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REAL INTEREST, MONEY SURPRISES AND ANTICIPATED INFLATION

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This paper investigates the hypothesis that surprise changes in the money supply and anticipated inflation (the Mundell-Tobin effect) are both inversely related to the expected real interest rate. The two novel aspects of the investigation are tests of the hypothesized impact of money surprises on real rates while simultaneously testing the Mundell-Tobin hypothesis and estimation employing transfer function methodology developed by Box and Jenkins (1970). The transfer function enables the investigator to entertain the hypothesis that residuals may not follow a simple AR-1 process, as is usually assumed in corrections for correlated residuals, but rather may be appropriately represented by a more complex ARMA process. Based on quarterly data from 1959-I - 1980-IV, results obtained constitutes failure to reject either an inverse relationship between money surprises and expected real interest or an inverse relationship between anticipated inflation and expected real interest. These findings do not constitute a rejection of market efficiency.

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1. Introduction

The hypothesis attributed to Fisher (1930) and more recently the innovative investigation by Fama (1975) have predisposed many economists to treat the expected real rate of interest as a constant. At the very least, as a "real" magnitude, the expected real interest rate is appealingly viewed as being independent of monetary phenomena.

The late 1970's and early 1980's have produced events which force re-evaluation of the maintained hypothesis of constancy of the expected real rate (hereafter referred to as the "real rate"). For example, from December, 1980 to June, 1981 the expected rate of inflation fell by 165 basis points from an annual rate of 10.51 percent to an annual rate of 8.86 percent.[1] Over the same period 3-month treasury bill rates continued to remain largely between 14 and 16 percent with average yields of 15.02 percent in December, 1980 and 14.95 percent in June, 1981. Since there is ample evidence that security markets continue fully to reflect changes in anticipated inflation in nominal market rates, a large drop in anticipated inflation which is not accompanied by a drop of similar magnitude in nominal interest rates forces consideration of a possible offsetting rise in the real rate.[2]

Statistical investigations regarding the possibility of movements in the real rate have appeared with increasing frequency since publication of Fama's (1975) provocative article.[3] Nelson and Schwert (1977) argued that Fama's test of the joint hypothesis of market efficiency and constancy of the real rate was not sufficiently powerful and after applying more powerful tests concluded that the data permitted rejection of the hypothesis of constancy of the real rate. Other investigations including those by

Hess and Bicksler (1975), Carlson (1977), Garbade and Wachtel (1978) and Levi and Makin (1979) have rejected the hypothesis of constancy of the real rate while tending to support the hypothesis that market interest rates include an efficient inflationary premium.

More recently investigators have moved from merely testing the hypothesis of constancy of the real rate to searching for an explanation for the real rate movements suggested by a large body of statistical evidence. Mishkin (1981) has investigated the relationship between the real rate and anticipated inflation suggested by Mundell (1963) and Tobin (1965). Levi and Makin (1979, 1981) and Hartman (1981) have considered effects of inflation uncertainty on the real rate. Dwyer (1981) has found that the real rate is independent of predictable changes in the money supply.

This paper investigates the hypothesis that surprise changes in the money supply are inversely related to the real interest rate while simultaneously allowing for operation of the Mundell-Tobin effect of anticipated inflation on the real rate.[4] The two novel aspects of the investigation are tests of the hypothesized impact of money surprises on real rates in conjunction with tests of the Mundell-Tobin hypothesis and estimation employing transfer function methodology developed by Box and Jenkins (1970). The latter aspect of the study is shown to produce a significant impact upon conclusions regarding the hypothesized impact of money surprises on real rates. In particular it is shown that a useful aspect of transfer functions is the ability to entertain the hypothesis that residuals may not follow a simple AR-1 process but rather may be appropriately represented by a more complex ARMA process.

Section 2 lays out the hypothesis to be tested and discusses techniques employed to estimate money surprises. Section 3 presents results of tests of constancy of the real rate and employs them to explain recent observed behavior of nominal interest rates. Section 4 employs the results to suggest an explanation of changes over time in the dominant source of movements in nominal interest rates. Some concluding remarks are presented in Section 5.

2. Natural and Cyclical Components of the Real Rate

Components of the Real Rate

The hypothesis to be tested here involves decomposition of the real rate into a long-run, underlying or "natural" component and a short-run, "cyclical" component. The analogy with the decomposition by Lucas (1973) of real output into a "natural" and a "cyclical" component is obvious.

