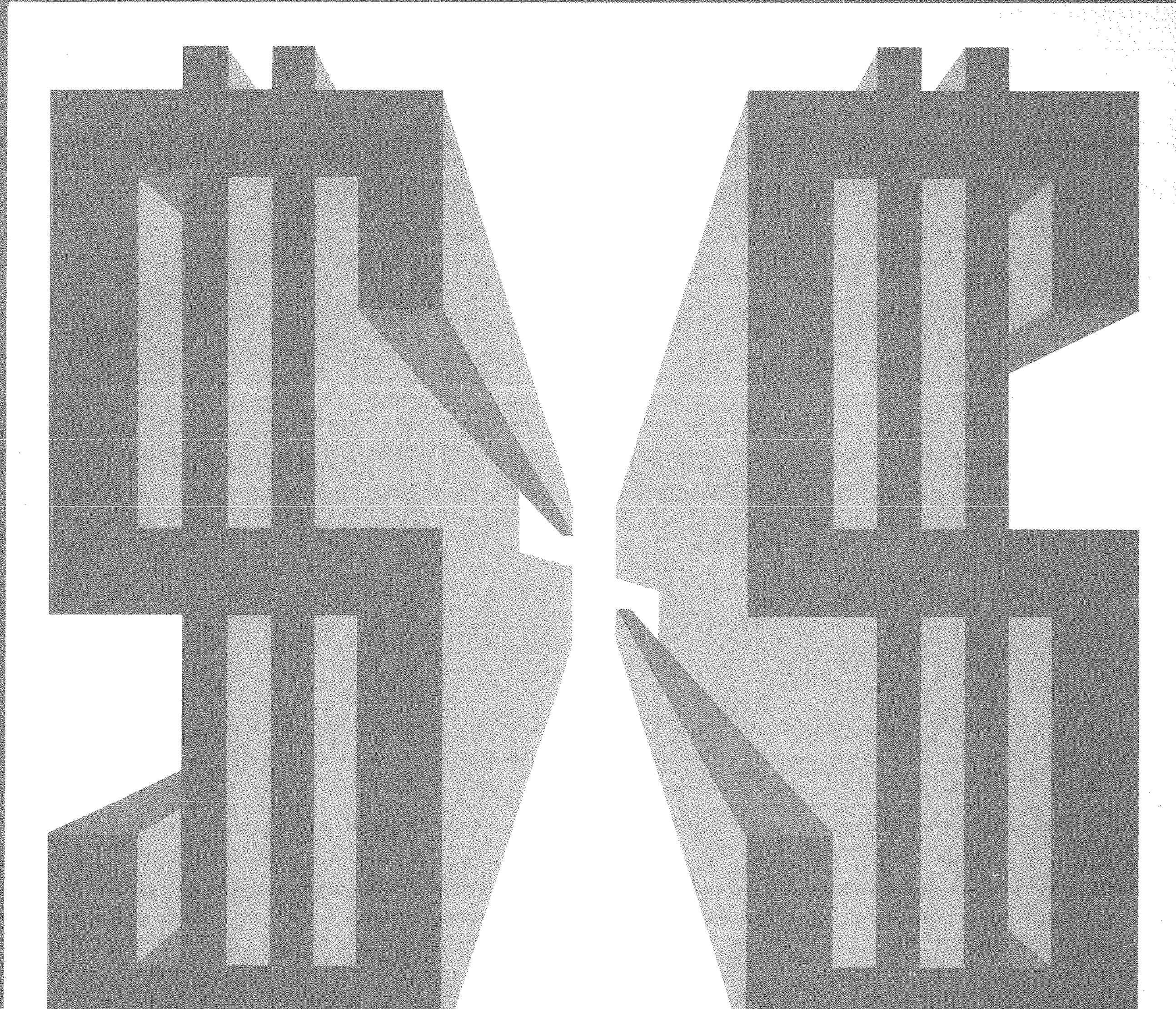
FEDERAL RESERVE BANK OF SAN FRANCISCO ECONOMIC REVIEW SUMMER 1981



MONETARY POLICY AND INTEREST RATES

Why Have Interest Rates Been So Volatile?

Paul Evans*

On October 6, 1979, the Federal Reserve announced that henceforth it would tightly control the money supply while letting the Federal-funds rate respond freely to market forces. The Federal Reserve hoped that this policy change would help it to stabilize employment and real income while bringing inflation down to a tolerable level.

The Federal Reserve did indeed free the Federal-funds rate — the rate clearly was much more volatile after October 6, 1979 than it was before that date, as can be seen from Panel a of Figure 1. That action, however, has produced no clear victory against inflation, and 1980 could hardly be considered a year of great stability in the real economy. Furthermore, both short-term and long-term interest rates have become much more volatile, as panels b and c of Figure 1 demonstrate.

Volatile interest rates — especially volatile long-term rates — may impose burdens on the real economy. Savers may find their portfolios riskier, and may therefore save less and shift from long-term to short-term securities.[1] Purchasers of houses, plant and equipment, and other long-lived physical assets may then be forced to finance their purchases with short-term debt, thus making these purchases riskier. If the additional risk reduces long-term investment as well as saving, the economy will experience less capital formation, and a smaller portion of that capital formation will go into long-lived assets. As a result, the economy's growth rate will slacken.

This paper investigates how much of the recent increase in interest-rate volatility stemmed from the change in monetary policy of October 6, 1979. It finds that this policy change produced only about 30 percent of the increased volatility in long-term interest rates, and that the rest came from sources not directly under Federal Reserve control. Almost all of this 30 percent resulted from the Fed's adherence to its monetary targets; by itself, the freeing of the funds rate had little to do with the increased rate volatility. Therefore, panel c of Figure 1 gives a misleading picture of the new monetary policy's impact on rate volatility and hence on investment and growth. The actual effect was substantially smaller.

The next section of this paper formulates a model of interest rates, and Sections II and III discuss the estimates resulting from the fitting of this model to weekly U.S. data. Next, Section IV decomposes the recent increase in interest-rate volatility into several components, and discusses each of those components. Finally, Section V summarizes the paper and draws some policy conclusions.

