No. 8801

ESTIMATING THE IMPACT OF MONETARY POLICY ON SHORT-TERM INTEREST RATES IN A RATIONAL EXPECTATIONS--EFFICIENT MARKETS MODEL: FURTHER EVIDENCE

by

Kenneth J. Robinson and Eugenie D. Short*

Research Department
Federal Reserve Bank of Dallas

February 1988

Research Paper

Federal Reserve Bank of Dallas

No. 8801

ESTIMATING THE IMPACT OF MONETARY POLICY ON SHORT-TERM INTEREST RATES IN A RATIONAL EXPECTATIONS--EFFICIENT MARKETS MODEL: FURTHER EVIDENCE

by

Kenneth J. Robinson and Eugenie D. Short*

Research Department
Federal Reserve Bank of Dallas

February 1988

* The views expressed in this article are solely those of the authors, and should not be attributed to the Federal Reserve Bank of Dallas or the Federal Reserve System.

Assessing the impact of changes in the growth rate of money on the pattern of nominal interest rate movements has been an important issue in research on the transmission mechanism of monetary policy. Traditional analysis of the effects of an increase in the growth rate of money on nominal interest rates hypothesized a stylized response pattern of an initial decline in interest rates, called the liquidity effect, followed by a rise in interest rates from the combined impact of income and price expectations effects. The liquidity effect from faster money growth reflects the fall in interest rates required to equate the supply and demand for real money balances following the acceleration in money supply growth. The income effect from an acceleration in money growth refers to the upward pressure on interest rates from a rise in nominal income. The increase in nominal income results from the combined impact of any rise in real money balances and real sector growth generated by the monetary stimulus. The price expectations effect reflects any altered expectations of the impact of faster money growth on price inflation. Higher price expectations will also tend to push up interest rates. The response pattern of interest rates to a more accommodative monetary policy is thus critically dependent upon the strength of the liquidity effect and the speed of adjustment to the income and price expectations effects.

The early literature on this issue--Friedman [1964], Cagan [1966] --confirmed a fairly long response time of as much as one to two years between the initial decline in interest rates from accelerated money growth and the reversal of this pattern to higher nominal interest rates. Later work by Cagan and Gandolfi [1969] found that interest rates declined for six months following an increase in money growth and thereafter began to rise. Gibson [1970] reported a time lag of between four to nine months between the initial decline and subsequent turnaround in interest rates. The time lag varied with the definition of money and interest rates used in the estimation.

More recent empirical work on the relationship between money growth and nominal interest rate changes either finds no relationship between these variables or a considerably shorter adjustment path between the initial decline and eventual rise in interest rates from accelerated money growth. Findings reported by Wilcox [1983], Hoehn [1983], Mehra [1985], and Reichenstein [1987] for the period including much of the decade of the 1970's do not identify a significant negative effect of money growth on interest rates. Other work for the period including Brown and Santoni [1983] and Melvin [1983] report a temporary, significant decline in interest rates but the time lag between the initial drop and subsequent increase in interest rates was only one month or less. Melvin's [1983] results indicate that interest rates moved above their original level by the second month after a monetary acceleration.

These recent studies conclude that the shortened response time to a change in monetary growth reflects the impact of changes in Federal Reserve operating procedures when the Federal Reserve began announcing target growth ranges for money. In addition, arguments are given that agents adjusted their expectations of price movements more quickly during that period of high price inflation. Prior to the high inflation years of the 1970s, policymakers tended to believe that expansionary monetary policy would significantly lower interest rates for a considerable duration. In contrast, beginning in the mid-1970s, U.S. monetary policy was formulated more with the view that high interest rates were the result of an accommodative monetary policy that fueled inflationary expectations. As a result, policymakers tended to respond to rising interest rates by lowering money growth. This institutional change induced investors to respond quickly to larger-than-anticipated increases in the money supply by bidding down the price of fixed-income securities in anticipation of subsequent Federal Reserve efforts to decelerate money growth. [1]

Estimates of the formation of inflation expectations reported by Blejer [1978], Cornell [1983], and Mehra [1985] indicate that the lag between money growth and inflation also shortened considerably during the 1970s. These studies, together with work on the theory of rational expectations and market efficiency, indicate that inflationary expectations can adjust quite quickly, particularly when the level of inflation is high. [2] The combined effect of rapid adjustments in inflationary expectations and quick investor response to anticipated changes in monetary policy can offset the short-run liquidity effect. Hence, even in the very short-run, the net effect of a change in money growth on interest rates is uncertain.