The natural portion of the real rate is determined by the marginal productivity of capital and the marginal rate of time preference of consumers.[5] The equilibrium natural real rate equates, at the margin, the subjective rate at which investors are willing to trade-off between current and future consumption with the rate at which the marginal product of capital defines the objective, technological marginal rate of transformation between current and future goods. Under the Mundell-Tobin effect, the natural portion of the real rate can be affected by changes in anticipated inflation. A rise in anticipated inflation causes a shift out of money balances and into real capital thereby depressing the marginal product of capital and the equilibrium real rate. This is the "Tobin Effect." Mundell (1963) describes a similar phenomenon whereby a rise in anticipated inflation depresses equilibrium real cash balances in turn elevating the steady state level of flow saving due to the real balance effect. Equilibrium is restored by means of a lower real interest rate which elevates the level of investment until it equals the higher level of saving. This effect, operating as it does on the steady state level of saving, is not expected to be subsequently reversed in the absence of further change in the rate of anticipated inflation.

The hypothesized impact of a money surprise on real interest arises from an assumption of "sticky" price adjustment. Money growth above its anticipated level results in an excess supply of money if prices are sticky in the short run, assuming also that surprise money growth does not immediately cause a rise in real income sufficient to absorb excess money supply. Until prices adjust fully to absorb excess money supply, the only alternative is for real interest to fall thereby lowering (cet. par.) nominal interest by an amount sufficient to clear the money market.

The impact of a money surprise on the real rate ought to be temporary, lasting only as long as stickiness of prices prevents adjustment to monetary equilibrium without some adjustment of the real rate. Its duration and existance is an empirical question the answer to which ought to shed some light on the speed of adjustment of overall prices.

The exact formulation to be investigated here includes the Fisher equation and a hypothesis dividing the real rate into natural and cyclical components (where all rates are continuously compounded):

$$i_t = r_t + \pi_t \tag{1}$$

$$r_t = r_t^n + r_t^c \tag{2}$$

$$r_t^n = \alpha_0 - \alpha_1 \pi_t \qquad (\alpha_0, \alpha_1 > 0) \tag{3}$$

$$r_t^c = -\gamma_1 (m_t - {}_{t-1}m_t^e) + e_t \qquad (\gamma_1 > 0) \tag{4}$$

where:

i_t = nominal interest rate at time "t."

r_t = expected real interest rate (with r_t^n the "natural" portion and r_t^c the "cyclical" portion).

$(m_t - {}_{t-1}m_t^e)$ = surprise money growth measured as the difference between the (log) current money supply and the (log) anticipated (as of t-1 for t) money supply.[6]

π_t = anticipated inflation or the log of the price level expected as of t for t + 1 less the log of the actual price level: ${}_tp_{t+1}^e - p_t$.

e_t = an error term, normally distributed with mean zero.

Substituting into (1) from (2), (3) and (4) gives an expression for the nominal interest rate in terms of a constant term, anticipated inflation, a money surprise and an error term:[7]

$$i_t = \alpha_0 + (1-\alpha_1)\pi_t - \gamma_1(m_t - {}_{t-1}m_t^e) + e_t \qquad (5)$$

Equation (5) suggests that regression of nominal interest on a constant, money surprise and anticipated inflation ought to: (a) provide an estimate of the portion of the natural real rate unaffected by anticipated inflation the constant term; (b) test the hypothesized negative impact of a money surprise on the real rate by checking to see if the coefficient on the surprise is significantly less than zero and; (c) test the hypothesized negative impact of anticipated inflation on real interest by checking to see if the coefficient on anticipated inflation is significantly below unity. Examination of the impact running from lagged values of anticipated inflation to contemporary nominal interest ought not to indicate subsequent reversal of the initial negative impact. Alternatively, the hypothesized, temporary negative impact of a money surprise ought not to persist in which case distributed lag coefficients on the money surprise term ought to sum to zero.

The notion being advanced here that monetary shocks cause the real rate to diverge temporarily from its long run equilibrium value is also investigated in a meticulous study by Cornell (1981) extending the work of Fama and Gibbons (1980). Cornell finds that monetary shocks connected with reserve settlements on Wednesdays cause temporary (1 day) movements in the (Fed funds) real rate of the sort hypothesized above in equation (3).[8] He suggests further that a possible reason for the failure of Fama and Gibbons to detect such effects is prompt action by the Fed to offset such shocks. Cornell explicitly recognizes, however, that given (p. 18): "a dramatic shift to a policy of slow constant growth of the monetary base...it may turn out that reserve problems which develop on Wednesday suddenly have a large and sustained impact on the ex ante real rate." In short, while Cornell's investigation of the impact of monetary shocks on the real rate is conceptually similar to this investigation, his explicit finding of a one-day impact resulting from Wednesday (lagged) reserve settlement shocks says nothing direct about the possible impact of a 1 quarter money shock on real rates of return on 90-day T-bills investigated here since he appears to view shocks as essentially being offset within a day. However, the above quotation clearly indicates a view that a shock which spans a quarter would produce an impact on the real rate measured at quarterly intervals.

In another related study, Grossman (1981) considers the response of interest rates on Treasury bills to weekly money supply announcements by the Fed. With the change in the bill rate between 3:30 and 5:00 p.m. on announcement day as the dependent variable, Grossman finds a positive link running from money surprises (positive if money is above a consensus, predicted level) to the change in interest rates. This positive relationship reflects, in Grossman's view, "the Systems technique of operation" whereby faster money growth results in movement toward the upper bound and causes the public to anticipate tightening by the Fed.