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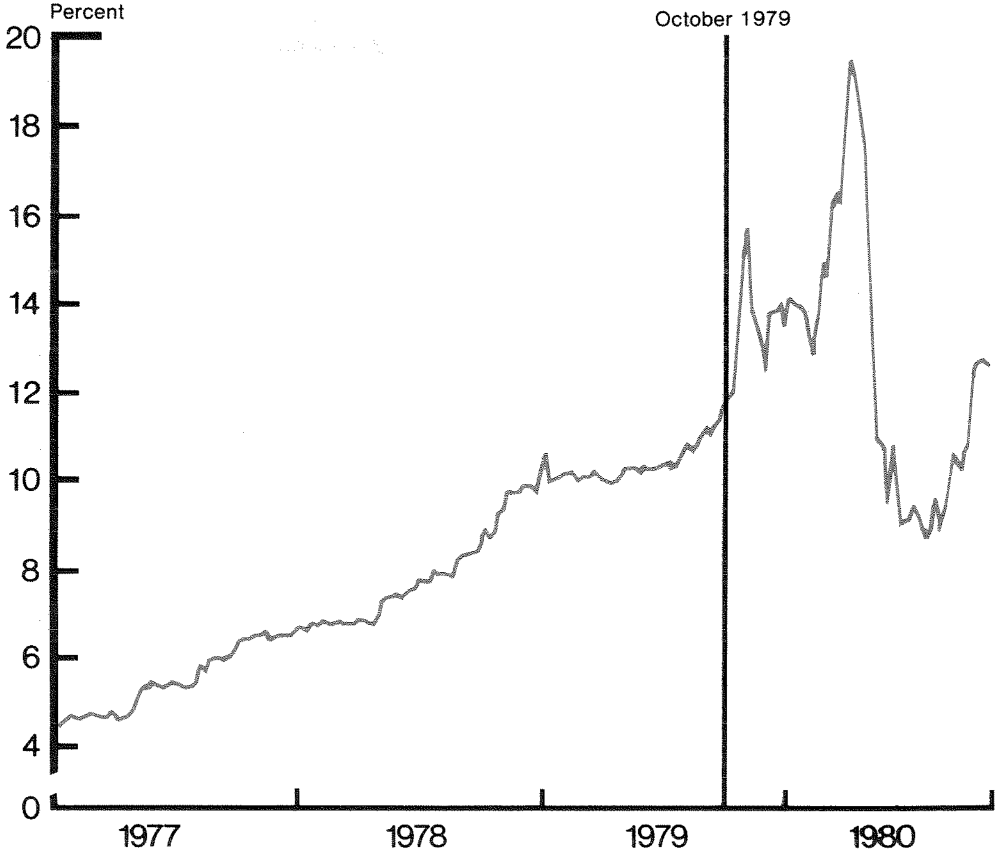
Figure A
Federal Funds Rate



I. Formulation of an Empirical Model

To begin, we formulate a model based on the hypothesis that the securities markets are efficient.[2] Simply speaking, the efficient-markets hypothesis claims that readily available information is so efficiently processed that no market participant can do systematically better than any other participant.

Samuelson (1965) and Sargent (1976) have shown that, to a close approximation, interest rates in an efficient market respond immediately and completely to any new information reaching the bond markets. The reason is that interest-rate changes generate capital gains or losses, which dominate the short-period returns to all but the shortest-term bonds.[3] If interest rates in fact changed slowly in response to new information, a savvy investor could use that information accurately to predict future capital gains or losses. Being able to make accurate predictions would be a veritable license to print money, because the investor could hold bonds when they were going to rise in price and sell them short when they were going to fall in price. For example, if the investor knew that government deficits raise interest rates gradually, he or she would react to an unusually low deficit by buying bonds and to an unusually high deficit by selling them short. By the time the interest rate actually changed, he or she would probably have made a fortune.

The efficient-markets hypothesis essentially assumes that a large number of savvy investors participate in the securities markets. Therefore, when these investors think, on the basis of new information, that interest rates will rise and hence that bond prices will drop, their efforts to sell their bonds immediately will drive up interest rates. In principle, the rise will be so rapid that no one can manage to sell a single bond before interest rates rise as far as they are going to rise.

The efficient-markets hypothesis implies that DR, the interest-rate change, is given approximately by

$$DR = K + BE + V, \qquad (1)$$

where K is a parameter, B is a vector of parameters, E is a vector of new information used in the empirical analysis, and V is an error term that captures the effects of all other information and that moves independently of E. The longer the term to maturity of the bond, the better is the approximation.

By definition, new information is that part of current information that was not known in the past. In order to give content to this definition, we must add an hypothesis about knowledge — namely, that one part of currently available information can be predicted from past information with the use of standard econometric techniques, and the other part (to be called "new information") cannot be so predicted. Specifically, let Z be the vector of variables used in the empirical analysis. Then, if bond-market participants knew Z(-1), the value of Z in the previous period, they would predict Z as AZ(-1), where A is a matrix of coefficients obtained by regression Z on Z(-1).[4] Therefore, E, the vector of new information about Z, is simply the error vector in the equation

$$Z = AZ(-1) + E. \qquad (2)$$

Note that E is serially uncorrelated, because past values of E are known by assumption and serial correlation would imply (contrary to assumption) that past values of E are useful in predicting current values of E. Similarly, V in equation (1) should be serially uncorrelated because it, too, is new information that should not depend on such information as its own past history.

Equations (1) and (2) suggest the following strategy. First, collect some series that are readily available (say, from government publications). Then estimate prediction equations, like (2), for these series and obtain the residuals, which are consistent estimates of E. Finally, regress changes in various interest rates on these residuals to obtain consistent estimates of K and B in equation (1). If the efficient-markets hypothesis is correct, past information should not change interest rates. Therefore, this hypothesis is refuted if any lagged E's have statistical significance in equation (1) or if V is serially correlated.