Most of the recent work from the 1970s through 1983 on the relationship between money growth and interest rates indicates that monetary acceleration has had an essentially neutral impact on short-term interest rates. Since then, however, the relationship may again have changed. In the recent past, financial innovations and deregulation of financial markets occasionally have combined to make the monetary aggregates less valuable guides in formulating monetary policy. This induced the Federal Reserve to alter operating procedures in late 1982 toward greater emphasis on interest rates and away from monetary aggregate targets. Moreover, in 1987 the Federal Reserve declined to specify a target growth range for the narrow M1 aggregate. [3] In addition to this change in operating procedures, the relationship between inflation and money growth also appears to have changed. Since 1983, the rate of inflation has slowed considerably despite accelerated money growth. From 1983 through 1986 inflation averaged 3.2 percent while the average rate of increase in the narrow M1 aggregate, though variable, was 9.8 percent. That compares to average growth in M1 of 6.6 percent from 1979 through 1982, the height of the recent inflationary environment in the U.S. when the CPI recorded average annual increases of approximately 10 percent.

The change in Federal Reserve operating procedures together with the deceleration in inflation may have again altered the response pattern of interest rates to changes in money growth. In an attempt to verify this, we extend the existing empirical work on the relationship between money growth and short-term interest rates through 1986. Following Mishkin [1983], we employ the efficient markets-rational expectations approach. This approach has the advantage of imposing a theoretical structure on the problem that allows both easier interpretation of the empirical results and more powerful statistical tests. The period examined is from 1959-1986. Different from both Mishkin's [1983] findings for the period 1959-76, and Reichenstein's [1987] extension of Mishkin's work for the period 1959-1983, the results obtained in this study verify the existence of a short-run liquidity effect. Moreover, results reported on the formation of inflation expectations estimated over the lengthened period, 1959-1986, also indicate that the role of money growth in the formation of inflation expectations may have changed in the 1980's. In contrast with previous findings, including Mishkin [1983], Mehra [1985] and Reichenstein [1987], money growth did not emerge as a significant determinant in the formation of price expectations during the period 1959-1986.

II. THE MODEL

The theory of efficient markets, or rational expectations, postulates that interest rates in financial markets reflect all available information. More formally, the rational expectations hypothesis maintains that the market's subjective probability distribution of any variable is identical to the objective probability distribution of that variable, conditional on all available past information. Under rational expectations an arbitrage condition exists in that no unexploited profit opportunities exist in financial markets. At the current price, market participants cannot expect to earn a higher-than-normal rate of return by investing in a particular security. To give this hypothesis empirical content, a model of market equilibrium of interest rates is needed.

Following Mishkin [1983], we assume that, for short-term interest rates, the one-period ahead forward rate equals the one-period ahead expected short rate plus a risk premium:

(1) $$_{t-1}F_t = E_m(r_t | \emptyset_{t-1}) + d_t^s,$$

and

(2) $$d_t^s = a_0 + a_1\sigma_t,$$

where:

r_t=one-period short-term interest rate at time t,

${}_{t-1}F_t$=forward rate for the one-period ahead rate at time t implied by the yield curve at t-1,

d_t^s=risk premium for ${}_{t-1}F_t$,

σ_t=a measure of uncertainty of short-rate movements.

$\emptyset_{t-1}$ = information available at t-1.

Combining the arbitrage condition implied by rational expectations with this model of market equilibrium gives the following:

(3) $$E(r_t - {}_{t-1}F_t - a_0 - a_1\sigma_t \mid \emptyset_t) = 0,$$

which states that $r_t - {}_{t-1}F_t$ is uncorrelated with any past available information. The corresponding efficient markets model we employ makes use of the liquidity preference approach to money demand as in Laidler [1985]. In this model, interest rates are assumed to be related to money growth as well as to movements in income and prices. Therefore, unanticipated changes in interest rates are hypothesized to be the result of unexpected movements in each of the following variables: money growth; growth in income; and inflation. This leads to the following estimation equation:

(4) $$r_t = {}_{t-1}F_t - a_0 - a_1\sigma_t + B_m(MG_t - MG_t^e) + B_y(IPG_t - IPG_t^e) + B_p(P_t - P_t^e) + \varepsilon_t,$$

where

MG_t, IPG_t, P_t=growth rates of money, industrial production (as a proxy for income) and prices, respectively,

MG^e_t, IPG^e_t, P^e_t=expected growth rates of money, industrial production and prices, respectively,

B_m, B_y, B_p=coefficients.