The positive sign of the relationship between a money surprise and the change in interest hypothesized by Grossman is the reverse of the relationship hypothesized by Cornell and this study. In effect, Grossman's rationale for this positive relationship is a policy reaction function built into Fed operating procedures during the September, 1977 through September, 1979 sample period examined. Money growth above the targeted level would cause the Fed to move to raise the federal funds rate and the public would anticpate such action thereby bidding up interest rates in anticipation of such a move. While this response may be possible over an intra-day time interval for a given policy regime, findings of Cornell and this study (reported below) suggest that, for daily or quarterly data where an attempt is made to control for anticipated inflation, greater-than-anticipated money growth will temporarily depress the real rate.

Measurement of Money Surprises

This study employs residuals from an ARMA (1,5) model of money (M1-B) growth as money surprises.[9] It would be possible to estimate money surprises using alternative measures of money such as M-2 and/or using alternative representations of anticipated money growth such as those linking behavior of the money supply to targets of monetary policy as in Barro (1977). While the range of conceivably possible measures of money surprises is wide, experimentation with a number of conceptually different measures in Makin (1982) produced highly correlated measures (all over 0.90) of money surprises and little impact upon results of testing the natural rate hypothesis.

There also arises the issue of sample data employed to estimate the model of money supply behavior. If the form of the ARMA model changes over time or coefficients of a given ARMA model change over time then forecasts as of time "t" should only employ data available as of time "t." This problem, alluded to by Sheffrin (1979), also appears to be more serious in principle than in practice (see Makin (1982)). It is worth noting here that Khan (1981) has developed a far more tractable alternative than Sheffrin's procedure of periodic re-estimation for estimation of surprises using only data which would have been available to forecasters at the time forecasts were being made. Khan's technique of "sequential estimation" employs the procedure of Brown, Durbin and Evan's (1975) to produce a series of any length of updated, coefficient estimates for a given ARMA model which requires only one matrix inversion to produce the initial ARMA model estimate. This procedure is appealing and can be used for a wide range of data series from which one desires to extract "surprises" in a logically consistent manner. For postwar U.S. money series, however, it appears that the procedure produces little impact on actual measures of "surprises." For the sample period from March, 1973 to June, 1981 a series on M-2 surprises estimated using Khan's method was regressed on a surprise series estimated from the March, 1973 - June, 1981 sample period. The result yielded a constant term not significantly different from zero (t-statistic = 0.97) and an estimated surprise coefficient of 0.93, only 1.21 standard errors below unity. The two series are presented below in Chart 2 from which the high degree of their correlation is obvious.

The overall result of careful consideration of alternative measures of postwar, U.S. money surprises, which may well not generalize to other series, is to suggest that in-sample ARMA models serve as well as any. This is a useful piece of information as it suggests that the simplest method of estimating money surprises serves as well as any of the more complex alternatives.

3. Testing for Constancy of the Real Rate

Estimation Results: Correcting for Correlated Residuals

Results of estimating interest rate equations are presented in Table 1. It is clear from equation (1.4) that after dealing with the problem of properly modeling residuals, it is impossible to reject the two hypotheses advanced in Section 2 about behavior of the real rate. A one percent positive money surprise produces a significant negative impact on the real interest rate estimated to be about 28 basis points while a one percent rise in anticipated inflation depresses the real interest rate by an estimated 25 basis points ($1 - 0.746 \approx 0.25$). The relevant test of the hypothesized negative impact of anticipated inflation on the real rate is whether the coefficient on π_t is significantly below unity. The estimated coefficient of 0.746 in equation (1.4) lies 2.71 standard errors below unity which is significant at the 0.01 level.

The significance of employing the transfer function technique to estimate equation (1.4) can be seen by comparing equations (1.1) through (1.3) with (1.4). In equation (1.1) it is clear that anticipated inflation alone leaves highly autocorrelated residuals (DW = 0.58). Addition of the money surprise term raises the Durbin-Watson statistic somewhat and adds to overall explanatory power but leaves an

TABLE 1

MONEY SURPRISES AND REAL INTEREST

Dependent Variable (3-Mo. T-Bill Rate)	Constant	Money Surprise[1]	Anticipated Inflation[2]	$\overline{R}^2$	DW	n
(1.1)	2.53		0.756	.77	0.58	87
	(12.38)		(17.23)			
(1.2)	2.46	-0.424	0.777	.78	0.67	87
	(12.14)	(2.21)	(17.68)			
(1.3)	2.39	-0.138	0.814	.43	[3]	86
	(4.55)	(1.26)	(7.97)			
(1.4)	2.66	-0.277	0.746	.91	[4]	88
	(5.59)	(2.66)	(7.97)			

(Sample period: 1959-I - 1980-IV; t-statistics are in parentheses).