II. Prediction Equations

Bond-market participants surely pay attention to a great many series of data — such as real GNP, the inflation rate, the government deficit, corporate credit demands, and monetary-policy variables. However, many of these series cannot be used here, because they are not available on a weekly basis. Moreover, since this paper is mainly concerned with the impact of monetary policy on interest rates, we limit the analysis to appropriate monetary series.

We assume that GM, the growth rate of the (unadjusted)[5] money supply (M-1B), and DFFR, the change in the Federal-funds rate, adequately characterize monetary policy. To extract the new information from these series, one must estimate prediction equations that relate them to past information known by bond-market participants. Essentially, one must estimate an equation system of the form (2) — first for the sample period extending from the first full week of 1977 to the last full week before October 6, 1979, and again for the sample period extending from the first full week after October 6, 1979, to the week ending on October 22, 1980.[6] Using the methodology advocated by Box and Jenkins (1976),[7] we obtained the following results for the sample period before October 6, 1979 (the figures in parentheses are standard errors):

$$GM = GM(-52) + \underset{(.000203)}{.00126} + EM$$
$$- \underset{(.063)}{.673}\,EM(-1) + \underset{(.085)}{.232}EM(-13)$$
$$- \underset{(.057)}{.156}EM(-14), \qquad (3)$$

S.E. = .006013, R^2 = .357;

$$DFFR = \underset{(.0114)}{.0515} + \underset{(1.89)}{4.72}EM(-1) + EFFR \qquad (4)$$

S.E. = .1361, R^2 = .042;

where EM is a residual from the regression for the money growth rate, EFFR is a residual from the regression for the Federal-funds rate, and (−i) attached to a symbol indicates that it is lagged i weeks.

For the sample period after October 6, 1979, we obtained

$$GM = (-52) + \underset{(.001201)}{.000413} + EM$$
$$- \underset{(.137)}{.290}\,EM(-1) + \underset{(.175)}{.587}\,EM(-13)$$
$$- \underset{(.110)}{.170}EM(-14) + \underset{(.233)}{.493}\,EM(-26)$$
$$- \underset{(.122)}{.143}EM(-27), \qquad (5)$$

S.E. = .007767, R^2 = .443;

$$DFFR = \underset{(.100)}{.074} + \underset{(13.8)}{37.2}\,EM(-2)$$
$$- \underset{(0.35)}{0.93}\,DR3MO(-2)$$
$$+ \underset{(0.68)}{3.05}\,DR12MO(-2) \qquad (6)$$
$$- \underset{(0.67)}{2.07}\,DR10YR(-2) + EFFR,$$

S.E., = .7158, R^2 = .478;

where DR3MO is the weekly difference in the three-month Treasury-bill rate, DR12MO is the weekly difference in the twelve-month Treasury-bill rate, and DR10YR is the weekly difference in the ten-year Treasury bond rate. Even though equations (3) and (4) or equations (5) and (6) may not look like the equation system (2), it is easy to show that they take that form.[8] This is because EM and EFFR in equations (3) - (6) are unknown only until GM and DFFR become known.

Equations (3) and (5) imply that only three kinds of effects are relevant in determining the money-supply growth rate in any given week. First, if all other effects are zero, GM equals GM(-52), the value that it assumed in the same week of the previous year[9]. Thus, GM tends to keep any weekly seasonal pattern it has assumed. Second, the term EM combines all of the influences on the money growth rate that could not have been predicted in the previous week. Third, the terms in lagged values of EM determine how GM will tend to move the year after EM has assumed a non-zero value.

To illustrate, suppose that EM rises by one percentage point in the first week of January some year, but is left unchanged in all other weeks. Equation (3) implies that the money growth rate is one percentage point higher in the first week of January of that year, .673 percentage points lower in the second week of January, .232 percentage points higher in the first week of April, .156 percentage points lower in the second week of April, and is unchanged in all other weeks of the year. At year's end the money supply is .403 (=1 − .673 + .232 − .156) percentage points higher than at the end of the previous year. Consequently, the average annual money growth rate rises by .403 percentage points. Moreover, since money growth will follow this same scenario in future years — note that GM (−52), the growth rate one year earlier, appears in the right-hand member of equation (3) — average money growth also rises by .403 percentage points in every future year.

A similar calculation using equation (5) yields a money growth rate that is one percentage point higher in the first week of January, .290 percentage points lower in the second week of January, .587 percentage points higher in the first week of April, .170 percentage points lower in the second week of April, .493 percentage points higher in the first week of July, and .143 percentage points lower in the second week of July. The money growth rate also follows this same pattern in every future year; the average rate rises by 1.477 (=1 − .290 + .587 − .170 + .493 − .143) percentage points.

It is important to note that a monetary surprise (EM≠0) permanently changes the **growth rate** of the money supply and not just its level. A positive surprise raises the growth rate; a negative surprise lowers the growth rate.

The results suggest that the Federal Reserve, before October 6, 1979, would have responded to a monetary surprise of one percentage point by raising the Federal-funds rate only about 4.72 basis points. (See equation (4).) No other variable was helpful in predicting changes in the funds rate. Surprises in the funds rate were usually small: about two-thirds of them were between −13.61 and +13.61 basis points. This fact demonstrates that the Federal Reserve more or less pegged the Federal-funds rate and responded sluggishly to monetary surprises.

The results also suggest a quite different Federal Reserve response since October 6, 1979 (See equation (6).) In this period, the Federal-funds rate responded to monetary surprises with a two-week lag rather than a one-week lag, and the response was much larger. Furthermore, lagged interest rates began to affect the funds rate.

The two-week lags in equation (6) have special significance. For a number of years, reserve requirements have been lagged two weeks, rather than imposed contemporaneously. This institutional feature implies that an increase in the money supply, and hence deposits, generates an increase in demand for reserves two weeks later. For this reason, the Federal-funds rate will tend to rise two weeks later unless the Federal Reserve completely accommodates this increase in demand. Therefore, because EM(−2) had no statistically significant effect on the funds rate before October 6, 1979, the Federal Reserve in that period must have largely accommodated changes in the demand for reserves. Since then, however, the Federal Reserve has apparently let the banks largely fend for themselves, for EM(−2) has a large and statistically significant coefficient in equation (6).