As Mishkin [1983] points out, this equation is the efficient-markets analog to the typical money-demand relationship in that it is only when new information hits the market that r_t will deviate from its expected rate. If a liquidity effect is present, then the coefficient on money growth, B_m, is negative. In this case, unanticipated increases in money lead, at least in the short run, to declines in interest rates. Further, a liquidity-preference view hypothesizes that the coefficients on the other variables are positive. Unanticipated increases in real income and inflation result in increases in short term interest rates.

III. EMPIRICAL RESULTS

Data

In estimating equation 4, seasonally adjusted, quarterly data for the time period 1959-1986 are used for the following variables:

r_t=90-day Treasury bill rate, last day of the quarter;

M1G=growth rate of M1, first difference in logs;

M2G=growth rate of M2, first difference in logs;

IPG=growth rate of industrial production, first difference in logs (as a proxy for real income);

INF=inflation rate, first difference in logs of CPI.

These data are obtained from the Board of Governors of the Federal Reserve system. Since the central bank can more closely control M1, and also since M1 should have the most immediate impact on short-term interest rates, this particular monetary aggregate might be preferred. In an effort to determine the extent to which the results are sensitive to the measure of money used, however, estimates of the parameters of equation 4 are attempted using both M1 and M2.

Forecasting Equations

The expectations variables are assumed to be rational forecasts obtained from linear forecasting equations. To obtain estimates of the expectations variables, multivariate forecasting equations are formulated using the Granger [1969] concept of predictive quality. That is, each of the four variables, M1G, M2G, IPG and INF was regressed on its own four lags, plus four lags of each of the other variables included in the estimation equation, plus four lags of each of the following variables: the unemployment rate (URATE); r_t; balance of payments on current account (CURRACCT); growth rate of real federal government expenditures (FEDEXP); high employment budget surplus (DEF); and the growth rate of federal government interest-bearing debt in the hands of the public (DEBTG). In choosing these variables, we followed Mishkin [1983] and also the literature on reaction functions [Barth, Sickles and Wiest, 1982]. That is, these variables appear to have influenced Federal Reserve behavior and would possibly be used in the formation of expectations by economic agents. The four lags of each of these variables were retained in a forecasting equation only if they were jointly significant at the five percent level. Results from this procedure are reported in Table 1. Since these equations contain lagged dependent variables, the Durbin-Watson test statistic is invalid. Therefore, we employ the test developed by Breusch [1977] and Godfrey [1978] (B-G) to detect serial correlation. In each case, the forecasting equations are found to possess serially uncorrelated error terms.

Risk Measure

The measure of uncertainty, σ_t, is constructed as the average absolute change in the Treasury bill rate over a number of quarters. Following Mishkin [1983, p. 85] the difference between the spot and forward rate $(r_t - {}_{t-1}F_t)$ was regressed on measures of σ_t. The best fit was obtained from σ_t calculated from twelve previous quarters. The results are given as:

$$(5) \qquad (r_t - {}_{t-1}F_t) = \underset{(0.0020)}{-0.000977} - \underset{(0.2625)}{0.56128^{**}} * \sigma_t$$

R^2=0.05; D-W=1.535, SSE=0.110, **=significant at 5% level.

This measure of risk is crude in that it is not based explicitly on any utility-maximizing behavior. Also, it is assumed that the manner in which agents evaluate their risk is constant over time. Therefore, the empirical results which follow are reported both with and without the risk variable included. The results are not substantively affected if this variable is excluded.

Results

Equation 4 is estimated using the Barro [1977] two-step procedure which entails using the residuals from the forecasting equations as independent variables in equation 4. A well known shortcoming with the two-step procedure is that it fails to account for the fact that the unobservable regressors have been estimated in the calculation of the parameters and standard errors in the second step. As a result, the second-step standard errors and related test statistics are incorrect. Unlike previous research in this area (Reichenstein [1987]), we use the procedure developed by Murphy and Topel [1985] to obtain the asymptotically correct covariance matrix which allows for valid statistical inference. Variations of equation 4 are estimated in an attempt to determine how robust the results are to the particular monetary aggregate chosen. Also, in an effort to determine how sensitive the results are to the risk variable, σ_t (SIGMA), we report results both including and omitting this variable. The initial estimates appear in Table 2.

