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Money and Interest Rates: The Effects of Temporal Aggregation and Data Revisions

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Econometric estimates of liquidity effects produce results that are, at best, mixed. Yet the liquidity effect remains a central transmission mechanism for monetary effects. This article examines how problems of data revisions and temporal aggregation affect the empirical effort. We test for liquidity effects, using both initially announced and finally revised M1 data, aggregating across different time intervals and time periods, using different aggregation techniques. We were able to uncover a liquidity effect only in the post-October 1979 period and only at a 13-week observational interval with nonaggregated end-of-period M1 data.

I. Introduction

In the traditional textbook model of the macroeconomy, the *liquidity effect* represents the first stage of the transmission mechanism of monetary policy: An expansion in the supply of money is assumed to cause a decline in the real rate of interest. The lower real rate of interest is subsequently responsible for affecting real economic activity. Similarly, in large-scale macroeconometric models, the first building block of the effects of monetary policy is the liquidity effect. Yet, despite the key role that the liquidity effect plays both in economic theory and in large-scale macroeconometric models, investigators have recently questioned its importance. Sims (1980), and Litterman and Weiss (1985), among others, provide evidence that money may no longer play a significant role in the propagation of business cycles, since World War II. Fama and Gibbons (1982) claim that variations in the real rate of interest are due to shifts of resources between consumption and investment and not to the textbook liquidity effect. In a careful study, Mishkin (1982) did not find a negative correlation between nominal interest rates and unanticipated money.

Although many macroeconomists have failed to uncover a significant liquidity effect in the postwar data, it appears that market participants perceive the existence of a strong liquidity effect. For example, Hardouvelis (1987) finds that during the 1980–1982 period, a time when the Federal Researve used bank nonborrowed reserves as an

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operating target, an unanticipated increase in nonborrowed reserves resulted in a large decline in both short- and long-term interest rates. This evidence carries a lot of weight for two reasons: First, it does not suffer from the usual simultaneity problems that plague most econometric work. The unanticipated component of nonborrowed reserves is predetermined and is the causal variable. Second, Hardouvelis claims that the surprise about nonborrowed reserves reflects a surprise about the supply of money: The presence of lagged reserve accounting, an institutional characteristic of the banking system at the time, implies that the unanticipated component of nonborrowed reserves reflects discretionary Fed actions.[1]

If market participants perceive the presence of a strong liquidity effect, how come it is so elusive to econometricians? Perhaps simultaneity problems make it very difficult to estimate the size of the liquidity effect. The recent voluminous literature on the market responses to the weekly announcements of M1, the narrow definition of money, provides a clear example of the difficulty of finding a liquidity effect by using simple correlations. Investigators have found that interest rates increase after an unanticipated increase in M1 (see Urich and Wachtel 1981, Grossman 1981, or Roley 1983. Yet, despite the positive association between money surprises and interest rates, which appears to be contrary to the existence of a liquidity effect, the interpretation of these responses is entirely consistent with the presence of a liquidity effect. Nichols, Small, and Webster (1983), Cornell (1982), Engel and Frankel (1984), Hardouvelis (1984), Roley and Walsh (1984, 1985), and others have argued that the positive response reflects the market participant's expectation that in the future the supply of money will grow less than the demand for money (perhaps because market participants expect the Fed to counteract the previous increase in the stock of money), requiring a higher real rate of interest to equilibrate the money market.

The purpose of this article is to illustrate some of the problems that plague the econometric effort of uncovering a liquidity effect. Specifically, we concentrate on issues of data revisions and temporal aggregation. The issue of data revisions is important because, as the money announcements literature reveals, the interest rate responses to changes in money depend upon, among other things, market perceptions. Market perceptions are based on preliminary rather than finally revised data. The issue of temporal aggregation is also important because past tests for liquidity effects seem to depend upon the choice of time interval and method of temporal aggregation: Makin (1983) uses average quarterly data on both interest rates and money and finds a statistically significant (but economically not so significant) liquidity effect. Wilcox (1983) uses average semiannual data on interest rates but end-of-period data on money and is unable to find a statistically significant liquidity effect. Mishkin (1982) uses end-of-period quarterly data on both interest rates and money and finds a positive instead of a negative correlation.

Section II presents the econometric framework. Section III describes the data, issues of estimation, and the results. We estimate a money supply–money demand model using a rich array of time intervals: 13, 6, and 3 weeks. For each of the three intervals we use either averaged or end-of-period data. And we perform the analysis with both

[1]Hardouvelis shows that forward interest rates as far ahead as one year fall after an unanticipated expansion of nonborrowed reserves. In another paper (Hardouvelis 1988) he also shows that the dollar depreciates as well. These reactions cannot be explained by hypotheses that rely on changes in the inflation premium or hypotheses of the real business cycle literature, which assume that money is neutral.

first-announced and finally revised data on M1. Section IV summarizes our main conclusions.