The two-week lag on the interest-rate terms suggests that these rates affect the Federal-funds rate by operating first on the demand for reserves. For example, a change in bond rates might drive businesses to borrow more from the banks, and this in turn would push up the demand for reserves two weeks later. This explanation, however, would lead to the conclusion that business-loan demand is roughly independent of the level of interest rates (−0.93 + 3.05 − 2.07 is roughly zero), but rises when the term structure becomes more humped (the twelve-month Treasury-bill rate rises relative to the three-month Treasury-bill rate and the ten-year Treasury-bond rate.)

Equations (4) and (6) provide one more insight. Since October 6, 1979, the Federal Reserve has evinced a much greater willingness to tolerate large movements in the Federal-funds rate: the standard error rises from .1361 percent a year in equation (4) to .7158 percent a year in equation (6). The greater movement in the funds rate, as well as the Federal Reserve's apparent willingness to let the banks bear some of the brunt of adjustment in the market for reserves, suggests only one conclusion: the Federal Reserve tried much harder to contol the money supply after October 6, 1979 than it ever did before. Nevertheless, the short-term variability of the money supply has also risen (the standard error of equation (5) is larger than that of equation (3)). Moreover, movements in the money supply have become more persistent, as we have seen in our analysis of equations (3) and (5).

III. Interest-Rate Equations

The residuals EM and EFFR represent "new information" about monetary policy. In this section, we estimate how bond markets have used this new information in setting interest rates, and then test whether these markets are efficient.

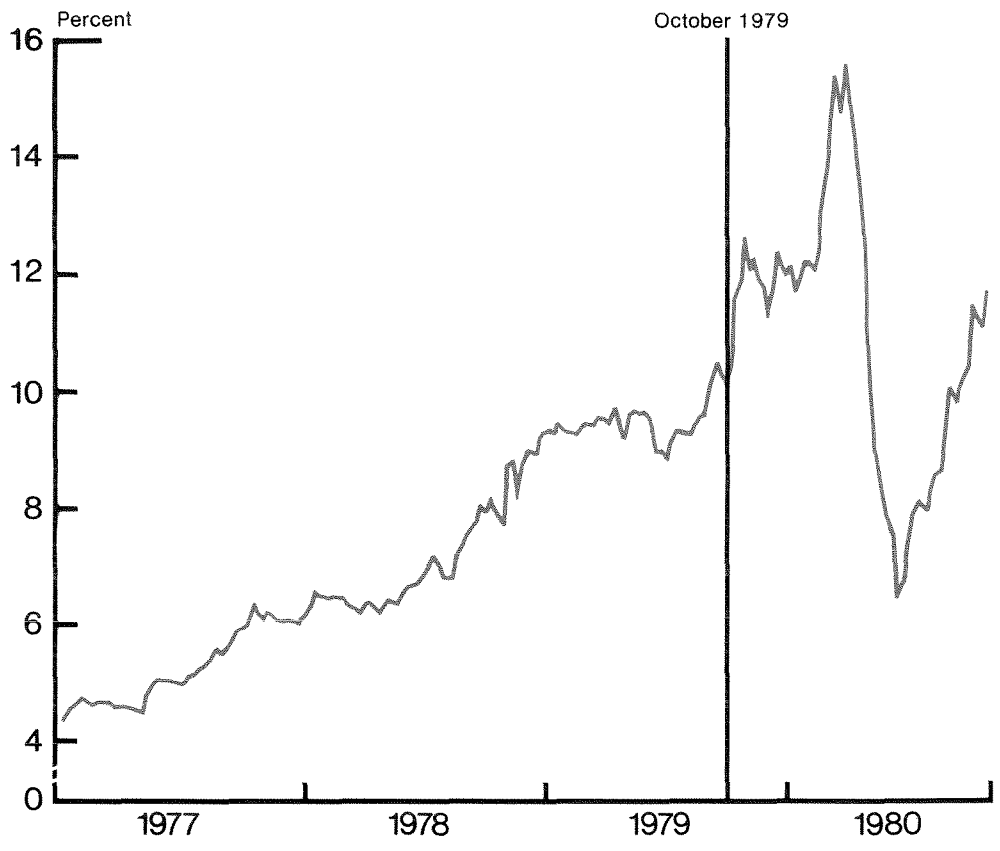
In Equation (1), DR referred to changes in end-of-period (say, end-of-week) interest rates. Our interest-rate data, however, are not end-of-week data, but rather averages of daily data for weeks beginning on Sundays and ending on Saturdays. This complication, and two others discussed below, imply that the appropriate equation is:

$$DR = k + bEM(-1) + cEM(-2) + dEFFR(+1) + eEFFR + V, \quad (7)$$

where DR is the difference in the bond rate averaged over weeks beginning on Sundays and ending on Saturdays; k, b, c, d and e are parameters; and V is an error term. In this

