really anticipated. The estimated coefficient on the mismeasured surprise will be biased toward zero assuming validity of the RE hypothesis that the (anticipated part of) the investigator's surprise has no impact on real activity. The estimated coefficient on the remainder of the investigator's measure of anticipated money growth will however be unbiased and should equal zero under the RE hypothesis.

Correcting for an omitted variable in the investigators anticipated money growth equation can also have important implications for validity of the RE hypothesis. In his comment on Barro (1977), Small (1979) found that the explanatory power of Barro's surprises fell sharply when correction was made for an omitted variable in Barro's anticipated money growth equation. Since Barro's exclusion of a predictor of money growth made part of his surprise predictable Small concluded: "Thus, if anything, Barro has provided evidence that _anticipated_ changes in monetary policy affect unemployment in the short run." (p. 1000).[3] The basic point is that inferences about validity of the RE hypothesis are conditional upon an accurate measure of economic agents' anticipated money growth during the sample period under investigation.

Another possibility is that the investigator employs a predictor of anticipated money growth not actually employed by economic agents in their true anticipated money growth equation. Such a predictor might either not be available to or be undiscovered by economic agents within the sample period. An example would be use of current instead of lagged explanatory variables in a money growth prediction equation. This practice, followed by a number of investigators, is criticized by Mishkin (1980). In this case part of the investigator's anticipated money growth is really a surprise and the coefficient on it is biased away from the zero value which would result given the RE hypothesis. The coefficient on the investigator's surprise will be an unbiased estimate of the impact of unanticipated money growth on real economic activity. The corollary proposition is that if the RE hypothesis is valid, a significant impact upon real activity of an investigator's measure of anticipated money can only result from inclusion of a superfluous predictor in the anticipated money growth equation.

Superfluous variables in the investigator's equation predicting money growth won't disturb the conclusion that surprises matter (given satisfaction of the RE hypothesis). However, if only the investigator's surprises are included in the equation explaining real activity as in Small (1979) and some equations estimated by Barro (1977), there is no test of whether it is <u>only</u> surprises which matter.

The preceding discussion reveals two possible reasons why an investigator's measure of anticipated money may affect real economic activity. First, apparent nonneutrality may result if the investigator includes a predictor of money growth in his equation that was not actually employed by economic agents during the sample period under investigation. In such a case part of the investigator's anticipated money growth would actually be a surprise. If neutrality holds, the coefficient on the investigator's measure of anticipated money growth ought, as a weighted average of zero and the coefficient on true surprises, to lie below the (unbiased) coefficient on the investigator's surprise term.

The second possible reason for nonneutrality is a violation of the RE hypothesis. Further, if the investigator's estimated coefficient on anticipated money growth is larger than that on unanticipated money growth, the implication is that the impact on real activity of true *ex ante* anticipated money growth outweighs that of true unanticipated money growth. This inference holds if either a true predictor of money growth is excluded from the investigator's equation or a redundant predictor is included.

2. The Impact of "Anticipated" and "Unanticipated" Money Growth on Growth of Employment and Output

Testing Format: Short Run

The discussion in Section 1 implies some modification of typical, empirical tests of the RE hypothesis. The dependent variables should be the rate of change of some index of "real" economic activity. In the short run, a monetary surprise ought to produce a rise in the rate of change in such real activity. Over the long run the net effect should be zero. Tests of the RE hypothesis should hold constant the level of inflation uncertainty and include measures of anticipated and unanticipated money growth simultaneously in equations explaining real economic activity. Attention must be paid to implications of possible misspecification of the "anticipated" money equation.

Initial tests consider the temporary impact of a monetary disturbance on real activity indicated, after addition of an expression for aggregate demand, by equation (5). Real, dependent variables considered are the rate of growth of employment (biannual and quarterly data) and the rate of growth of real output (quarterly data). The latter is particularly useful for comparison with results obtained by other investigators like Barro and Rush (1979) and Sheffrin (1979).