II. Theoretical Framework

In searching for a liquidity effect, we adopt Mishkin's (1982) money supply-money demand framework. Mishkin presents the strongest results against the presence of a liquidity effect; thus it is interesting to reexamine his evidence. The two basic equations that we estimate have the following form:

$$i_t - {}_{t-1}f_t = a_0 + a_1 RISK_{t-1} + a_m UNMG_t + a_y UNYG_t + a_p UNPG_t + u_t, \tag{1}$$

$$i_t - {}_{t-1}f_t = b_0 + b_1 RISK_{t-1} + b_m UAMG_t + b_y UAYG_t + b_p UAPG_t + v_t. \tag{2}$$

Equation (1) is derived by Mishkin (1982) from a money demand-money supply framework and the assumption of efficient markets. Equation (2) is the same as equation (1) with the exception that its unanticipated independent variables originate from averaged data within each period.

The term i_t represents the annualized Treasury bill yield with maturity equal to the unit period t observed during the first day following t. The term ${}_{t-1}f_t$ is a corresponding forward rate observed during the first day of period t. The unit period t will have a length of 13, 6, or 3 weeks. Weeks are fiscal weeks; that is, they begin on a Thursday and end on a Wednesday. For example, when t represents a 6-week period, i_t is a 6-week T-bill yield observed on the first Thursday following the 6-week period t, and ${}_{t-1}f_t$ is a 6-week forward rate 6 weeks ahead observed during Thursday of the first fiscal week of period t, and constructed from the 12- and 6-week rates. Thus $i_t - {}_{t-1}f_t$ can be interpreted as the unanticipated change in the 6-week T-bill yield from the beginning to the end of the six-week period t.

Following Mishkin, the first two terms on the right-hand side of (1) and (2), $-(a_0 + a_1 RISK_{t-1})$, represent the risk premium for ${}_{t-1}f_t$, where $RISK_{t-1}$ belongs to the information set of market participants at the beginning of period t and is a proxy for the time-varying component of the risk premium.[2] $UNMG_t$ is the unanticipated (at the beginning of period t) component of the annualized growth rate of the narrowly defined stock of money, M1.[3] The growth rate is constructed from end-of-period data, that is from the last fiscal week of periods t and $t-1$. $UAMG_t$ corresponds to $UNMG_t$ except that the growth rate is constructed from averaged data within each period. $UNYG_t$ is the unanticipated component of the annualized growth rate of weekly unemployment claims constructed from end-of-period data, while $UAYG_t$ is a similar

[2] Pagan (1984) criticizes model-based estimates of volatility that are used as data in follow-up regressions. We include $RISK_{t-1}$ in our regressions in order to conform to the work of Mishkin. None of our conclusions change if we exclude $RISK_{t-1}$ from the analysis.

[3] We have also performed the empirical analysis using the St. Louis monetary base and the originally announced M1 series taken from the Federal Reserve's H.6 statistical release. The monetary base results closely resemble the final M1 results presented in Tables 1 and 2. The results for the originally announced M1 series are presented in Tables 3 and 4.

variable constructed from averaged data. Finally, $UNPG_t$ is the unanticipated component of the annualized growth rate of the Bureau of Labor Statistics spot commodity price index constructed from end-of-period data, while $UAPG_t$ is a similar variable constructed from averaged data. Construction of the anticipated component of each of these series is model-based and discussed below.

$UNPG_t$ and $UAPG_t$ control for the variability in the unexpected rate of commodity price inflation over period t. If changes in commodity price inflation are good predictors of future changes in the overall inflation rate, then $UNPG_t$ and $UAPG_t$ may well capture the presence of a Fisher effect in nominal interest rates.[4] $UNYG_t$ and $UAYG_t$ are expected to capture the presence of an income effect (a high level of unemployment claims signals a low level of economic activity). $UNMG_t$ and $UAMG_t$ are expected to capture the market's reaction to monetary innovations including a liquidity effect (see our discussion of results, below). And finally, $-(a_0 + a_1 RISK_t)$ is expected to capture the risk premium in forward rates. Accordingly, we hypothesize that the coefficients a_p and b_p are positive and represent an inflation premium; a_y and b_y are negative and capture the inverse of the income effect; a_m and b_m are negative and represent the liquidity effect; and a_1 and b_1, the risk premium coefficients, are negative.

III. Empirical Evidence

Data and Econometric Issues

The interest rate data employed are Thursday afternoon (prior to money announcement) yields to maturity based on asked prices. They were taken from the quotation sheets of the Federal Reserve Bank of New York. All remaining data were taken from Data Resources Incorporated and represent seasonally adjusted final-revision numbers.[5] A consistent weekly (Thursday through Wednesday) M1 series is available only beginning in January 1975, which is therefore the beginning of our sample.[6] The unemployment claims variable represents initial unemployment claims for the week. The spot commodity index is the Bureau of Labor Statistics 22-commodity spot index. Finally, $RISK$, the risk proxy is a moving variance of the previous 26 weeks associated with the yield on the T-bill corresponding to the unit interval.

The anticipated components of the series were generated with multivariate autoregressive models using the series described above with two lags and $RISK_{t-1}$ as an extra independent variable. The unanticipated components, which are right-hand-side variables in equations (1) and (2), are simply the error terms from these models. Alternative models of generating the unanticipated components of these series, such as univariate models or simple VARs, provide quite similar results. However, our specification has an advantage: Typically, the use of generated regressors implies that performing ordinary least squares tests in equations (1) or (2) provides inconsistent

[4]Furlong (1989) provides evidence that commodity price swings precede swings in the consumer price index.