Figure B

Three-Month Treasury Bill Rate



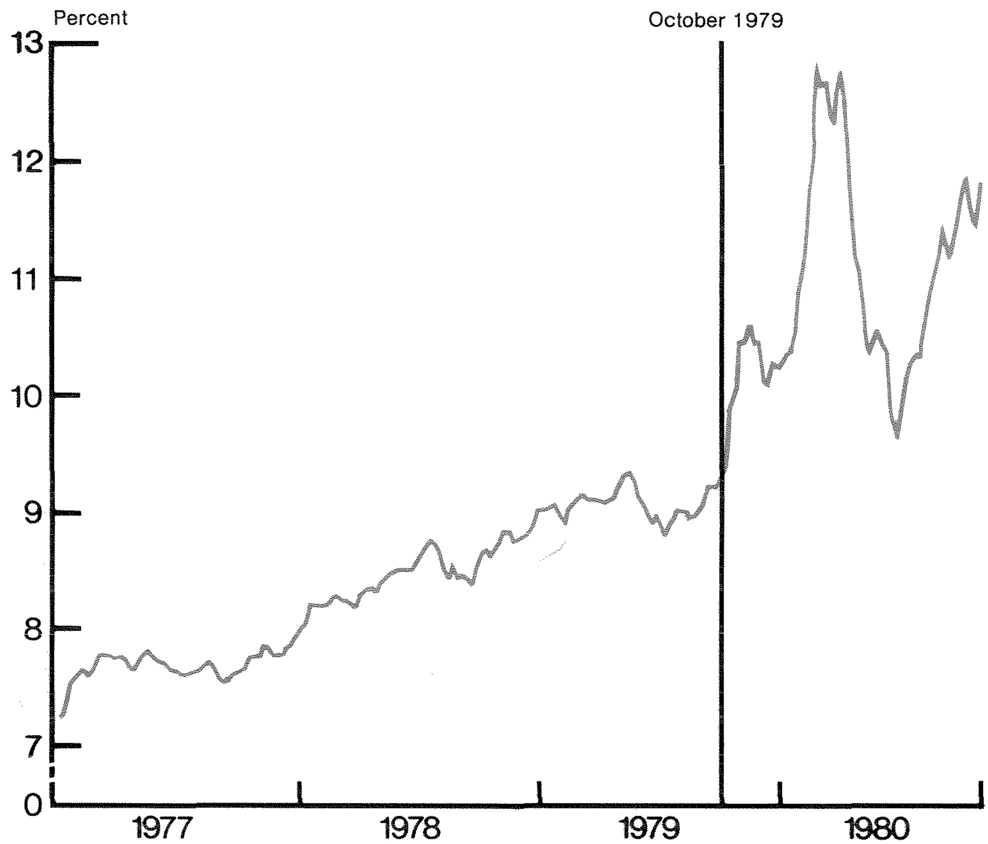
equation, EM(−1), EM(−2), EFFR(+1) and EFFR take the place of E, and the error term V is serially correlated, unlike its counterpart in equation (1). To be specific, V should be a first-order moving average.[10] The Federal Reserve generally releases M-1B data with an eight-or nine-day lag. Moreover, these data are averages of daily data for weeks ending on Wednesdays rather than Saturdays. For this reason, the bond markets know only EM(−2) during the first few days of any week, and then learn EM(−1).[11] Therefore, both EM(−1) and EM(−2) belong in equation (7).

The Federal-funds rate data used to fit equations (4) and (6) are averaged over weeks ending on Wednesdays. Since bond-market participants probably keep track of the funds rate on an hour-to-hour (or even minute-to-minute) basis, they already know part of EFFR before the week begins on Sunday, and then learn part of EFFR(+1) before the week ends on Saturday. Therefore, including EFFR(+1) and EFFR in equation (7) is appropriate.[12]

We used Treasury-bill and Treasury-bond rate data, as well as the residuals from equations (3) - (6), to fit equation (7) for the sample periods before and after October 6, 1979. According to the efficient-markets hypothesis, including EM(−3), EM(−4), EFFR(−1), EFFR(−2), etc., in equation (7) — or specifying its error term to be a second (or higher) order moving average — should add no statistically significant explanatory power. We have found this hypothesis to be true for the long-term interest rates. The regressions for

Figure C

Twenty-Year Treasury Bond Rate



some of the short-term interest rates, however, improved somewhat when we lengthened their lags or error-term structures.[13] Tables 3 and 4 report the best regressions.[14] Table 1 summarizes those results, which have the following implications.

1. Unexpected monetary increases tend to raise interest rates, and unexpected monetary decreases tend to lower them — contrary to a common belief among economists. In that popular view, if the Federal Reserve increases the money supply and nothing else happens, the public will hold more money than it wants. In the short run, incomes and goods prices will not change very much; therefore, interest rates must fall to make the public content to hold the increased money supply. That analysis is faulty, however, perhaps because it assumes that the stock of money rises because the Federal Reserve consciously chooses to increase it. Suppose instead that the money stock rises because of a rise in the quantity of money demanded at prevailing interest rates. If the Federal Reserve does not entirely accommodate the increased demand, interest rates must rise to make the public content to hold less money than desired at the initial interest rates. Incidentally, if this analysis is valid, monetary surprises are primarily due to changes in money demand rather than in money supply.

2. Since October 6, 1979, the bond markets have responded about ten times as much as before to weekly money-supply data. Specifically, a monetary surprise of one percentage point tended to raise interest rates only 3-7 basis points before October 6, 1979, but tended to raise them 31-86 basis points after that date. Since interest rates respond to monetary surprises as useful economic indicators, bond-market participants must believe that monetary surprises tell them more now about the future state of the economy than they used to do. Apparently, the monetary-policy change has increased the information content in weekly money-supply data (or at

Table I
Cumulative Interest-Rate Effects of Various Surprises*

	Effect of One-Percentage-Point Increase in			
	Money Supply		Federal Funds Rate	
Security	Before 10/6/79	After 10/6/79	Before 10/6/79	After 10/6/79
Three-month Treasury Bill	5.62 (2.94)	85.7+ (13.3)	61.2+ (13.3)	35.0+ (22.8)
Six-month Treasury Bill	6.60+ (2.14)	83.0+ (11.5)	57.6+ (9.9)	26.0+ (21.4)
Twelve-month Treasury Bill	6.98+ (1.94)	61.2+ (15.6)	49.7+ (8.6)	29.2+ (10.7)
Three-year Treasury Bond	6.77+ (1.76)	54.0+ (10.5)	34.4+ (7.8)	28.0+ (11.3)
Five-year Treasury Bond	5.99+ (1.46)	44.6+ (9.2)	22.7+ (6.5)	18.6+ (10.0)
Seven-year Treasury Bond	4.76+ (1.32)	38.4+ (8.4)	19.1+ (5.8)	14.0+ (8.1)
Ten-year Treasury Bond	4.02+ (1.24)	35.7+ (7.2)	16.6+ (5.5)	14.0+ (7.8)
Twenty-year Treasury Bond	3.11+ (1.02)	31.2+ (6.4)	13.5+ (4.5)	10.7+ (6.9)

*The effects are measured in basis points. The figures in parentheses are standard errors.
+ Statistically significant at the .05 level.

least has made the market believe so).