Regardless of the particular monetary aggregate chosen or whether or not the risk variable is included, a significant liquidity effect is found. That is, the coefficient on unanticipated money growth is significantly negative. Further, the other variables possess their hypothesized signs and are statistically significant. [4,5]

Heteroscedasticity

The dependent variable in the models estimated is, in effect, a forecast error. There is no reason to assume, however, that the variance of this forecast error is constant through time. Rational expectations requires only that, on average, market participants' forecasts are correct. In an effort to determine if the variance of the forecast error changes over time, Glesjer's [1969] test for heteroscedasticity is undertaken. The results from these tests are found in Table 3 and indicate that it is the square of the inflation rate which seems to determine the heteroscedasticity. Other variables were tested, including money growth and money growth squared, inflation, unanticipated money growth, unanticipated money growth squared, unanticipated inflation and unanticipated inflation squared. All of these variables were found to be insignificant.

Results for the models corrected for the presence of heteroscedasticity using weighted least squares are found in Table 4. A significant liquidity effect is still present when M1 is used. For the broader monetary aggregate however, the empirical results now fail to show a significant liquidity effect.

The presence of a significant liquidity effect in the models estimated is in contrast to Mishkin [1983] and Reichenstein [1987] both of whom find no significant liquidity effect present. Reichenstein estimated his model using monthly data. It could be the case that the Federal Reserve's operating horizon is longer than one month, in which case a significant liquidity effect may not be discovered with monthly data.

It could be argued that the presence of a liquidity effect is due to a fundamental change in the manner in which economic agents formulate expectations. Chow tests were conducted on the regressions generating expectations of M1 growth and inflation. It was assumed that a break occurred beginning in 1980 to coincide with the change in Fed operating procedures undertaken at that time. It was also in 1980 that transactions deposits began paying interest nationwide. For both variables, a significant F statistic, 2.56 for $M1G_t^e$ and 2.68 for P_t^e, indicated a structural change occurred in the decade of the 1980's. Further evidence that a change in inflationary expectations may have occurred is presented in Table 5. Following Mehra [1985], the Livingston survey measure of inflationary expectations is regressed against money growth and current and past inflation. It can be seen that the coefficient of money growth on inflationary expectations increases substantially from the 1960's to the 1970's. The decade of the 1980's, however, finds money growth to be insignificant as an explanatory variable in the formation of inflationary expectations. This is not surprising given the unprecedented decline in velocity which has characterized much of the 1980's.

IV. CONCLUSION

Empirical research on the relationship between changes in money growth and short-term interest rates indicates that the relationship varies over time. Estimates of the magnitude and duration of the short-term liquidity effect reveal that both factors can change when estimated over different time periods. Evidence obtained through the 1960's supports a negative and significant short-term liquidity effect with a time lag between the initial decline in interest rates and subsequent reversal ranging from a few months to more than a year. In contrast, estimates of the relationship between accelerated money growth and short-term interest rates from the 1970's through the early 1980's revealed either no significant relationship between changes in money growth and nominal interest rate movements or a considerably shortened duration of lower nominal rates. Evidence reported in this paper suggests that this relationship again changed in the 1980's. Estimates of the short-term liquidity effect obtained with data extended to include 1983 through 1986 again reveal a negative and significant relationship between unanticipated changes in money growth and short-term interest rates. This altered relationship appears to reflect the impact of changes in Federal Reserve operating procedures in late 1982 together with an apparent change in the measured relationship between inflation and money growth.

Using a rational expectations--efficient markets approach, this paper finds a significant liquidity effect associated with an expansionary monetary policy. Several specifications are estimated in an effort to resolve potential difficulties associated with both the appropriate measure of money to be used as well as the risk variable employed. Further, potential econometric problems including simultaneity and heteroscedasticity are addressed. Finally, unlike previous work employing the two-step procedure, the estimation technique used here accounts for the fact that the unobservable regressors are measured with error, thus allowing for valid statistical inference. In all cases, unanticipated increases in money growth lead to declines in short-term interest rates. One possible explanation for the reemergence of the liquidity effect may lie in the changing pattern of expectations formation due to changes in

Federal Reserve operating procedures as well as recent unprecedented declines in velocity.