[5]The use of finally revised numbers for the nonmoney data may cause some possible measurement error in our constructed surprise variables because typically the revisions are not part of the information set of market participants. The Results section uses both the initial release and the final revision of the M1 series.

[6]However, the money announcement series discussed below begins in 1972.

estimates of the coefficients' standard errors. For correct inferences the OLS standard errors have to be adjusted. Pagan (1984) has shown, however, that in our specification the OLS standard errors are consistent estimates of the true standard errors. In addition, tests of parameter stability of these projection equations before and after the October 1979 change in operating procedure show no significant coefficient instability.

We use nonoverlapping observations. That is, when examining reactions of, say, 6-week forward rates, we sample our data at 6-week intervals. Our 3-week tests sample at 3-week intervals and similarly for our 13-week tests.

Results

Table 1 shows the results of equation (1), which uses point-in-time data for the unanticipated components of the explanatory variables, and Table 2 shows the results of equation (2), which uses averaged data. The tables present results for three different horizons: 3 weeks, 6 weeks, and 13 weeks. For each horizon, the results are shown for the entire sample period as well as for the pre-October 1979 and post-October 1979 subperiods. On October 6, 1979, the Federal Reserve announced that it would no longer follow interest rate targets, and that its primary focus would be the quarterly growth rate of M1, the narrow definition of money. To emphasize its seriousness, the Federal Reserve switched from borrowed reserves operating targets to nonborrowed reserves. Since that time, many authors have shown that the period following the dramatic October 1979 announcement represents a different monetary regime (see Hardouvelis and Barnhart (1989) and its references). Indeed, our own Chow tests of structural change confirm a break in October 1979.[7] Hence, it is important to examine separately the pre- and post-October 1979 sample periods.

Let us begin with the response to unanticipated money. Recall that Mishkin estimated an equation similar to (1) and found a positive and significant response to unanticipated money in a quarterly sample that ended in 1976. Our 13-week sampling interval in Table 1 resembles very closely the equation estimated by Mishkin. Observe that in the pre-October 1979 period we also find a positive and significant interest rate response to unanticipated money. Under the assumption that unanticipated money, *UNMG*, is uncorrelated with the error term of equation (1), our pre-October 1979 results, as well as the results of Mishkin, can be interpreted as evidence that a liquidity effect is not present in the data. However, the assumption of exogeneity of *UMNG* may not be correct. Suppose, for example, that the Federal Reserve follows interest rate targets and responds within quarter t to an increase in interest rates by expanding the money supply. This response generates a positive correlation between our dependent variable, $i_t - {}_{t-1}f_t$, and $UNMG_t$; hence in this case the assumption of exogeneity of $UNMG_t$ is invalid. Before October 1979 the Federal Reserve responded to changes in interest rates on a daily basis, and the exogeneity assumption is, indeed, unwarranted. However, after October 1979, the Federal Reserve abandoned interest rate targeting and focused

[7] In the presence of serial correlation, the Chow test took the following form: First we tested to see if the autoregressive terms are equal across time periods, that is, if $\rho_1 = \rho_2$. We found no case in which they were. We then transformed each variable by differencing by the appropriate ρ; that is, $\hat{x} = x_t - \rho x_{t-1}$. We then performed a standard OLS Chow test (using dummies) and report the result of the F test on the restriction of insignificant dummies.

Table 1. Response of Interest Rates to Unanticipated Finally Revised Money Using End-of-Period Data

(Sample = January 1975–August 1985)[a]

$$i_t - {}_{t-1}f_t = a_0 + a_1 RISK_{t-1} + a_m UNMG_t + a_y UNYG_t + a_p UNPG_t + u_t$$

Sample	*N* obs	a_0	a_1	a_m	a_y	a_p	R^2	*SEE*	*DW*	ρ	$F(4, N-5)$	*FIAUD*	*FNE*	Chow
						3-Week interval								
Full	172	−33.59**	−2.22	2.02**	−0.01	0.15	0.14	99.58	—	0.28**	2.36	4.45**	4.36**	4.45*
		(12.08	(3.69)	(0.76)	(0.01)	(0.21)				(0.07				
Pre-Oct '79	74	−14.18	2.30	−0.21	−0.00	0.19	0.03	41.91	1.81	—	0.50	0.50	0.77	—
		(7.49)	(29.56)	(0.64)	(0.00)	(0.14)								
Post-Oct '79	98	−59.82**	0.92	2.31*	−0.15**	0.19	0.22	120.38	—	0.25*	4.13**	2.55	3.10*	—
		(20.78)	(4.78)	(1.16)	(0.05)	(0.34)				(0.11)				
						6-Week Interval								
Full	86	−73.87**	−0.23	5.69*	−0.26*	0.65	0.17	140.16	2.06	—	4.09**	4.27**	6.26**	1.44
		(17.16)	(5.88)	(2.34)	(0.11)	(0.55)								
Pre-Oct '79	36	−45.89**	11.75	3.65	0.03	0.42	0.14	47.08	1.79	—	1.25	3.33*	2.70	—
		(12.05)	(51.71)	(2.48)	(0.07)	(0.31)								
Post-Oct '79	50	−102.00**	3.69	4.36	−0.49*	0.29	0.22	175.06	2.25	—	3.12*	2.71*	4.04	—
		(31.09)	(8.05)	(3.26)	(0.19)	(0.91)								
						13-Week Interval								
Full	39	101.60**	18.14	−10.02	−1.37	1.52	0.14	196.72	2.01	—	1.37	1.71	5.35**	3.21*
		(36.26)	(14.25)	(8.36)	(0.99)	(1.67)								
Pre-Oct '79	16	−34.23	35.56	15.74*	1.51*	−1.81	0.57	71.97	—	−0.76	5.23*	5.02*	4.50*	—
		(20.50)	(95.75)	(5.97)	(0.52)	(1.02)				(0.28)				
Post-Oct '79	22	−138.00*	25.17	−24.98*	−3.58*	1.95	0.41	216.96	1.90	—	2.97*	0.60	4.76*	—
		(64.63)	(17.99)	(11.68)	(1.53)	(3.03)								