3. Before October 6, 1979, monetary surprises affected short-term interest rates more than long-term interest rates, and affected intermediate-term rates even more than short-term rates. To explain this finding, suppose that a security's term to maturity indicates the type of new information to which its interest rate is most sensitive. For instance, the three-month Treasury-bill rate is most sensitive to new information about what the economy will do in the next three months, whereas the ten-year Treasury-bond rate is sensitive to new information about what the economy will do for the next ten years. It then follows that, before October 6, 1979, monetary surprises conveyed relatively more information about what the economy would do six months to a year in the future (intermediate-term) than about what it would do for the next six months (short-term) or after a year (long-term). Apparently, during the period when the Federal-funds rate was pegged, changes in money demand (which produce monetary surprises) took six months to a year to exert their greatest effects on the economy.

4. After October 6, 1979, monetary surprises have affected short-term interest rates much more than long-term rates. Apparently, when nonborrowed reserves are used as the operating instrument, as they are today, changes in money demand exert their greatest effects on the economy almost immediately.

5. Surprises in the Federal-funds rate have affected short-term interest rates much more than they have long-term rates. For example, before October 6, 1979, a surprise of one percentage point would have raised the three-month Treasury-bill rate 61 basis points, while raising the twenty-year bond rate by only 14 basis points. Presumably, surprises in the funds rate tell the bond markets less about the far future than about the near future.

6. Surprises in the Federal-funds rate have affected interest rates less since October 6, 1979, than before. In particular, a surprise of one percentage point raised interest rates by 14-61 basis points before October 6, 1979, but only by 11-35 basis points since then. Apparently, letting the Federal-funds rate respond freely to market forces has reduced the information content of rate surprises for predicting the future state of the economy.[15]

Table 2
Percentage Decomposition of Increase in Volatility of Interest Rates

	Source of Increased Volatility				
	Increased Coefficients on Surprises in		Increased Variances of Surprises in		
Security	Money Supply	Federal Funds Rate	Money Supply	Federal Funds Rate	Nonfinancial Factors
Three-month Treasury Bill	28.2	-1.9	7.2	21.3	45.2
Six-month Treasury Bill	35.0	-9.7	8.9	21.6	44.2
Twelve-month Treasury Bill	27.1	-18.2	7.1	23.8	58.2
Three-year Treasury Bill	28.1	-5.0	7.3	12.5	57.1
Five-year Treasury Bond	25.7	-3.2	6.7	8.3	62.6
Seven-year Treasury Bond	24.5	-3.4	6.4	7.0	65.6
Ten-year Treasury Bond	27.8	-2.2	7.2	6.7	60.5
Twenty-year Treasury Bond	27.4	-2.4	7.0	5.7	62.3

Table 3
Interest-Rate Regressions for Period Before October 6, 1979

Security	Coefficients of* EM(-1)	EM(-2)	EFFR(+1)	EFFR	Moving-Average Coefficients* Lag 1	Lag 2	Constant*	R^2	S.E.	Q(12)**
Three-month Treasury Bill	0.97	4.65$^+$	.389$^+$	.223$^+$	-.080	-.349$^+$	.0402$^+$	.211	.1551	7.3
	(2.12)	(2.03)	(.093)	(.095)	(.082)	(.082)	(.0075)			
Six-month Treasury Bill	2.39	4.21$^+$	.425$^+$	.151$^+$	-.009	-.246$^+$	.0381$^+$	.254	.1103	9.6
	(1.54)	(1.48)	(.070)	(.070)	(.086)	(.086)	(.0070)			
Twelve-month Treasury Bill	2.39	4.59$^+$	.392$^+$	.105$^+$	.131		.0343$^+$	.310	.0971	10.8
	(1.39)	(1.35)	(.060)	(.061)	(.086)		(.0092)			
Three-year Treasury Bond	2.63$^+$	4.14$^+$	.286$^+$	.058	.200$^+$		.0242$^+$	.275	.0883	5.5
	(1.26)	(1.23)	(.055)	(.055)	(.085)		(.0089)			
Five-year Treasury Bond	2.57$^+$	3.42$^+$	.203$^+$	.024	.230$^+$		.0196$^+$	.255	.0733	8.8
	(1.04)	(1.02)	(.046)	(.046)	(.085)		(.0076)			
Seven-year Treasury Bond	2.25$^+$	2.51$^+$	.170$^+$	.021	.176$^+$		.0168$^+$	.217	.0661	8.5
	(0.94)	(0.92)	(.041)	(.041)	(.086)		(.0065)			
Ten-year Treasury Bond	1.57	2.45$^+$	.136$^+$	.030	.185$^+$		.0148$^+$	.185	.0624	8.7
	(0.89)	(0.87)	(.039)	(.039)	(.086)		(.0062)			
Twenty-year Treasury Bond	1.34	1.77$^+$	.116$^+$	.019	.254$^+$		.0123$^+$	.203	.0514	8.5
	(0.73)	(0.71)	(.032)	(.032)	(.084)		(.0054)			

*The standard error of each coefficient appears below it in parentheses.

**Q(12) is the Box-Pierce statistic, a measure of serial correlation. None of the entries in this column indicates significant serial correlation at any conventional significance level.

+Statistically significant at the .05 level.