[1]The money surprise is measured by residuals from an AR-1, MR-5 model of M1-B growth estimated using quarterly data from 1959-I - 1980-IV. The chi-square test of the hypothesis that residuals are white noise has a significance level of 0.94.

[2]Anticipated inflation is based on Livingston survey data on 6-month inflationary expectations. Interpolation is employed to obtain a quarterly series.

[3]Equation (3) is estimated with the Cochrane-Orcutt correction for serial correlation (p = .725; t - 9.06).

[4]Equation (4) is estimated as a transfer function. Residuals are modeled by an AR-1; MA-3 model (t-statistics 5.78, 5.59, significance level of chi-square that first 24 residuals are white noise is 0.555).

unacceptably high level of indicated autocorrelation in residuals. The usual procedure would be to correct equation (1.2) for autocorrelated residuals. The result of employing the Cochrane-Orcutt procedure is reported as equation (1.3). The result is a drop in overall significance levels leaving one to conclude from equation (1.3) that a money surprise does not produce a statistically significant negative impact on the real rate. However, inspection of the residuals from equation (1.2) suggests that they are not adequately represented by an AR(1,0) model. Estimation of a transfer function (equation (1.4)) reveals that an AR(1,3) model is required to leave white-noise residuals. Proper modeling of residuals produces a substantive impact upon the conclusion regarding the negative impact of a positive money surprise on the real rate, to the effect that the data do not permit rejection of the hypothesized relationship. This result carries with it the implication that prices are somewhat sticky, at least for a period of up to one quarter.

It would of course be desirable to provide prior hypotheses regarding implications for estimated parameter values or estimated standard errors of mismodeling residuals. Hendry (1977) has investigated the question and found that little in general can be said particularly where higher order processes are involved.[10] The best operational rule is simply to model residuals in a way that leaves white noise residuals and not to simply assume that an AR(1,0) representation is correct.

Possible Impact of Money Surprise on Anticipated Inflation

It is worth noting that the estimated coefficient on anticipated inflation is little affected by inclusion of a money surprise term. The possibility exists that the level of anticipated inflation may be positively correlated with a money surprise which, given a negative impact of a money surprise on the real rate, would tend to bias downward the estimated impact of anticipated inflation on nominal interest when the money surprise is omitted from the equation. Such a possibility deserves consideration in the light of a persistent tendency for the estimated impact of anticipated inflation upon nominal interest to lie below the value of unity anticipated under the Fisher hypothesis.[11] The fact is, however, at least for the sample under investigation here, that the correlation coefficient between anticipated inflation and money surprise is only 0.21. The overall implication is that the persistent finding that the estimated coefficient on anticipated inflation lies below unity may well be due to the negative impact of anticipated inflation on the real rate rather than to biasedness associated with omission of a money surprise. Failure to entertain this hypothesis has led investigators to search over a wide range of alternative explanations including measurement error on anticipated inflation, "fiscal illusion" (Tanzi (1980)) and failure to control adequately for other events such as the level of economic activity on inflation uncertainty which may also affect the real rate. All of these possible effects may be valid, but it would be useful to reconsider them in the light of a possible Mundell-Tobin effect.[12]

Persistence of Money Surprise and Anticipated Inflation Effects

If the impact of a money surprise is found not to be reversed after a quarter or more the implication is that prices tend to be sticky over a longer period of time. A persistent impact of anticipated inflation on subsequent real rates would suggest a permanent impact upon the rate of capital formation under the Mundell-Tobin hypothesis. These possibilities can easily be checked with output from the transfer function estimation procedure. Cross correlations between unexplained changes in the dependent variable and each of the exogenous variables enable a check on possible distributed-lag relationships. For the money surprise, the Chi-Square test statistic for cross correlations with 12 degrees of freedom is 14.3 with a p-value of 0.28. While this result constitutes only a marginal rejection of possible lagged relationships over 12 periods, inspection of the plot of cross correlations reveals that all of the cross correlations lie below two standard errors from zero. The most significant cross correlation at lag 3 did not enter significantly when added to equation (1.4). A hypothesis of price stickiness for periods of more than one quarter is supported by these findings whereby the initial downward pressure on the real rate is not subsequently reversed. Such a finding is contrary to the views of many economists regarding the degree of price flexibility and in view of the marginal rejection of a lagged relationship between money surprises and the real rate suggested above, more investigation may be called for. For now it is worth noting that the (insignificant) lagged cross correlations between the money surprise and the unexplained portion of the dependent variable are all positive from quarters 1 through 3. This suggested a tendency for (negative) effects of the surprise to be erased over a somewhat irregular pattern spanning about 9 months.