[a]Data in parentheses are standard errors. Abbreviations are as follows:

**	Statistically significant at the 1% level.
*	Statistically significant at the 5% level.
i_t	T-bill rate of maturity of 3, 6, or 13 weeks observed on first trading day of period $t + 1$, measured in basis points.
${}_{t-1}f_t$	Forward T-bill rate corresponding to i_t, observed on first trading day of period t.
$RISK_{t-1}$	Variance of the 3-week, 6-week, or 13-week T-bill over the weekly sample period from $t - 27$ through $t - 1$.
$UNMG_t$	Unanticipated annualized percentage change in M1 from last week of period $t - 1$ to last week of period t.
$UNYG_t$	Unanticipated annualized percentage change in unemployment claims from last week of period $t - 1$ to last week of period t.
$UNPG_t$	Unanticipated annualized percentage change in Bureau of Labor Statistics commodity spot price index from last week of period $t - 1$ to last week of period t.
N obs	Number of observations.
R^2	Coefficient of determination.
SEE	Regression standard error.
DW	Durbin - -Watson statistic.
ρ	First-order autocorrelation of the OLS residuals.
$F(4, N - 5)$	F statistic of the null hypothesis that $a_1 = a_m = a_y = a_p = 0$.
FIAUD	F statistic of the null hypothesis that $\gamma_m = \gamma_y = \gamma_p = 0$ in equation (3) of text.
FNE	F statistic of the null hypothesis that $\beta_i = -\gamma_i \; \forall \; i$ in equation (3) of text.
Chow	Chow test of structural change across the subperiods.

Table 2. Response of Interest Rates to Unanticipated Finally Revised Money Using Average-of-Period Data

(Sample = January 1975–November 1985)[a]

$$i_t - {}_{t-1}f_t = a_0 + a_1 RISK_{t-1} + a_m UAMG_t + a_y UAYG_t + a_p UAPG_t + u_t$$

Sample	N obs	a_0	a_1	a_m	a_y	a_p	R^2	SEE	DW	ρ	F(4, N − 5)	FIAUD	FNE	Chow
						3-Week interval								
Full	173	−32.86**	−2.33	3.02**	−0.03	0.33	0.17	97.36	—	0.28*	4.12**	1.34	3.24	2.12
		(11.72)	(3.59)	(0.91)	(0.04)	(0.24)				(0.08)				
Pre-Oct '79	74	−7.83	−53.32	0.40	0.02	0.45**	0.14	44.22	—	0.09	2.65*	0.41	1.00	—
		(8.23)	(28.23)	(0.76)	(0.02)	(0.17)				(0.13)				
Post-Oct '79	98	−49.57*	−0.04	3.60*	−0.18	0.17	0.21	120.58	—	0.23*	3.74**	0.42	1.56	—
		(20.05)	(4.65)	(1.50)	(0.10)	(0.42)				(0.11)				
						6-Week interval								
Full	86	−73.87**	−0.23	8.56**	−0.71**	0.92	0.34	124.99	2.27	—	10.37**	0.06	4.00*	2.95*
		(15.30)	(5.24)	(2.95)	(0.21)	(0.67)								
Pre-Oct '79	36	−41.04*	18.12	4.88*	0.06	0.83	0.26	45.53	—	0.34	2.24	1.47	0.74	—
		(15.16)	(58.41)	(1.92)	(0.13)	(0.41)				(0.19)				
Post-Oct '79	48	−106.40**	5.20	6.59	−1.04**	0.49	0.44	152.35	—	−0.25	8.39**	0.42	2.59	—
		(22.79)	(5.89)	(4.19)	(0.29)	(1.13)				(0.17)				
						13-Week interval								
Full	35	−86.20	19.85	2.99	−3.32**	2.91	0.60	162.46	—	0.42*	16.06**	0.67	1.55	2.45
		(51.65)	(14.47)	(9.61)	(0.73)	(1.99)				(0.20)				
Pre-Oct '79	17	11.39	−108.60	11.43	2.35**	−1.12	0.49	67.44	1.87	—	2.88	2.85	1.80	—
		(27.65)	(122.60)	(10.85)		(0.75)	(1.34)							
Post-Oct '79	19	−125.70	24.13	−5.56	−2.55	7.89	0.68	199.31	1.74	—	7.51**	0.22	0.18	—
		(63.43)	(17.04)	(14.22)	(1.27)	(4.57)								