An interesting extension of the model may lie in a more formal specification of the risk variable. It is somewhat crude to suppose that risk permia are constant over time. Engle [1982] and Engle, Lilien and Robins [1987] offer a technique that allows for nonconstant liquidity or risk permia in an effort to obtain more efficient parameter estimates. Use of the ARCH or ARCH-M models in estimating the effects of policy changes on interest rates would possibly allow for a more formal treatment of time-varying risk permia.

TABLE 1

ESTIMATES OF FORECASTING EQUATIONS

	M1G	M2G	IPG	INF
Constant	0.00839 (0.0027)	0.0104 (0.0027)	-0.0062 (0.0064)	0.0026 (0.0022)
M1G(-1)	0.0608 (0.1146)			
M1G(-2)	0.2551 (0.1145)			
M1G(-3)	-0.0204 (0.1169)			
M1G(-4)	0.2563 (0.1085			
M2G(-1)		0.3809 (0.1066)	0.3876 (0.2743)	
M2G(-2)		0.1241 (0.1079)	0.8852 (0.2594)	
M2G(-3)		0.0713 (0.1120)	-0.2150 (0.2758)	
M2G(-4)		-0.0818 (0.1088)	0.1258 (0.2655)	
IPG(-1)	-0.0281 (0.0554)	-0.1365 (0.0391)	0.3055 (0.1053)	0.0248 (0.0372)
IPG(-2)	-0.0602 (0.0542)	0.0004 (0.0413)	-0.1423 (0.1119)	-0.0535 (0.0414)
IPG(-3)	-0.0056 (0.0459)	0.0141 (0.0343)	0.0763 (0.0907)	0.0006 (0.0380)
IPG(-4)	-0.0146 (0.0388)	-0.0267 (0.0325)	-0.1031 (0.0791)	0.0408 (0.0327)
INF(-1)	0.2612 (0.1954)		-0.5903 (0.3416)	0.2519 (0.1098)
INF(-2)	-0.3761 (0.1964)		0.3928 (0.3365)	0.4436 (0.1093)
INF(-3)	-0.0163 (0.1999)		-0.2279 (0.3479)	0.3315 (0.1153)
INF(-4)	0.2096 (0.2061)		-0.4216 (0.3810)	-0.0637 (0.1203)
r(-1)	-0.0058 (0.0012)			0.0017 (0.0007)

TABLE 1 (Continued)

	M1G	M2G	IPG	INF
r(-2)	0.0069 (0.0018)			-0.0016 (0.0009)
r(-3)	-0.0023 (0.0020)			-0.0001 (0.0010)
r(-4)	0.0006 (0.0014)			-0.00006 (0.0007)
URATE(-1)				-0.0059 (0.0028)
URate(-2)				0.0090 (0.0028)
URATE(-3)				-0.0046 (0.0038)
URATE(-4)				0.0012 (0.0025)
DEF(-1)	0.0001 (0.0001)			0.00008 (0.00004)
DEF(-2)	-0.00003 (0.00008)			-0.0001 (0.00004)
DEF(-3)	0.000008 (0.00009)			0.00001 (0.00005)
DEF(-4)	-0.00015 (0.00008)			0.00005 (0.00004)
DEBTG(-1)		-0.0211 (0.0283)		
DEBTG(-2)		0.0471 (0.0282)		
DEBTG(-3)		0.0233 (0.0287)		
DEBTG(-4)		0.0364 (0.0276)		
R^2	0.57	0.38	0.47	0.81
B-G	2.45	1.29	2.04	0.71
SSE	0.005	0.004	0.025	0.002

NOTE: Standard Errors in Parentheses

TABLE 2

ESTIMATES OF EFFICIENT MARKETS-RATIONAL EXPECTATIONS MODELS
1959-1986

Coefficients of:

Model	Constant	$(M1G-M1G^e)$	$(M2G-M2G^e)$	$(IPG-IPG^e)$	$(INF-INF^e)$	SIGMA	F
A	-0.0017 (0.0032)	-0.2993** (0.1448)		0.3152* (0.0694)	0.5525** (0.2436)	-0.4344 (0.2767)	2.23*
$R^2 = 0.26$; D-W = 1.53							
B	-0.0013 (0.0027)		-0.5657* (0.1537)	0.3287* (0.0658)	0.4347 (0.2335)	-0.5056** (0.2920)	1.98*
$R^2 = 0.33$; D-W = 1.652							
C	-0.0047* (0.0024)	-0.2861* (0.1416)		0.3003* (0.0640)	0.5366** (0.2370)		2.45*
$R^2 = 0.2185$; D-W = 1.497							
D	-0.0047* (0.0022)		-0.5020* (0.1507)	0.3042* (0.0599)	0.4358 (0.2300)		2.18*
$R^2 = 0.27$; D-W = 1.591							