Rates of change of employment and output are regressed on measures of anticipated and unanticipated money growth and the Livingston measure of inflation uncertainty. The first set of results is for biannual data running from April, 1953 through October, 1975. The biannual format and sample period are dictated by the measure of inflation uncertainty.[4] The basic equation estimated by ordinary least squares is (where primes (´) denote rates of change):[5]

$$n'_t=\beta_0+\beta_1 m^{e'}_t-\beta_1 m^{e'}_{t-1}+\beta_2 m^{u'}_t-\beta_2 m^{u'}_{t-1}-\beta_3\sigma_t+u_t \qquad (\beta_i > 0;\ i=1\text{-}3)$$

where

n'_t = rate of change in employment from April to October (October to April).

$m^{e,u'}_t$ = expected, or unexpected money growth from March to September (September to March).[6]

σ_t = inflation uncertainty among respondents to Livingston survey as of April for the April-October inflation rate.

("t-1" indicates rate of change over 6 months prior to "t").

Measuring Anticipated Money Growth

In order to allow for different formulations which might be employed to estimate monetary surprises, three widely different techniques are employed to decompose actual money growth into "anticipated" and "unanticipated components. Measures of anticipated money growth are taken from an ARIMA model, and from two other completely independent sources, Barro and Rush (1979) and Sheffrin (1979).

It will be seen below that results are not sensitive to the particular measure of anticipated money growth employed. This outcome is somewhat surprising in view of the controversy surrounding the question of appropriate measurement of anticipated money growth. [See Barro (1977) and the comment by Small (1979)].[7] Also, the discussion in Section 1 suggests some pay-off from alternative efforts to model anticipated money growth. However, the simple fact is that the widely divergent concepts behind models of expected money growth considered here produce results which are highly correlated. The ARIMA model developed here for quarterly data produced a series whose correlation coefficients with comparable series of Barro-Rush and Sheffrin were, respectively, 0.87 and 0.91.[8] Initially, for tests using biannual data, anticipated money growth is estimated by an ARIMA model with seasonal moving average terms.[9]

Barro and Rush (1979) and Sheffrin (1979) estimated quarterly equations describing anticipated money growth. A quarterly ARIMA model for money growth was also estimated using data drawn from the same sample period covered by the biannual data. Livingston's measure of inflation uncertainty was linearly interpolated to produce a quarterly series. Transition to a quarterly format permits assessment of sensitivity of biannual results to use of an ARIMA model to estimate anticipated money growth. The quarterly format is kept as close as possible to the biannual. For example, the rate of change of employment from, say, July to October is related to the rate of anticipated or unanticipated money growth over the third quarter and to the level of inflation uncertainty, anticipated as of the first quarter to prevail during the second and third quarters. Indices of inflation uncertainty as of quarters 1 and 3 are interpolated from Livingston indices as of quarters 2 and 4. Since the quarterly index of inflation uncertainty is lagged a quarter it is indicated in employment growth equations as σ_{t-1}.

In order to check for power of employment decisions to affect output or, alternatively, for pervasiveness of the impact of independent variables on employment of all inputs, the rate of growth of real GNP (expressed as GNP in 1972 dollars) was also used in place of employment growth in quarterly equations.

Anticipated Versus Unanticipated: Biannual

Results of estimating biannual equations for employment growth are reported in Table 1. Equation (1.1) contains a number of interesting results. Contemporary anticipated money and inflation uncertainty are the only variables with a significant impact on employment growth. This conclusion is reinforced by a look at equations 1.2 and 1.3 which suggest, in addition, dominance of anticipated money over unanticipated money as an explanatory variable.