[a]Data in parentheses are standard errors. Abbreviations are as follows:

**	Statistically significant at the 1% level.
*	Statistically significant at the 5% level.
i_t	T-bill rate of maturity of 3, 6, or 13 weeks observed on first trading day of period $t+1$, measured in basis points.
${}_{t-1}f_t$	Forward T-bill rate corresponding to i_t, observed on first trading day of period t.
$RISK_{t-1}$	Variance of the 3-week, 6-week, or 13-week T-bill over the weekly sample period from $t-27$ through $t-1$.
$UNMG_t$	Unanticipated annualized percentage change in M1 from last week of period $t-1$ to last week of period t.
$UNYG_t$	Unanticipated annualized percentage change in unemployment claims from last week of period $t-1$ to last week of period t.
$UNPG_t$	Unanticipated annualized percentage change in Bureau of Labor Statistics commodity spot price index from last week of period $t-1$ to last week of period t.
N obs	Number of observations.
R^2	Coefficient of determination.
SEE	Regression standard error.
DW	Durbin – -Watson statistic.
ρ	First-order autocorrelation of the OLS residuals.
F(4, N − 5)	F statistic of the null hypothesis that $a_1 = a_m = a_y = a_p = 0$.
FIAUD	F statistic of the null hypothesis that $\gamma_m = \gamma_y = \gamma_p = 0$ in equation (3) of text.
FNE	F statistic of the null hypothesis that $\beta_i = -\gamma_i \; \forall \; i$ in equation (3) of text.
Chow	Chow test of structural change across the subperiods.

on the growth rate of M1 over quarterly intervals. During this later period the exogeneity assumption of $UNMG_t$ is more justifiable. It should not come as a surprise, therefore, that the response to unanticipated money becomes negative and significant, as the liquidity effect predicts. Table 1 bears this out. In Table 2, which uses averaged data on money, the post-October 1979 response in the 13-week interval is also negative but is not significant. The reason Table 1 shows a significant response but Table 2 does not is not very clear. It could be that *UNMG* is a better proxy than *UAMG* of the Fed's money growth targets, since *UNMG* resembles more closely the Fed's actual targeting procedure than does *UAMG*.

Turning to the 3- and 6-week intervals, we observe that even after October 1979 the response to unanticipated money is positive. In fact, in the 3-week interval, the post-October 1979 positive response is stronger than the pre-October 1979 response. Given the intuitive results for the 13-week interval, these responses are surprising. One explanation for the positive post-October 1979 response of interest rates to unanticipated money may be the announcement effect we discussed earlier, in the Introduction. When market participants find out that money is higher than anticipated, they expect that the Federal Reserve will subsequently restrict the supply of money to bring it closer to its quarterly target ranges. The anticipation of a future restriction in the supply of money increases interest rates. This explanation is reasonable, especially because in the 3-week observational interval the positive interest rate response is stronger after October 1979 than before. It is after October 1979 that markets began responding to money announcements strongly, primarily because it was then that they percieved the Fed's new seriousness about following M1 targets.[8] Of course, other explanations may also be proposed. But for our purposes, the item of primary interest is the instability of the coefficient of unanticipated money across observation intervals of varying length. It reveals the difficulty of uncovering a liquidity effect econometrically.

Tables 3 and 4 repeat the results of Tables 1 and 2 but instead of using finally revised M1 numbers, they use the originally announced M1 numbers. Originally announced M1 numbers should be more appropriate for capturing any announcement effects than the finally revised series, which, being the stock of money actually held by the public, may better capture liquidity effects. While the conceptual differences between the two sets of tables are significant, the actual differences between them are less significant and do not bear any evidence consistent with the hypothesis that finally revised money numbers should capture a liquidity effect more easily than originally released numbers.[9]

The results for the remaining variables of equations (1) and (2) are generally in line with theoretical expectations. We frequently find a consistent and significant income effect, but its economic importance is minor. An unexpected increase of one percentage point in annualized unemployment claims typically results in a decrease just less than one basis point in interest rates. We also find a significant negative coefficient on our

[8]M1 is announced with a 2-week delay. Our sampling does not match properly with the data contained in the announcement. Hence, $UAMG_t$ and $UNMG_t$ are not the same as the actual money surprises but are correlated with those surprises. Our aim here is not to replicate the money announcement studies but to compare the coefficient of unanticipated money across the different observation intervals.

[9]Roley and Walsh (1984) study the differences between original and finally revised numbers on a weekly frequency and on the days of the money announcements. In addition, they draw a distinction between the unanticipated component of the money announcement and unperceived money stock changes occurring throughout the statement week. They find both to be significant in explaining interest rate movements in the post-1979 period, while data revisions are found insignificant.