The Chi-Square test statistic for cross correlations with anticipated inflation given 12 degrees of freedom is 8.52 which carries a

β-value of 0.744. This constitutes a highly significant rejection of a possible lagged relationship between the real rate and anticipated inflation and suggest, consistently with the Mundell-Tobin hypothesis that a rise in anticipated inflation produces a permanent negative impact on the real rate.[13]

Controlling for Other Variables

In an earlier study of the effects of anticipated inflation on nominal interest, Levi and Makin (1979, 1981) controlled for the impact of output growth and inflation uncertainty upon the real rate, finding both to have a negative impact. Bomberger and Frazer (1981) also found that a Livingston measure of inflation uncertainty had a significant negative impact on interest rates.

More recently, Hartman (1981) has argued that the real rate ought to be defined as the nominal rate less the expected rate of inflation plus the variance of the inflation rate. This implies a measure of inflation variance on the right-hand side of equation (4) with a coefficient of minus 1. Neither real growth nor inflation uncertainty entered significantly when added to equation (1.4) either separately or together. This result suggests that the money surprise term in equation (1.4) is capturing the impact on the real rate of inflation uncertainty and output growth. Larger money surprises may well elevate inflation uncertainty. The natural rate hypothesis suggests that money surprises raise the level of real output but not its rate of growth. However, price stickiness within a quarter or inventory effects may cause money surprise effects on real output growth. The price stickiness requirement is consistent with the finding that a money surprise is inversely related to the real rate. Full reconciliation of results reported here with earlier investigations will require further investigation but ought to provide additional insights into short run real effects of monetary disturbances.

4. Sources of Nominal Interest Rate Changes

The association of money surprises with movements in expected real rates of interest suggests that, controlling for expected inflation, the behavior of such surprises ought to give an indication of the behavior of the unobservable, expected, real interest rate. Inspection of Table 2 suggests that expected inflation rates rose steadily from 1973 through 1974, fell until the end of 1976 and then rose steadily until 1980 after which they dropped by over 1.6 percent from December 1980 to June 1981. It appears, however, that volatility of expected inflation over the period was moderate (a standard deviation of 1.22 percent for the 12/72 - 12/78 period) and even fell lower during the 6/79 - 6/81 period to a standard deviation of 1.05 percent. During the latter period expected inflation rates were high but fairly stable.

Charts 1 and 2 and Table 3 suggest a contrasting picture for the level and volatility of money surprises. The mean absolute monetary surprise which measures the level of pressure on U.S. expected real interest rose sharply after October 1979 for both M1-B and M-2. So too did the standard deviation of absolute money surprises.

Since U.S. nominal interest rates have been highly volatile, since October 1979 the implication of Tables 2 and 3 and Charts 1 and 2 is

TABLE 2

MEAN AND STANDARD DEVIATION OF 6-MONTH CPI FORECASTS
(Livingston Survey Data at Annual Rates)

Date	Mean	Standard Deviation	
		Cross Section	Over Time
12/72	3.22	0.83	
6/73	4.00	1.31	
12/73	5.17	2.10	
6/74	7.12	2.38	
12/74	7.70	2.32	
6/75	5.63	2.12	1.22 (12/72 - 12/78)
12/75	5.84	1.38	
6/76	5.30	1.30	
12/76	5.23	1.81	
6/77	5.92	1.36	
12/77	5.99	1.23	
6/78	6.40	1.57	
12/78	6.97	1.75	
6/79	8.31	2.35	
12/79	10.14	2.37	
6/80	10.67	2.57	
12/80	10.51	2.58	1.05 (6/79 - 6/81)
6/81	8.86	2.83	

TABLE 3

ABSOLUTE MEAN AND STANDARD DEVIATION OF U.S.
MONETARY SURPRISES
(At Annual Percentage Rates;
Seasonally Adjusted Monthly Data)

Time Period	M1-B[1]		M-2[2]	
	Mean	Standard Deviation	Mean	Standard Deviation
3/73 - 10/78	3.34	2.38	2.61	2.19
11/78 - 7/81	6.84	5.74	3.30	3.16
3/73 - 9/79	3.56	2.56	2.45	2.10
10/79 - 7/81	8.21	6.27	4.21	3.49

[1]"Surprises" measured by residuals from an AR-3 model of M1-B growth estimated over the period from January 1965 through February 1973 and updated monthly through July 1981. See Khan (1981).

[2]Same procedure as M1-B using AR-1 model

that volatility of expected real interest has accounted for more movements of nominal interest than has volatility of expected inflation.

Some of the most intense upward pressure on real interest rates in the United States appears to have materialized during the second quarter of 1981. Charts 1 and 2 suggest that the reason for this is a sequence of negative money surprises during that time. It appears that in the wake of the very large negative and then positive monetary surprises inherent in the imposition and then removal of credit controls during 1980, another sequence of surprises, this time positive-negative, has materialized in the first half of 1981.