TABLE 1

EFFECTS OF ANTICIPATED AND UNANTICIPATED MONEY
GROWTH ON EMPLOYMENT GROWTH BIANNUAL--
1953:04--1975:10

	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8
Constant	0.2220 (0.51)	0.6730 (1.77)	1.6171 (4.66)	1.6202 (4.64)	0.6744 (1.75)	0.6306 (1.52)	0.4306 (1.33)	0.4700 (0.76)
$m_t^{e'}$	0.5747 (2.54)	0.4984 (4.03)			0.4960 (3.95)	0.4927 (3.96)	0.3900 (3.05)	0.6535 (2.68)
$m_{t-1}^{e'}$	0.1977 (1.22)						0.2916 (2.24)	
$m_t^{u'}$	-0.0777 (-0.52)		-0.0510 (-0.29)	-0.0890 (-0.50)	-0.0311 (-0.20)			-0.0811 (-0.53)
$m_{t-1}^{u'}$	-0.2641 (-1.03)		0.2104 (1.19)					-0.3377 (-1.20)
$m_{t-2}^{u'}$								0.1551 (0.78)
$m_{t-3}^{u'}$								0.0500 (0.26)
$m_{t-4}^{u'}$								0.0599 (0.37)
σ_t	-0.7926 (-3.39)	-0.7364 (-3.09)	-0.7499 (-2.70)	-0.7589 (-2.72)	-0.7341 (-3.05)	-0.7182 (-2.88)	-0.8192 (-3.55)	-0.8167 (-3.10)
n_{t-1}'						0.0347 (0.28)		
R^2	.46	.38	.18	.15	.38	.38	.45	.46
DW	2.04	2.03	1.77	1.68	2.05	2.09	2.03	2.03
F/F^{05}								1.02/2.47

(t-statistics in parentheses)

Lagged values of anticipated and unanticipated money do not have the anticipated equal but opposite impact upon employment growth. One possibility is that this result is due to the (unavoidable) use of a particular time interval when estimating equations such as (1.1). The basic concept involved is the notion that any monetary shock which causes employment or output growth to rise should do so only temporarily and eventually the impact on growth ought to be reversed. Otherwise, there follows the implication that a monetary shock permanently elevates the level of employment or output, which is very difficult to rationalize even if prices are sticky.

The results reported in Table 1 suggest that the initial "short run" period during which a monetary shock elevates growth of employment persists over a year (see equation (1.7)). Further, as will be seen later on, reversals tend to be somewhat irregularly spread over a period running from one to 2.5 years after the initial shock.

To avoid consuming many degrees of freedom by regressing employment or output growth on long distributed lags for both anticipated and unanticipated money growth, initial focus will be on the short run. Specifically, RE hypothesizes that initial effects of surprise money growth on employment or output growth ought to dominate initial effects of anticipated money growth. The remainder of Table 1 and Tables 2, 3 and 4 present results of testing that hypothesis. It is consoling to note that Durbin-Watson statistics in equations like 1.2 and 1.5 where lagged values for anticipated and surprise money are omitted but highly significant contemporary anticipated money and inflation uncertainty are included, do not indicate omission of significant explanatory variables.

Continuing with discussion of Table 1, equations (1.2) through (1.5) clearly establish the significant impact of anticipated money growth ($m_t^{e'}$) on employment growth and its dominance over unanticipated money growth. Also established is the significance of inflation uncertainty (σ) as an explanatory variable, although it should be noted that the dominance of anticipated over unanticipated money growth is undisturbed by exclusion of σ. Results of estimating equations (1.2) and (1.4) without σ are:

$$n_t' = \underset{(-0.66)}{-0.1876} + \underset{(3.78)}{0.5101}\, m_t^{e'} \qquad R^2 = .24;\ DW = 1.73$$

$$n_t' = \underset{(4.88)}{0.7554} - \underset{(-0.60)}{0.1127}\, m_t^{u'} \qquad R^2 = .01;\ DW = 1.57$$

Clearly σ acts as a significant explanatory variable and helps to eliminate some serial correlation in the errors. Due to its high level of significance, the inflation uncertainty term is included in all subsequently reported equations.

If employment growth is a target of monetary policy, feedback may flow from lagged employment growth to current anticipated money growth, causing the appearance that anticipated money growth is an important explanatory variable when really a first order autoregressive process is determining employment growth. It is clear from comparison of equations (1.2) and (1.6) that inclusion of lagged employment growth has virtually no impact on estimated relationship of equation (1.2).