Table 3. Response of Interest Rates to Unanticipated Originally Released Money Using End-of-Period Data

(Sample = January 1972–August 1985)[a]

$$i_t - {}_{t-1}f_t = a_0 + a_1 RISK_{t-1} + a_m UNMG_t + a_y UNYG_t + a_p UNPG_t + u_t$$

Sample	N obs	a_0	a_1	a_m	a_y	a_p	R^2	SEE	DW	ρ	F(4, N − 5)	FIAUD	FNE	Chow
						3-Week interval								
Full	219	−38.74**	0.10	0.89	0.03	0.01	0.06	108.95	—	0.21**	1.13	3.89**	4.00**	2.80*
		(10.62)	(3.68)	(0.49)	(0.02)	(0.11)				(0.07)				
Pre-Oct '79	125	−8.68	−35.04*	0.05	−0.00	0.08	0.05	59.21	1.94	—	1.64	2.39	3.12*	—
		(7.59)	(16.27)	(0.36)	(0.02)	(0.07)								
Post-Oct '79	94	−82.70**	6.18	2.46*	0.05	−0.37	0.12	147.19	—	0.23*	2.01	2.63	2.33	—
		(26.00)	(5.86)	(1.04)	(0.03)	(0.44)				(0.10)				
						6-Week interval								
Full	110	−77.92**	−4.72	2.44	−0.27**	0.35	0.14	133.21	2.05	—	4.41**	7.07**	9.42**	0.92
		(14.32)	(5.46)	(1.51)	(0.10)	(0.23)								
Pre-Oct '79	60	−37.19**	−51.47	0.45	−0.06	0.26	0.13	74.71	2.29	—	2.02	1.48	1.98	—
		(13.94)	(30.82)	(1.18)	(0.11)	(0.14)								
Post-Oct '79	50	−134.40**	3.28	5.11**	−0.33	−0.48	0.19	173.84	1.99	—	2.70*	8.33**	9.45**	—
		(33.67)	(8.17)	(2.90)	(0.15)	(0.97)								
						13-Week interval								
Full	49	−83.75*	16.21	−0.31	−0.80	1.99	0.19	191.14	1.98	—	2.55	0.58	1.32	15.09*
		(31.30)	(13.63)	(6.33)	(0.44)	(1.17)								
Pre-Oct '79	29	−34.06	−55.71	4.90	0.06	0.94	0.24	70.55	1.57	—	1.91	0.79	1.81	—
		(19.63)	(50.99)	(2.94)	(0.20)	(0.54)								
Post-Oct '79	19	−82.30	−4.98	−22.94*	−5.52**	4.28*	0.76	179.63	—	0.50*	16.58**	0.92	2.60	—
		(99.57)	(19.29)	(9.63)	(0.85)	(1.95)				(0.17)				

[a]Data in parentheses are standard errors. Abbreviations are as follows:

**	Statistically significant at the 1% level.
*	Statistically significant at the 5% level.
i_t	T-bill rate of maturity of 3, 6, or 13 weeks observed on first trading day of period $t + 1$, measured in basis points.
${}_{t-1}f_t$	Forward T-bill rate corresponding to i_t, observed on first trading day of period t.
$RISK_{t-1}$	Variance of the 3-week, 6-week, or 13-week T-bill over the weekly sample period from $t - 27$ through $t - 1$.
$UNMG_t$	Unanticipated annualized percentage change in M1 from last week of period $t - 1$ to last week of period t.
$UNYG_t$	Unanticipated annualized percentage change in unemployment claims from last week of period $t - 1$ to last week of period t.
$UNPG_t$	Unanticipated annualized percentage change in Bureau of Labor Statistics commodity spot price index from last week of period $t - 1$ to last week of period t.
N obs	Number of observations.
R^2	Coefficient of determination.
SEE	Regression standard error.
DW	Durbin – -Watson statistic.
ρ	First-order autocorrelation of the OLS residuals.
F(4, N − 5)	F statistic of the null hypothesis that $a_1 = a_m = a_y = a_p = 0$.
FIAUD	F statistic of the null hypothesis that $\gamma_m = \gamma_y = \gamma_p = 0$ in equation (3) of text.
FNE	F statistic of the null hypothesis that $\beta_i = -\gamma_i \ \forall \ i$ in equation (3) of text.
Chow	Chow test of structural change across the subperiods.

Table 4. Response of Interest Rates to Unanticipated Originally Released Money Using Average-of-Period Data

(Sample = January 1972–August 1985)[a]

$$i_t - {}_{t-1}f_t = a_0 + a_1 RISK_{t-1} + a_m UAMG_t + a_y UAYG_t + a_p UAPG_t + u_t$$