Forces operating on nominal interest rates during the first half of 1981 can be described in terms of events affecting expected inflation and expected real interest rates. Election of a new president and expectations of budget-balancing and/or monetary control tended to lower expected inflation over the first six months of 1981 (see Table 2). The brief acceleration of money above expected levels tended to depress real interest rates during the first quarter of 1981 with the combined effect that nominal interest rates, particularly short rates, fell during the first quarter of 1981. However, an apparent "mini-accord" at the end of March 1981 between the U.S. Treasury and the Fed saw sharply increased pressure to keep monetary aggregates, then above target, at or below targeted levels. The result was a sharp deceleration of money growth during the second quarter of 1981 which came as a surprise to most observers (see Charts 1 and 2). Such large negative surprises put strong upward pressure on expected real interest rates which more than swamped the depressing impact of lower inflationary expectations. It may have been that most of the drop in inflationary expectations had come during the first quarter of 1981 so that most of the second quarter sharp rise in expected real interest rates (estimated, based on Tables 1, 2 and 3 to be between 2 and 3 percent) was transmitted directly to nominal rates with no offset from lower expected inflation.

5. Concluding Remarks

This paper has tested the hypotheses that money surprises and anticipated inflation are both inversely related to the expected real rate of interest. Based on quarterly data from 1959-I – 1980-IV, results obtained constitute failure to reject either hypothesis.

An examination of the behavior of money surprises before and after institution of new operating procedures by the Federal Reserve Board in October, 1979 indicates a sharp elevation of both the level and volatility of such surprises. Based on results reported here, the increased volatility of money surprises, during a time when the volatility of anticipated inflation had, if anything, fallen relative to pre-October 1979, suggests that the post-October 1979 period has seen movements of nominal interest rates due more to changes in expected real interest rates than to changes in anticipated inflation.[13] This would explain Hodrick's observation of a change in the sign of observable comovements of nominal interest differentials and exchange rates prevalent since October, 1979 as well as the apparent absence of response of nominal interest rates to a drop in inflationary expectations during the first half of 1981.

The primary implication for monetary policy of findings reported here is to dispute the result of Fama and Gibbons (1980) whereby a sudden transition to a sharply reduced rate of growth of the money base would reduce short-term nominal rates. On the contrary, empirical findings reported in Section 3 suggest that, unless a negative money surprise results in an instantaneous equal percentage drop in inflationary expectations, the overall result will be a rise, at least temporarily, in the nominal rate due to a rise in the real rate. Such a rise appears likely since no such close relationship between money surprises and anticipated inflation is evident in the data examined here.

Overall, the implied conclusion for monetary policy is identical to that reached by Cornell (1981), p. 19:

> "Until further work is done, however, it would be dangerous to accept the classical hypothesis that the ex ante real interest rate is unaffected by monetary policy."

Chart 1: M1-B Surprises (At Annual Growth Rates)