NOTE: * = significantly different from zero at the 1% level

** = significantly different from zero at the 5% level

Standard Errors in Parentheses

TABLE 3

GLESJER TEST FOR HETEROSCEDASTICITY

Model:

Model	
A	$\text{ABSRES} = \underset{(0.0008)}{0.0046} + \underset{(2.2082)}{6.6511^{*}} * \text{CPISQ}$
A	$\text{RES}^2 = \underset{(0.0003)}{0.0004} + \underset{(0.0646)}{0.1899^{*}} * \text{CPISQ}$
B	$\text{ABSRES} = \underset{(0.0008)}{0.0046^{*}} + \underset{(1.9913)}{5.2602^{*}} * \text{CPISQ}$
B	$\text{RES}^2 = \underset{(0.00002)}{0.00004} + \underset{(0.0572)}{0.1518^{*}} * \text{CPISQ}$
C	$\text{ABSRES} = \underset{(0.0008)}{0.0051^{*}} + \underset{(2.0572)}{5.5343^{*}} * \text{CPISQ}$
C	$\text{RES}^2 = \underset{(0.00002)}{0.00004} + \underset{(0.0643)}{0.1631^{*}} * \text{CPISQ}$
D	$\text{ABSRES} = \underset{(0.0008)}{0.0052^{*}} + \underset{(1.9839)}{4.4112^{**}} * \text{CPISQ}$
D	$\text{RES}^2 = \underset{(0.000002)}{0.00005^{*}} + \underset{(0.0595)}{0.1229^{**}} * \text{CPISQ}$

NOTE: ABSRES = absolute value of residual

RES^2 = residual squared

CPISQ = inflation rate squared

* = significantly different from zero at 1% level

** = significantly different from zero to 5% level

Standard Errors in Parentheses

TABLE 4

MODELS CORRECTED FOR HETEROSCEDASTICITY

Model	Constant	$(M1G-M1G^e)$	$(M2G-M2G^e)$	$(IPG-IPG^e)$	$(INF-INF^e)$	SIGMA
A	0.0012	-0.4697*		0.2857*	0.1891	-1.5041*
	(0.0010)	(0.0891)		(0.0565)	(0.1409)	(0.1324)
B	0.0016		-0.1205	0.2534*	0.2717	-1.7643*
	(0.0012)		(0.1305)	(0.0749)	(0.1691)	(0.1389)
C	-0.0108*	-3.0551*		0.0159	-2.3714*	
	(0.0004)	(0.3156)		(0.0273)	(0.2885)	
D	-0.0098*		2.3918*	0.3108*	0.7450*	
	(0.0002)		(0.1086)	(0.0152)	(0.0888)	

NOTE: * = significantly different from zero at the 1% level

Standard Errors in Parentheses

FOOTNOTES

[1] See Roley [1983, 1987]

[2] See Muth [1961] and Mishkin [1983] for a discussion about the rapid adjustment in inflationary expectations which may occur, particularly in high-inflation time periods.

[3] In the fall of 1982, the Federal Reserve switched from targeting nonborrowed reserves to a borrowed reserve target. Such a regime is closely related to targeting the federal funds rate. See Goodfriend and Whelpley [1986].

[4] The F values in the last column of Table 2 are the test statistics of the cross-equation constraints implied by rational expectations and market efficiency [Mishkin, pp. 50-51]. Significant test statistics in each of the models can result from either a failure of rationality or of the model of market equilibrium employed. As Mishkin [1983, p. 87] points out, the crude risk variable (and its exclusion) could give rise to misspecification in the model of market equilibrium. Thus, it seems more plausible to attribute the significant F statistics to model misspecification rather than a failure of market efficiency. Since the Durbin-Watson statistics are in the inconclusive range, the models were also estimated after correcting for the presence of first-order serial correlation. The results were not appreciably affected. That is, a significant liquidity effect is present in all four models and the other variables retain their hypothesized sign and are significant.