Impact of Lagged Monetary Surprises

Some investigators have argued that lagged surprises ought to affect employment and output growth due either to a need to rebuild inventories as in Haraf (1978) and Blinder and Fischer (1978) or to informational lags and an accelerator effect in a model including capital developed by Lucas (1975). Barro (1977, 1978) found lagged surprises to be highly significant in unemployment and real output equations. Equation (1.8) reports on the joint significance of current and four lagged surprises in the presence of anticipated money growth and inflation uncertainty. The F value for the five surprise terms jointly is $F^{5}_{38} = 1.02$ [5 percent critical value = 2.47]. Even allowing for the impact of lagged surprise terms does not disturb the inference that anticipated money growth dominates surprises.

Impact of Lagged Anticipated Money

Equation (1.7) indicates that one lagged measure of anticipated money growth produced a significant positive impact for the sample period running biannually from April, 1953 through October, 1975, although the impact was only about three-quarters that of the contemporary measure of anticipated money growth. Anticipated money growth lagged two periods was insignificant. Here the short run appears to last at least one year.

Alternative Measures of Monetary "Surprises"

It is appropriate to see if conclusions drawn from Table 1 are sensitive to alternative measures of anticipated money growth. Results obtained using quarterly measures of money surprises developed by Barro and Rush (1979) and by Sheffrin (1979) are compared with results yielded by a quarterly ARIMA model to measure surprises.

Table 2 reports on results of estimating quarterly equations to check sensitivity of our conclusions drawn from Table 1 either to a biannual format or, more significantly, to the particular ARIMA model employed there to estimate anticipated money growth. In addition, it is convenient to consider the impact upon growth of real output of variables already related to employment growth.

Equations (2.1) through (2.3) establish that conclusions drawn from biannual data about relative explanatory power of anticipated and unanticipated money growth and the significance of inflation uncertainty are largely undisturbed in a quarterly format. It is true that some autocorrelation of residuals is indicated. This is evidently due to use of quarterly averages of employment numbers to calculate rates of growth of employment comparable to data on rates of growth of real output.

TABLE 2

$$n_t' = \beta_0 + \beta_1 m_t^{e'} + \beta_2 m_t^{u'} + \beta_3 \sigma_{t-1} + u_t \quad \text{[Quarterly: 1953-I--1975--IV]}$$

	Est. of Money Growth: ARIMA					Alternative $m^{e'}$ (Employment Growth)					
	Employment Growth				Real Output Growth	Barro-Rush			Sheffrin		
	(2.1)	(2.2)	(2.3)	(2.4)	(2.5)	(2.6)	(2.7)	(2.8)	(2.9)	(2.10)	(2.11)
Constant	0.5632	0.8574	0.5590	0.3702	1.3541	0.4318	0.8568	0.4328	0.5489	0.8541	0.5397
	(3.42)	(3.81)	(3.36)	(2.23)	(4.90)	(2.60)	(5.79)	(2.60)	(3.32)	(5.76)	(3.22)
$m_t^{e'}$	0.3281		0.3314	0.2490	0.6152	0.5032		0.5078	0.3682		0.3715
	(3.33)		(3.33)	(2.59)	(3.73)	(4.34)		(4.34)	(3.42)		(3.42)
$m_t^{u'}$		-0.0151	0.0344		0.3739		-0.0067	-0.0488		0.0202	0.0477
		(-0.11)	(0.27		(1.78)		(-0.005)	(-0.42)		(0.17)	(0.42)
σ_t					**-1.0207**						
					(-5.40)						
σ_{t-1}	-0.4277	-0.4266	-0.4270	-0.3020		-0.4749	-0.4264	-0.4814	-0.4267	-0.4252	-0.4242
	(-3.82)	(-3.59)	(-3.79)	(-2.68)		(-4.38)	(-3.56)	(-4.37)	(-3.82)	(-3.34)	(-3.77)
n_{t-1}'				0.3215							
				(3.34)							
R^2	.22	.13	.22	.31	.34	.28	.13	.28	.23	.13	.23
DW	1.37	1.16	1.36	1.98	1.49	1.34	1.16	1.36	1.34	1.16	1.32

(t-statistics in parentheses)

since conclusions drawn from estimating the same equations with end-of-quarter employment numbers are undisturbed and Durbin-Watson statistics are satisfactory: In particular:

[(2.1), DW = 1.59, R^2 = .15; (3.2), DW = 1.44, R^2 = 0.08; (2.3), DW = 1.59, R^2 = .15].