Pre-Sample Estimation

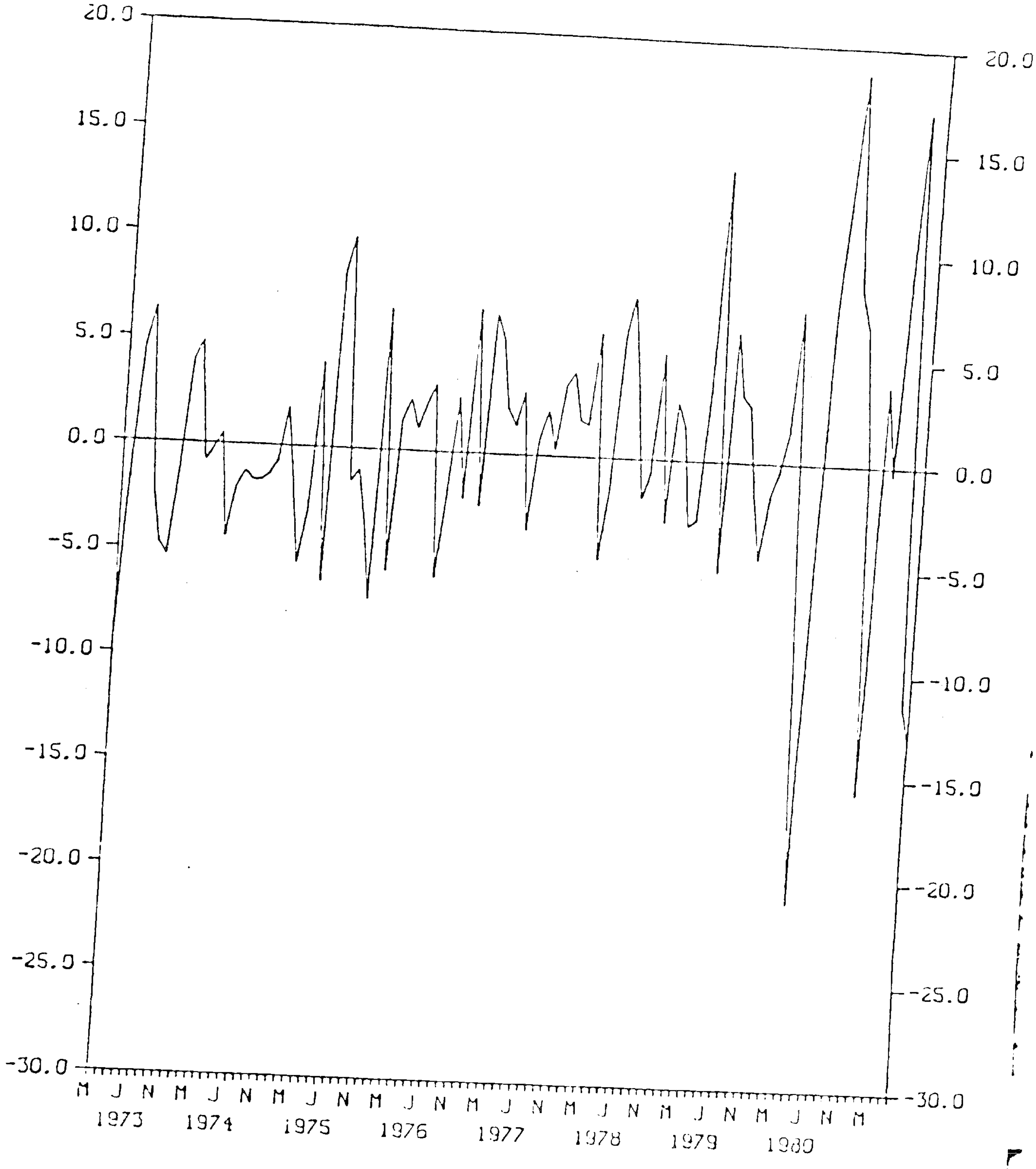
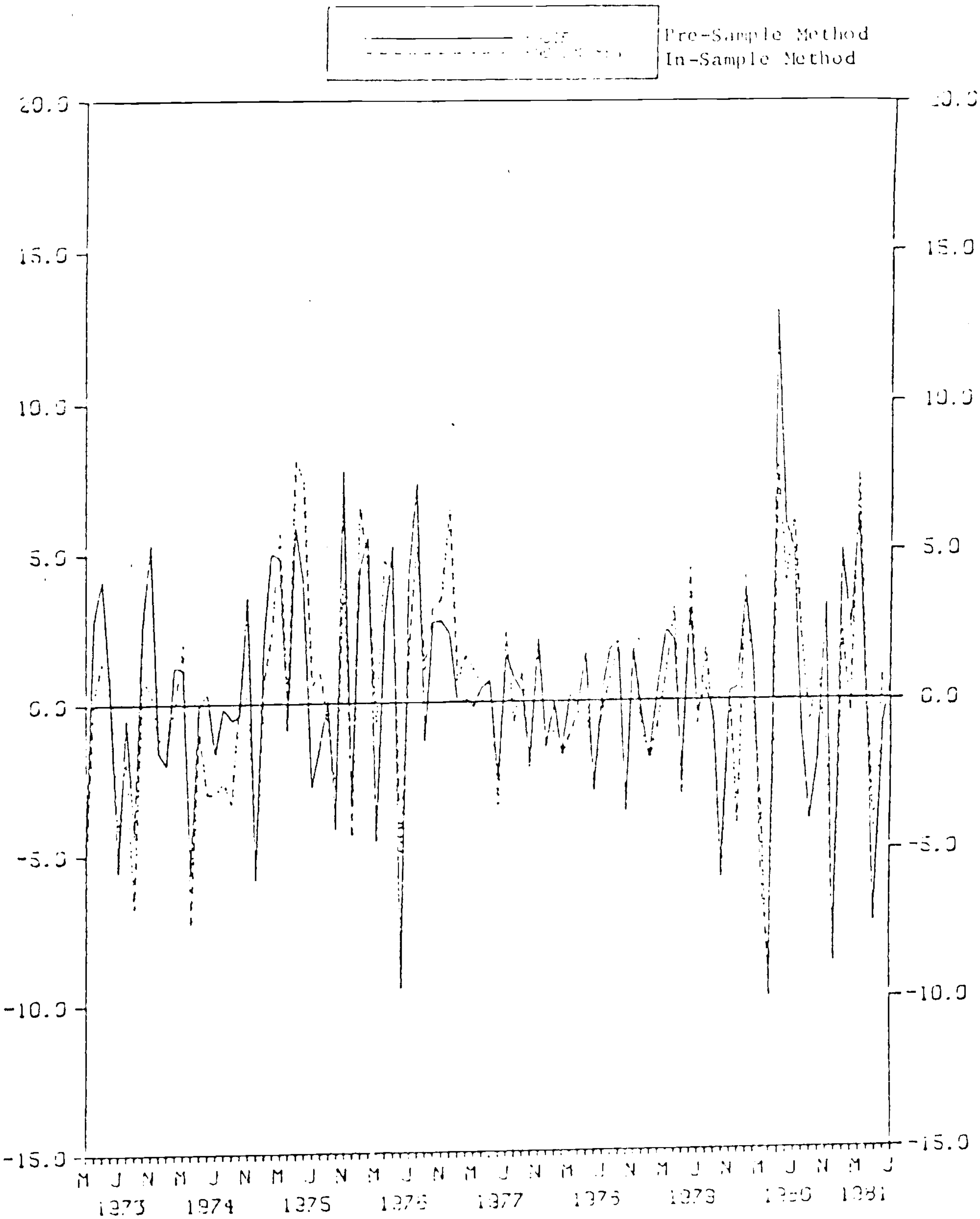