[5] Mishkin [1983, p. 80] points out a potential problem in the models estimated. If the money supply process is not exogenous then these equations suffer from simultaneous equation bias. As a result, the estimates could give misleading impressions regarding the impact of unanticipated money growth on interest rates. In an effort to resolve any possible simultaneity, the models are estimated using instrumental variables for the unanticipated money growth terms. The instruments used are lagged values of the variables in the original equations, such as lagged unanticipated money growth, lagged unanticipated inflation, etc. Once again, all four models estimated confirm the presence of a significant liquidity effect in that unanticipated money growth is significantly negatively correlated with interest rate movements.

LITERATURE CITED

Barro, R.J. "Unanticipated Money Growth and Unemployment in the United States," American Economic Review 67 (1977) 101-115.

Barth, J. R. Sickles and P. Wiest. "Assessing the Impact of Varying Economic Conditions on Federal Reserve Behavior," Journal of Macroeconomics 26 (1982) 47-70.

Blejer, M.I. "Money and the Nominal Interest Rate in an Inflationary Economy: An Empirical Test," Journal of Political Economy 86 (1978) 529-534.

Breusch, T.S.. "Testing for Serial Correlation in Dynamic Linear Models," Australian Economic Papers 17 (1979) 1287-1294.

Brown, W.W. and G.J. Santoni, "Monetary Growth and the Timing of Interest Rate Movements," Federal Reserve Bank of Saint Louis Review 67 (1983) 16-25.

Cagan, P. "The Channels of Monetary Effects on Interest Rates," National Bureau of Economic Research, 1966.

---- and A. Gandolfi. "The Lag in Monetary Policy as Implies by the Time Pattern of Monetary Effects on Interest Rates," American Economic Review 59 (1969) 277-284.

Cornell, B. "The Money Supply Announcement Puzzle: Review and Interpretation," American Economic Review 73 (1983) 644-657.

Friedman, M. "The Monetary Studies of the National Bureau," The National Bureau Enters its 45th Year, 44th Annual Report, National Bureau of Economic Research (1964) 7-25.

Gibson, W.E. "Interest Rates and Monetary Policy," Journal of Political Economy 78 (1970) 431-455.

Glesjer, H. "A New Test for Heteroscedasticity," Journal of the American Statistical Association 64 (1969) 316-323.

Godfrey, L.G. "Testing for Higher Order Serial Correlation in Regression Equations When the Regressors Include Lagged Dependent Variables," Econometrica 46 (1978) 297-303.

Goodfriend, Marvin and William Whelpley. "Federal Funds: Instrument of Federal Reserve Policy," Economic Review Federal Reserve Bank of Richmond 72 (1986): 3-11.

Granger, C.W.J. "Investigating Causal Relations by Econometric Models and Cross-Spectral Methods," Econometrica 37 (1969) 424-438.

Hoehn, J.G. "Recent Monetary Control Procedures and the response of Interest Rates to Fluctuations in Money Growth," Federal Reserve Bank of Dallas Economic Review (1983) 1-10.

Laidler, D. The Demand for Money: Theories and Evidence, 3rd edition (New York: Harper and Row 1985).

Mehra, Y. "Inflationary Expectations, Money Growth and the Vanishing Liquidity Effect of Money on Interest: A Further Investigation," Federal Reserve Bank of Richmond Economic Review 71 (1985) 23-35.

Melvin, M. "The Vanishing Liquidity Effect of Money on Interest: Analysis and Implications for Policy," Economic Inquiry 21 (1983) 188-202.

Mishkin, F. A Rational Expectations Approach to Macroeconometrics: Testing Policy Ineffectiveness and Efficients-Markets Models (Chicago: The University of Chicago Press, 1983).

Murphy, Kevin M. and Robert H. Topel. "Estimation and Inference in Two-Step Econometric Models," Journal of Business and Economic Statistics 3 (1985): 370-379.

Muth, John F. "Rational Expectations and the Theory of Price Movements," Econometrica 29 (1961): 315-335.

Reichenstein, W. "The Impact of Money on Short-Term Interest Rates," Economic Inquiry 25 (1987) 67-82.

Roley, V. Vance. "The Response of Short-Term Interest Rates to Weekly Money Supply Announcements," Journal of Money, Credit and Banking 15 (1983): 344-54.

------. "The Effects of Money Announcements Under Alternative Monetary Control Procedures," Journal of Money, Credit and Banking 19 (1987): 292-307.

Wilcox, J.A. "Why Real Rates Were so Low in the 1970's," American Economic Review 73 (1983) 44-53.