Sample	N obs	a_0	a_1	a_m	a_y	a_p	R^2	SEE	DW	ρ	$F(4, N-5)$	$FIAUD$	FNE	Chow
						3-Week interval								
Full	221	−39.06**	0.05	1.24*	−0.03	0.11	0.07	108.20	—	0.17**	1.59	2.86*	4.21**	5.76
		(10.01)	(3.49)	(0.63)	(0.02)	(0.11)				(0.07)				
Pre-Oct '79	127	−7.92	−42.27*	0.03	−0.01	0.09	0.07	62.77	1.86	—	2.12	2.05	2.99*	—
		(8.00)	(17.11)	(0.49)	(0.02)	(0.07)								
Post-Oct '79	95	−80.36**	5.48	2.82*	−0.27*	−0.01	0.15	141.76	1.98	—	3.91**	0.88	1.99	—
		(20.36)	(4.51)	(1.32)	(0.11)	(0.51)								
						6-Week interval								
Full	110	−78.16**	−4.68	4.88**	−0.45**	0.90*	0.26	123.68	2.04	—	9.28**	0.36	4.78*	8.24*
		(13.30)	(5.07)	(1.78)	(0.13)	(0.39)								
Pre-Oct '79	60	−33.70*	−52.13	0.86	−0.07	0.54	0.14	79.37	2.04	—	2.24	2.00	3.02*	—
		(14.68)	(32.50)	(1.51)	(0.11)	(0.30)								
Post-Oct '79	49	−128.90**	2.18	9.84**	−0.76**	1.23	0.51	135.39	—	−0.25	12.52**	0.63	3.10*	—
		(21.28)	(5.29)	(2.95)	(0.21)	(0.90)				(0.16)				
						13-Week interval								
Full	48	−96.28**	13.81	12.60	−1.49**	2.08	0.44	164.70	1.67	—	8.59**	1.46	1.11	3.86*
		(27.40)	(11.56)	(6.70)	(0.52)	(1.10)								
Pre-Oct '79	28	−49.54	−3.30	10.67*	−0.08	0.74	0.44	82.22	—	0.28	2.74	2.51	3.37*	—
		(29.39)	(67.84)	(4.54)	(0.35)	(0.59)				(0.26)				
Post-Oct '79	18	−173.30	22.30	5.95	−2.66*	3.57	0.67	205.19	—	0.13	6.93**	0.33	0.99	—
		(80.96)	(19.53)	(13.56)	(1.13)	(3.68)				(0.35)				

[a]Data in parentheses are standard errors. Abbreviations are as follows:

**	Statistically significant at the 1% level.
*	Statistically significant at the 5% level.
i_t	T-bill rate of maturity of 3, 6, or 13 weeks observed on first trading day of period $t+1$, measured in basis points.
${}_{t-1}f_t$	Forward T-bill rate corresponding to i_t, observed on first trading day of period t.
$RISK_{t-1}$	Variance of the 3-week, 6-week, or 13-week T-bill over the weekly sample period from $t-27$ through $t-1$.
$UNMG_t$	Unanticipated annualized percentage change in M1 from last week of period $t-1$ to last week of period t.
$UNYG_t$	Unanticipated annualized percentage change in unemployment claims from last week of period $t-1$ to last week of period t.
$UNPG_t$	Unanticipated annualized percentage change in Bureau of Labor Statistics commodity spot price index from last week of period $t-1$ to last week of period t.
N obs	Number of observations.
R^2	Coefficient of determination.
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$F(4, N-5)$	F statistic of the null hypothesis that $a_1 = a_m = a_y = a_p = 0$.
$FIAUD$	F statistic of the null hypothesis that $\gamma_m = \gamma_y = \gamma_p = 0$ in equation (3) of text.
FNE	F statistic of the null hypothesis that $\beta_i = -\gamma_i \; \forall \; i$ in equation (3) of text.
Chow	Chow test of structural change across the subperiods.

proxy for time-varying risk, as expected. Finally, we do not find a significant Fisher effect. This may be due to the use of a spot commodity index rather than the CPI, which is unavailable at the weekly frequency.

Contrasting the results of Table 1 with Table 2 (or Table 3 with Table 4) indicates the importance of temporal aggregation (averaging of the independent variables). The estimated coefficients are much more frequently significant with the averaged data than with the end-of-period data. In the case of income effects, where we tend to find our most significant results, the size of the coefficients frequently more than doubles. The stronger results of equation (2) may be due to the elimination of noise (transitory components) that the averaging accomplishes.

Accompanying each regression there is an F statistic for the null hypothesis that the coefficients of the independent variables are jointly zero. This null hypothesis is clearly rejected. In each table we also present two additional F statistics, *FNE* and *FIAUD*. *FNE* tests the null hypothesis that the effect of the anticipated components of money (*FMG*), output (*FYG*), and prices (*FPG*) are zero. *FIAUD* tests the null hypothesis that the response of interest rates to the unanticipated components of money, output, and prices is the same as the response to the anticipated components of money, output, and prices.[10] The test is conducted by estimating

$$\begin{aligned} i_t - {}_{t-1}f_t = \beta_0 + \beta_S RISK_{t-1} + \beta_M MG_t + \beta_Y YG_t + \beta_P PG_t \\ + \gamma_M FMG_t + \gamma_Y FYG_t + \gamma_P FPG_t + \epsilon_t, \end{aligned} \tag{3}$$

where MG, YG, and PG are the annualized growth rates of money and our proxies for income and the price level; and FMG, FYG, and FPG are the respective model-based forecasts.