Chart 2: M-2 Surprises (At Annual Growth Rates)



FOOTNOTES

1. This figure is based on Livingston survey data for 6 month horizon expectations regarding the consumer price index. The twelve month horizon figure for CPI also indicated a drop of 165 basis points while 6 and 12 month horizon numbers for WPI indicated drops of 192 and 174 basis points respectively. Updated Livingston survey data is now compiled by the Federal Reserve Bank of Philadelphia.

2. Another event in the international sphere has raised questions about the constancy of the real rate. Until November of 1978 it was typical to observe, in the United States at least, rising relative nominal interest rates accompanied by depreciation of the dollar against foreign currencies like the deutschemark and the yen. Such comovement was readily explained in terms of a rise in U.S. nominal rates due to higher anticipated inflation. However, as reported in Hodrick (1981), since 1980 rising relative nominal interest rates in the United States have tended to be associated with dollar appreciation and conversely. A proximate explanation for this phenomenon would be an assertion that real interest rate movements have tended to dominate as causes of nominal rate movements during the early 1980's. If such were true the observed dollar appreciation which has coincided with rising nominal U.S. interest rates could be explained by incipient capital inflows attendant upon higher U.S. real rates which simultaneously caused the nominal interest rate to rise.

3. Even well before the investigations discussed here Irving Fisher himself reported, based on an investigation of market interest rates during the 19th and late 20th centuries in London, New York, Berlin, Calcutta and Tokyo, that "the real rate of interest in terms of commodities is from seven to thirteen times as variable as the market rate of interest expressed in terms of money." (Fisher (1930), p. 415).

4. Mishkin (1981) found a significant negative impact upon the real rate of a lagged actual (CPI) inflation rate taken as a proxy for anticipated inflation. An ARIMA (0,1,1) inflation model with a seasonal MA-L term also provided an expected inflation proxy with a significant negative impact on the real rate.

5. Alamouti (1980) provides a similar description of determination of the real rate. Determination of the real rate in this manner is suggested directly by the full title of Fisher's (1930) classic: <u>The Theory of Interest as Determined by Impatience to Spend Income and Opportunity to Invest It</u>.

6. Since actual money growth less anticipated money growth is written as: $(m_t - m_{t-1}) - ({}_{t-1}m_t^e - m_{t-1}) = (m_t - {}_{t-1}m_t^e)$.

7. Tax effects alluded to by Darby (1975) and Feldstein (1976) are ignored for now. Mishkin (1981) finds that inclusion has little impact on conclusions regarding non-constancy of the real rate.

8. Cornell is clearly thinking of shocks to the monetary base in the form of a shortage or excess of bank reserves.

9. The Chi-Square test statistic for the hypothesis that the residuals of the ARMA(1,5) model is 6.84 with 14 degrees of freedom which implies a significance level of 0.94. The model was estimated using quarterly data from 1959-I - 1980-IV.

10. Hendry also suggests that identifying the correct order of error autocorrelation is more important than the form (AR or MA). More specifically had the true error process been ARMA(0,1) an ARMA (1,0) would do reasonably well. But since the true process in equation (1.4) was ARMA(1,3), ARMA(1,0) represents a serious misspecification.

11. A value above unity is anticipated if tax effects articulated by Darby (1975) and Feldstein (1976) are considered. See Tanzi (1980) for a discussion of these articles and others which investigate the quantitative impact of changing inflationary expectations on nominal interest. Tanzi argues that "fiscal illusion" or failure to account for taxes may be responsible for lower than expected coefficients when nominal interest rates are regressed on anticipated inflation.

12. Levi and Makin (1978, 1979, 1981) have investigated a number of these effects in a model including a Mundell-Tobin effect. This paper, however, adds consideration of "money surprise" effects on the real rate.

13. The problem of inference here is complicated by the fact that the Mundell-Tobin hypothesis hinges upon the <u>difference</u> of the coefficient on anticipated inflation from <u>unity</u> and not from zero. However, both the incorporation of a change in anticipated inflation into nominal interest and the real impact under the Mundell-Tobin hypothesis are expected to be permanent. This generates a prior hypothesis of persistence with no subsequent reversal which is not contradicted by the data.

14. A similar suggestion has been advanced by Keran and Pigott (1980).

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