The explanation for this effect of averaging is given by Working (1960).

Equation (2.4) indicates that although lagged employment growth is more significant than in the biannual equations, its presence does not disturb the explanatory power of anticipated money growth.

Equation (2.5) which takes growth of real output rather than employment growth to be the dependent variable does little to disturb conclusions drawn from behavior of employment growth. Unanticipated money growth is not significant at the 5 percent level of significance in the presence of inflation uncertainty and anticipated money growth. Inflation uncertainty was found to operate somewhat more quickly on real output growth than on employment growth so σ lagged one quarter less was used in output growth equations.

Equations (2.6) through (2.11) report on results using Barro-Rush (1979) and Sheffrin (1979) measures of anticipated money growth in place of our own ARIMA model. If anything these alternative filters for actual money growth only serve to establish more firmly the significance of anticipated money growth over monetary surprises in explaining employment growth.

Table 3 employs Barro-Rush measures of anticipated and unanticipated money growth to consider further the sensitivity of our results to the manner employed to estimate anticipated money growth and to see how well conclusions about employment growth generalize to real output growth using Barro-Rush data. Sheffrin's data is not considered separately here because his measure of anticipated money growth is highly correlated (0.91 correlation coefficient) with Barro's. Comparing equation (3.1) with (2.8) indicates that adding four lagged values of Barro's monetary surprise does not disturb the conclusion that only anticipated money growth (Barro's) and inflation uncertainty matter. The F-value for the five money surprise coefficients is 0.741, far short of the 5 percent critical value of 2.34.

Equation (3.2) indicates that anticipated money growth and inflation uncertainty significantly affect real output growth although some slight serial correlation is present in the residuals.[10] Adding Barro's contemporary monetary surprise (equation (3.3)) does nothing to clean out autocorrelation but it does raise slightly the explanatory power of the equation. However, the "surprise" term still does not pass the F-test for significance at the 5 percent level. Comparing equations (3.2) and (3.4), the 5 money surprise coefficients decisively fail the F-test for joint significance even at the 5 percent level.

TABLE 3

BARRO-RUSH DATA: EMPLOYMENT GROWTH AND REAL OUTPUT GROWTH
(Sample Period: 1953-I--1975-IV, Quarterly)

	Employment Growth	Real Output Growth		
	(3.1)	(3.2)	(3.3)	(3.4)
Constant	0.4206 (2.13)	1.2811 (4.47)	1.2681 (4.47)	1.2620 (3.66)
m_t^{e}	0.5082 (2.65)	0.7702 (3.85)	0.7353 (3.70)	0.7363 (2.25)
m_t^{u}	-0.0346 (-0.29)		0.3546 (1.79)	0.3627 (1.77)
m_{t-1}^{u}	-0.0969 (-0.55)			-0.0604 (-0.20)
m_{t-2}^{u}	0.0344 (0.25)			0.0840 (0.35)
m_{t-3}^{u}	0.1419 (1.08)			0.0500 (0.22)
m_{t-4}^{u}	0.1270 (0.95)			-0.0382 (-0.17)
σ_{t-1}	-0.4648 (-3.93)			
σ_t		-1.1114 (-5.85)	-1.0584 (-5.57)	-1.0529 (-5.15)
R^2	.31	.33	.36	.36
DW	1.38	1.58	1.51	1.51
	$[F^5_{84}/F_{.05}=0.741/2.34]$		$[F^1_{88}/F_{05}=3.19/3.96]$	$[F^5_{84}/F_{.05}=0.673/2.34]$

(t-statistics in parentheses)

In view of the results presented in Tables 2 and 3, it is not possible to argue that the real GNP equations provide decisive evidence of the significance of any of three measures of ex post monetary surprises and it is certainly not possible to argue that surprises dominate anticipated money growth even if lagged values are included. The lag structure and fit of output growth and employment growth equations is similar, with the exception of a slighly faster negative impact on employment growth of inflation uncertainty. Changes in anticipated money growth and inflation uncertainty cause output growth to vary more than employment growth. This may be due to "inventorying" of labor by firms which do not lay off all redundant labor in a slump in order to be able to expand rapidly in a boom without the high cost of locating and training new workers.