The hypothesis that the effects of the anticipated components are the same as the effects of the unanticipated components is equivalent to $\gamma_M = \gamma_Y = \gamma_P = 0$. The *FIAUD* statistics show that with averaged data the null hypothesis is rarely rejected, which implies that the distinction between anticipated and unanticipated variables is perhaps overemphasized in the empirical literature. The results from using end-of-period data, however, are mixed. The hypothesis that the anticipated components *FMG*, *FYG*, and *FPG* do not matter is equivalent to $\beta_i = -\gamma_i \ \forall i$.[11] As the *FNE* statistics show, the hypothesis is clearly rejected, particularly with shorter unit time intervals and in the pre-1979 time period.

IV. Conclusion

This article provides a new look at the old issue of the relationship between money and interest rates. It systematically explores issues of temporal aggregation and data revisions in a money supply–money demand framework. We were able to detect a liquidity effect only in the post-October 1979 period and in the 13-week observation interval. We attributed the observed negative association between unanticipated money

[10] Frydman and Rappaport (1987) have claimed that the distinction between anticipated and unanticipated variables, which is an outcome of the efficient markets hypothesis, may be overemphasized in the literature.

[11] To see this, express MG_t as the sum of FMG_t, the anticipated component, and UMG_t, the unanticipated component, and similarly YG_t and PG_t. Frydman and Rappaport argue that the present implementation of the test avoids measurement error problems that are inherent in econometric proxies of market expectations.

and interest rates to the Federal Reserve's adoption of quarterly M1 targets, which made the quarterly growth of M1 more exogenous than before October 1979. At observation intervals other than 13 weeks or during the pre-October 1979 period, we were unable to uncover a liquidity effect.

We also found that the empirical problem of data revisions in M1 is not as important as the problem of temporal aggregation. Time averaging of the independent variables substantially changes estimated magnitudes. Also, observation intervals of varying sizes imply different coefficient estimates in terms of both sign and significance. Thus, in empirical work, issues of temporal aggregation should not be dismissed as simple theoretical curiosa.

References

Cornell, B. (August 1982) Money supply announcements, interest rates, and foreign exchange. *Journal of International Money and Finance* 1:201-208.

Engel, C. M., and Frankel, J. A. (January 1984) Why money announcements move interest rates: An answer from the exchange rate market. *Journal of Monetary Economics* 13:31-39.

Fama, E. F., and Gibbons, M. R. (May 1982) Inflation, real returns, and capital investment. *Journal of Monetary Economics* 9:297-324.

Frydman, R., and Rappaport, P. (September 1987) Is the distinction between anticipated and unanticipated money growth relevant in explaining output? *American Economic Review* 77:693-703.

Furlong, F. T. (Winter 1989) Commodity prices as a guide to monetary policy. *Economic Review* (Federal Reserve Bank of San Francisco), no. 1, pp. 21-38.

Grossman, J. (November 1981) The rationality of money supply expectations and the short-run response on interest rates to monetary surprises. *Journal of Money, Credit and Banking* 13:409-423.

Hardouvelis, G. A. (September 1984) Market perceptions of Federal Reserve policy and the weekly monetary announcements. *Journal of Monetary Economics* 14:225-240.

Hardouvelis, G. A. (June 1987) Reserves announcements and interest rates: Does monetary policy matter? *Journal of Finance* 47:407-422.

Hardouvelis, G. A. (March 1988) Economic news, exchange rates and interest rates. *Journal of International Money and Finance* 7:23-35.

Hardouvelis, G. A., and Barnhart, S. W. (1989) The evolution of Federal Reserve credibility: 1978-1984. *Review of Economics and Statistics* 71:385-393.

Litterman, R. B., and Weiss, L. M. (January 1985) Money, real interest rates, and output: A reinterpretation of postwar U.S. data. *Econometrica* 53:129-156.

Makin, J. (September 1983) Real interest, money surprises, anticipated inflation and fiscal deficits. *Review of Economics and Statistics* 65:374-384.

Mishkin, F. (March 1982) Monetary policy and short-term interest rates: An efficient markets-rational expectations approach. *Journal of Finance* 35:63-72.

Nichols, D. A., Small, D. H., and Webster, C. E. (June 1983) Why interest rates rise when an unexpectedly large money stock is announced. *American Economic Review* 73:383-388.

Pagan, A. (February 1984) Econometric issues in the analysis of regressions with generated regressors. *International Economic Review* 25:221-247.

Roley, V. V. (August 1983) The response of short-term interest rates to weekly money announcements. *Journal of Money, Credit and Banking* 15:344-354.

Roley, V. V., and Walsh, C. E. (May 1984) Unanticipated money and interest rates. *American Economic Review* 74:49-54.

Roley, V. V., and Walsh, C. E. (Supplement 1985) Monetary policy regimes, expected inflation, and the response of interest rates to money announcements. *Quarterly Journal of Economics* 100:1011-1039.

Sims, C. A. (May 1980) Comparison of interwar and postwar cycles: Monetarism reconsidered. *American Economic Review* 70:250-257.

Urich, T. J., and Wachtel, P. (December 1981) Market responses to the weekly money supply announcements in the 1970's. *Journal of Finance* 36:1063-1072.

Wilcox, J. (March 1983) Why real rates were so low in the 1970's. *American Economic Review* 73:44-53.