Table 4
Interest-Rate Regressions for Period After October 6, 1979

Security	Coefficients of* EM(-1)	EM(-2)	EM(-3)	EFFR(+1)	EFFR	EFFR(-1)	EFFR(-2)	EFFR(-3)	EFFR(-4)	Moving-Average Coefficients* Lag 1	Lag2	Constant*	R^2	S.E.	Q(12)**
Three-month Treasury Bill	26.1$^+$	36.6$^+$	23.0$^+$	-.070	.181	-.020	.224$^+$	.226$^+$	-.191$^+$	.321$^+$	.641$^+$	.015	.736	.3832	7.2
	(7.8)	(7.5)	(7.8)	(.099)	(.110)	(.110)	(.104)	(.094)	(.089)	(.131)	(.132)	(.106)			
Six-month Treasury Bill	25.1$^+$	35.7$^+$	22.2$^+$	-.079	.137	-.007	.116	.199$^+$	-.106	.420$^+$	.564$^+$	.009	.763	.3245	12.3
	(6.5)	(6.8)	(6.7)	(.085)	(.096)	(.095)	(.089)	(.082)	(.075)	(.139)	(.140)	(.091)			
Twelve-month Treasury Bill	21.5$^+$	26.9$^+$	12.8$^+$	.143	.149$^+$					.170	.314$^+$	.043	.560	.3603	4.6
	(7.0)	(7.4)	(7.2)	(.077)	(.075)					(.148)	(.155)	(.073)			
Three-year Treasury Bond	26.3$^+$	27.7$^+$		.132	.148					.046		.050	.441	.3854	7.3
	(7.4)	(7.4)		(.080)	(.080)					(1.55)		(.055)			
Five-year Treasury Bond	22.0$^+$	22.6$^+$		.126	.060					.198		.051	.431	.3399	4.6
	(6.5)	(6.5)		(.071)	(.071)					(.151)		(.056)			
Seven-year Teasury Bond	20.2$^+$	18.2$^+$		.094	.046					.174		.049	.393	.3090	3.6
	(6.0)	(5.9)		(.064)	(.064)					(.152)		(.050)			
Ten-year Treasury Bond	19.9$^+$	15.8$^+$		.087	.053					.098		.048	.419	.2646	3.0
	(5.1)	(5.1)		(.055)	(.055)					(.154)		(.040)			
Twenty-year Treasury Bond	17.5$^+$	13.7$^+$		.042	.065					.092		.050	.395	.2364	3.5
	(4.5)	(4.5)		(.049)	(.049)					(.153)		(.035)			

*The standard error of each coefficient appears below it in parentheses.

**Q(12) is the Box-Pierce statistic, a measure of serial correlation. None of the entries in this column indicates significant serial correlation at any conventional significance level.

+Statistically significant at the .05 level.

IV. Decomposition of the Increase in Rate Volatility

In this section, we attempt to explain why interest rates have become much more volatile since October 6, 1979, than they were previously.

Equation (7) implies that VR, the volatility[16] of the bond rate R, is

$$VR = (b^2 + c^2)VEM + (d^2 + e^2)\,VEFFR + VV,$$

where VEM, VEFFR and VV are the variances of surprises in money, the Federal-funds rate, and the error term; and b, c, d and e are the coefficients of EM(−1), EM(−2), EFFR(+1) and EFFR. To a first approximation, differencing this equation then yields

$$\begin{aligned} DVR = {} & (D(b^2 + c^2))\overline{VEM} \\ & + \overline{(b^2 + c^2)}DVEM \\ & + (D(d^2 + e^2))\overline{VEFER} \\ & + \overline{(d^2 + e^2)}DVEFFR + DVV \end{aligned} \qquad (8)$$

where DVR, $D(b^2 + c^2)$, DVEM, $D(d^2 + e^2)$, DVEFFR and DVV are the differences in VR, $b^2 + c^2$, VEM, $d^2 + e^2$, VEFFR and VV between the two sample periods; and $\overline{VEM}$, $\overline{(b^2 + c^2)}$, $\overline{VEFFR}$ and $\overline{(d^2 + e^2)}$ are the average values of VEM, $b^2 + c^2$, VEFFR and $d^2 + e^2$ in the two sample periods.

One can decompose the increase in volatility of each interest rate into five components due to 1) larger coefficients on monetary surprises; 2) larger variance of monetary surprises; 3) larger coefficients on the surprises in the Federal-funds rate; 4) larger variance of Funds-rate surprises; and 5) a more variable error term. Since the first four terms are supposed to capture the effects of monetary changes, the last term may be called the nonmonetary component.

We have used equation (8) and the empirical results reported in Tables 3 and 4 to calculate the fraction of the interest-rate volatility attributable to each component.[17] The results appear in Table 2. Since equation (8) approximates an identity, the decomposition in Table 2 has no economic content by itself. To give it content, we have made four specific assumptions, as follows.

1. The nonmonetary component is independent of monetary policy. If the money supply and the Federal-funds rate provide a sufficiently complete characterization of monetary policy, and if equations (3)-(6) adequately describe that policy, this assumption follows immediately.

2. Changes in monetary policy have little effect on the variance of monetary surprises. This variance presumably reflects the weekly variance of money demand or of bank-loan demand, as Judd and Scadding argue elsewhere in this issue of the **Economic Review.** Monetary policy may well be able to control the money supply closely over periods as long as a quarter or two, but has little control on a weekly basis. In other words, a shift in monetary policy can change the coefficients in an equation like (3) or (5), but can have little effect on the standard error.

3. The coefficients b and c rose because the equation generating the money supply changed from (3) to (5), and because the Federal Reserve raised the coefficient on EM substantially (see equations (4) and (6)). These changes were part of the Fed's effort to target the money supply. Since stricter targeting makes monetary surprises more informative, interest rates responded much more to monetary surprises after October 6, 1979 than before.

4. The coefficients d and e fell because of a rise in the variance of surprises in the funds rate. This increased variance reduced the information contained in monetary surprises, thereby causing interest rates to respond less to any given surprise.