Long Run Impact of Changes in Anticipated Money Growth

The "prerational" view of business cycles and the impact of monetary disturbances as espoused by Friedman (1968), Phelps (1968) and others does not argue that acceleration of money growth will produce permanent real effects on employment.

> Even though the higher rate of money growth continues, the rise in real wages (as labor later demands and gets higher real wages due to excess demand for labor arising from firms' accelerated hiring) will reverse the decline in unemployment and then lead to a rise which will tend to return unemployment to its former level. Friedman (1968), p. 10.

In terms of employment growth, the initial rise in response to higher money growth ought subsequently to become a fall, with a zero net effect over time. The net impact on output growth ought to be zero as well. This is also the result indicated by equation (5) if the interval from "t-1" to "t" is viewed as the long run.

A net long run effect close to zero is not clearly indicated by the data. Table 4 reports results of estimating equation (2.1) including 10 lagged (quarterly) values of (ARIMA) anticipated money growth as additional explanatory variables. In equation (4.1) the sum of the anticipated money growth coefficients from lags 0-5 is 0.771. Coefficients turn negative at lag 6 and sum to -0.435 from 6-10. The F-statistic for the joint significance of all explanatory variables is 3.45. In the presence of contemporaneous expected money growth and inflation uncertainty, the test for the joint significance of all 10 lagged values of expected money growth yields an F-statistic of 1.45 which is short of the critical (5 percent) value of 1.97.

The long run reversal of an initial positive impact on employment of an acceleration of anticipated money growth on employment does begin after 18 months in the sample employed here. The effect, period-by-period, seems to be somewhat uneven within the sample and therefore is difficult to detect.

Comparable tests on growth of output reported as equations (4.2) and (4.3) indicate a larger impact (sum of lag 0-2 coefficients = 0.834) more quickly reversed (sum of lag 3-10 coefficients = -0.691). This result cannot be viewed as highly significant however. In the presence of contemporaneous expected money growth and inflation uncertainty, as in equation (4.3), the test for the joint significance

TABLE 4

LONG RUN EFFECTS OF ANTICIPATED MONEY

	Employment Growth			Real Output Growth	
m^{e} at Lag	(4.1)	(3.1)		(4.2)	(4.3)
0	0.2113 (1.53)	0.3282 (3.33)		0.6503 (2.66)	0.5807 (3.50)
1	0.1169 (0.69)			-0.0133 (-0.045)	
2	0.2460 (1.46)			0.1974 (0.66)	
3	0.0058 (0.034)			-0.0478 (-0.160)	
4	0.0764 (0.445)			-0.2160 (-0.713)	
5	0.1165 (0.6765)			-0.0526 (-0.174)	
6	-0.1220 (-0.709)			0.0054 (0.018)	
7	0.0153 (0.088)			-0.3424 (-1.10)	
8	-0.198 (1.11)			-0.0387 (-0.124)	
9	-0.0079 (-0.045)			-0.1099 (-0.35)	
10	-0.1217 (-0.816)			0.1112 (0.42)	
Constant	0.3882 (2.22)	0.5632 (3.42)		1.495 (4.98)	1.406 (5.05)
$\dot{\sigma}_{t-1}$	-0.2824 (-2.01)	-0.4277 (-3.82)	$[\sigma_t]$	-0.769 (-2.91)	-1.034 (-5.41)
$\bar{R}^2$	0.24	0.206		0.27	0.30
D.W.	1.49	1.37		1.64	1.54
Sum of Squares	21.32	25.24		66.09	71.61
F/F^{01}	3.45/2.41	12.80/4.01		3.86/2.41	20.65/4.01

of all 10 lagged values of expected money growth yields an F-statistic of 0.66, well below the critical (5 percent) level of 1.97.

The implication of these results is to suggest only a weak and variable pattern of reversal of the highly significant, initial positive effects of anticipated money growth on employment and output growth. Either result taken separately is contrary to much contemporary thinking on effects of monetary disturbances. Taken together they are particularly damaging to a number of widely accepted hypotheses. While some suggestions, particularly regarding the significance of the manner in which anticipated money is measured, have been advanced as a possible way to square some of the results with the RE hypothesis taken together the findings make it difficult to avoid raising serious questions about the validity of that hypothesis itself.

3. Concluding Remarks

The prevailing view in neoclassical macroeconomics propounded by Lucas (1973) and others, termed the RE hypothesis here, holds that only a current monetary surprise will elevate the current level of real economic activity. If the Lucas specification is modified, following Nelson and Plosser (1980) so that real output or employment is assumed to follow difference stationary process rather than a trend stationary process, the main implication of the RE hypothesis becomes that a current monetary surprise should produce an impact on the current rate of change of real economic activity that is completely reversed after a lag of one period.

This study finds that three alternative measures of ex post anticipated money growth produce a stable impact on employment growth and output growth in the United States over a 1953-75 sample period.[11] Beyond this, it is impossible to reject the hypothesis that the initial, positive real impact of anticipated money is not temporary.

The impact of anticipated money growth on employment growth and output growth also dominates the impact of contemporaneous and lagged "surprises" in money growth. In the presence of anticipated money growth and inflation uncertainty, contemporaneous and lagged "surprises" persistently failed F-tests for joint significance. A contemporaneous monetary surprise by itself also proved insignificant in the presence of anticipated money growth and inflation uncertainty.

The discussion in Section 1 of possible bias arising from an investigator's mismeasurement of true anticipated money growth as seen by economic agents within a given sample period reveals that non-neutrality discovered in Section 2 cannot be fully explained by appeal to such mismeasurement. If anything, implications of possibly biased measures of anticipated (and thereby of unanticipated) money only enhance damage to the RE hypothesis implicit in empirical findings reported in Section 2. In no case where RE holds, with either omitted or redundant variables in the investigator's measure of anticipated money growth should, as in findings reported here, the estimated coefficient on anticipated money be significantly larger than that on unanticipated money.

To the conclusions reported here regarding real effects of anticipated money, which must be termed highly improbable under the RE hypothesis, can be added the finding that a rise in inflation uncertainty as measured by Livingston survey data significantly depresses real economic activity. This result is robust, appearing in virtually all formulations of tests of the RE hypothesis conducted for this study. While suggested by earlier writers including Keynes and Friedman, the precise manner in which inflation uncertainty acts to depress economic activity is not at present well understood. Considerable research remains to be done in order to develop a fuller understanding of this phenomenon.

In sum, results presented here force one to consider rejection of the core of RE that only surprises matter. Some investigators including Poole (1976), Gordon (1979) and Friedman (1979) have suggested that costly information may provide some basis for this alternative. More careful measurement and testing will be required to resolve the issue.

FOOTNOTES

* I owe thanks for helpful discussion to Charles Nelson and members of my seminar in advanced macroeconomics. Responsibility for any errors is my own.

1. Sheffrin (1979), is the only investigator who tests RE with actors who form expectations based only on data available to them up to the time the expectation is actually being formed. His procedure requires the tedious calculations of "n" expectation formulae (using n - j observations) over a sample period with "n" observations on the dependent variable.

   Although Sheffrin's considerable efforts are commendable, his approach constitutes a necessary but not a sufficient condition to satisfy the requirement that the investigator is actually modelling *ex post* or *ex ante* representation of anticipated money growth prevailing at some point in time.

2. Alternatively the RE hypothesis is sometimes tested with the unemployment rate in place of real output as in Barro (1977). This formulation can be rearranged to specify employment as the dependent variable. The rate of unemployment, U, may be written as:

$$U_t = (L_t - N_t)\ L_t$$

where

L_t = labor force,

N_t = number employed.

In logs $u_t = \ell_t - n_t$.

Rewriting equation (1)

$$u_t = u_{n_t} - \alpha_1(p_t - p_t^e) + u_{1_t} \qquad (1.a)$$

where the natural rate of unemployment

$$u_{n_t} = \ell_{n_t} - \eta_{n_t} \qquad (1.b)$$

Together, (1.a) and (1.b) imply

$$\eta_t = \eta_{n_t} + \alpha_1 (p_t - p^e_t) - u_{1_t} \qquad (1.c)$$

where $\ell_t = \ell_{n_t}$.

This formulation is expressed directly in terms of employment and not in terms of the share of the labor force unemployed. The latter requires controlling for labor force behavior (see Barro (1977)) in order to extract implications of a monetary "surprise" for employment. Empirical tests in Section 2, below, employ both (1), real output, and (1.c) employment equations in tests of RE.

3. A direct test of this assertion would have been possible had Small included anticipated money growth directly in his equation explaining the rate of unemployment. An equivalent test can be performed by including actual money growth along with surprise money growth as in Barro (1977).

4. The entire sample period runs (biannually) from April 1949 through October 1975. The shorter period is selected to facilitate comparison of results obtained here with work of other investigators and to permit the use of long lags on monetary "surprises." Results for the entire sample period and for shorter periods (October, 1960 and October, 1965 each through October, 1975) are available from the author on request. While there are some changes in estimated coefficients, the significance of which will be explored in a subsequent paper, levels of significance and general conclusions drawn here are shown not to be sensitive to choice of same period.

5. It is worth noting that the basic equation avoids the problems of observational equivalence of tests of Keynesian and classical models alluded to by Sargent (1976) and McCallum (1979). Under a given policy regime it can be shown that actual and unanticipated money may both operate upon real output since a distributed lag on actual money may proxy for a contemporary money surprise. But here actual money growth is decomposed into independent components, anticipated and unanticipated. What is directly confronted is the classical proposition that "unanticipated matters and anticipated does not."

6. Data on employment is collected for the week containing the 12th day of the month. Therefore November employment is really early November and is more appropriately related to the money supply measured as the average of daily figures during October.

7. It is useful to bear in mind when considering an equation to predict money growth like Barro's (1977) that if anticipated money growth is being represented in a model which precludes any systematic impact of monetary policy upon real variables such as the rate of unemployment, it requires an assumption of consistent irrationality on the part of the monetary authority to include such a real variable in an equation measuring anticipated money growth. Barro seems to recognize this: "This observation (that unemployment rates are independent of systematic countercyclical money movements effect by policy makers) raises questions concerning the rationality of the countercyclical policy response that appears in the equation (2)" (describing anticipated money growth) (Barro (1977), p. 114). There is, however, no operational response by Barro to this problem.

8. An experiment was conducted with the money supply data used in the biannual analysis in Section 2. Two additional investigators were asked to estimate an ARIMA model of money growth using the same sample employed to construct the series used in results reported here. The correlation coefficients between the biannual series on anticipated money growth employed in Section 2 and the two additional series were 0.88 and 0.87. The correlation coefficient between the two additional series was 0.97. Explanatory power of the biannual model used in Section 2 was about 10 percent above that of the other two models of money growth.

9. The specific biannual ARIMA model measuring anticipated money growth contained one autoregressive term, one moving average term and three seasonal moving average terms:

$$(1-\phi, B)m_t' = (1-\Delta_1 B^4-\Delta_2 B^8-\Delta_3{}^{12})(1-\theta_2 B^2) + \delta$$

$$R^2 = 0.55; \; F^5_{50} = 12.2; \; \text{Standard Error} = .86135$$

where

B = lag operator,

ϕ_1 = autoregressive coefficient,

θ_2 = moving average coefficient,

$\Delta_i (i=1...3)$ = seasonal moving average coefficient.

10. Here again, the autocorrelation is likely due to the Working (1960) effect since real output figures are quarter averages rather than end-of-period figures.

11. Actually the results hold for 1949-75 and a number of subperiods as well, but only the 1953-75 results are reported in detail here.

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