Given these assumptions, the decomposition procedure (Table 2) suggests several important implications. First, factors beyond the Federal Reserve's direct control accounted for most of the increased volatility of interest rates. Nonfinancial factors accounted for about 45 percent of the increased volatility of short-term interest rates, and for up to 65 percent of the volatility of intermediate-and long-term rates. Factors causing monetary surprises contributed about 7 percent more, so that all sources together accounted for 52-72 percent of the increased volatility. Second, making the Federal-funds rate more sensitive to monetary surprises generally resulted in 25-30 percent of the increased interest-rate volatility. Third, any Federal Reserve attempt to reduce the variance of surprises in the Federal-funds rate after October 6, 1979 would have reduced interest-rate volatility, but significantly so only for short-term rates. For example, preventing the variance of surprises in the funds rate from rising would have reduced the volatility of the three-month Treasury-bill rate by 19.4 percent (=21.3 − 1.9), but would have reduced the volatility of the twenty-year Treasury-bond rate by only 3.3 percent (=5.7 − 2.4).

V. Summary and Conclusions

The efficient-markets hypothesis implies that interest rates adjust immediately to new information. Our empirical results support this hypothesis for long-term interest rates, since they suggest that bond markets quickly use new information about the money supply and the Federal-funds rate.

The Federal Reserve's October 6, 1979 change in monetary policy altered the way that bond markets set interest rates. Previously, a monetary surprise of one percentage point raised interest rates by 3-7 basis points, and a surprise of one percentage point in the Federal-funds rate raised rates by 14-61 basis points. After October 1979, such surprises would have raised interest rates by 31-86 and 11-35 basis points, respectively. Clearly, monetary surprises have become rather important, while surprises in the Federal-funds rate have become substantially less important.

Analysis of the decomposition of rate volatility suggests that 52-72 percent of the increased volatility resulted from factors not under the Federal Reserve's direct control. About 25-30 percent of the increased volatility resulted from making the Federal-funds rate respond to monetary surprises. The rest came from freeing the Federal-funds rate to respond to nonmonetary market forces; this source was responsible for as much as 20 percent of the increased volatility of short-term rates, but for as little as 3 percent of the increased volatility of long-term rates.

These findings suggest several public-policy implications — primarily, that the Federal Reserve has not been responsible for most of the increase in interest-rate volatility. The post-October 1979 period has seen many unexpected events that could have changed interest rates or shifted the demand for money. For example, militant students seized hostages in Iran, the Russians invaded Afghanistan, decontrol of oil prices began, President Carter authorized credit controls, the silver market collapsed, and the U.S. underwent a radical change in political direction. Clearly, none of these events was a direct consequence of the monetary-policy change. Furthermore, future years may see a return to normalcy, with a sharp reduction in interest-rate volatility.

Second, the Federal Reserve's decision to move the Federal-funds rate more in response to monetary surprises entails more volatility of both long-and short-term interest rates. It probably also helps the Federal Reserve to hit its targets for money growth and hence for inflation. For this reason, the increased volatility — and the resultant reduction in capital formation and redirection of capital towards shorter-lived assets — may be the price that must be paid to hit these targets. The price has certainly proven to be higher than many believed before October 6, 1979. Whether this price has been too high depends on how important it is to hit monetary targets, and how much the increased volatility reduces savings and changes the composition of investment.

Finally, Federal Reserve intervention in the market for reserves to eliminate surprises in the Federal-funds rate would mean only a slight reduction in the volatility of long-term interest rates. If the Federal Reserve intervened, however, it would simply replace private agents as the speculator in that market. This paper has established no presumption that the Fed is a better speculator than private agents — and even if it were, it would not need to intervene directly itself. A timely and credible public announcement of the Fed's superior information would make the market as efficient as it could ever be — simply because efficient securities markets make optimal use of all the information available to them.

FOOTNOTES

1. For example, see Herman (1981).

2. See Fama (1970) for a discussion of the efficient-markets hypothesis and for a review of some empirical work supporting it.

3. Mishkin (1980) has shown that one-quarter holding-period yields of long-term bonds are indeed dominated by capital gains and losses.

4. Clearly, I am assuming here that a linear predictor is best.

5. I have used unadjusted data, because I believe that the method by which the Federal Reserve obtains its seasonally adjusted data does more harm than good.

6. Henceforth, I shall refer to these sample periods as "before October 6, 1979" and "after October 6, 1979."

7. This methodology entails examining the sample autocorrelations and partial autocorrelations of these series, identifying univariate processes for each series, fitting these processes, subjecting each fitted process to tests of model adequacy, crosscorrelating the residuals of these processes, identifying the bivariate process generating the two series, fitting this bivariate process, and testing whether the fitted process is adequate. See Box and Jenkins (1976) and Granger and Newbold (1977) for a complete description of this methodology.

8. For example, equations (3) and (4) take the form (ignoring the constant term)

$$z = H(L)e,$$

where z is a vector composed of GM −GM(−52) and DFFR; e is a vector composed of EM and EFFR: and H(L) is a 2x2 matrix in polynomials in the lag operator L, which is defined such that $L^i z = Z(-i)$. Since H(L) is invertible,

$$H^{-1}(L)z = e.$$

Suppose that

$$H^{-1}(L) = I - J_1 L - J_2 L^2 - \ldots$$

Then $z = J_1 z(-1) + J_2 z(-) + \ldots + e$.

Let Z be the vector obtained by stacking z, z(−1), . . . , and let E be the vector with EM in the first entry, EFFR in the second entry, and zeros in the remaining entries.

Then

$$Z = AZ(-1) + E,$$

where

$$A = \begin{bmatrix} J_1 & J_2 & J_3 & \ldots \\ I & 0 & 0 & \ldots \\ 0 & I & 0 & \ldots \\ 0 & 0 & I & \ldots \\ \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot \end{bmatrix}$$

9. This statement ignores the constant term and assumes that a year has exactly 52 weeks.

10. To keep the analysis as simple as possible, I assume that

$$dr_{it} = v_{it},$$

where dr_{it} is the change in the bond rate from the end of day i-1 of week t to the end of day i of week t (day 0 of week t is day 7 of week t - 1), and v_{it} is a serially uncorrelated error term. This equation implies that DR_{it}, the change in the bond rate from the end of day i of week t - 1 to the end of day i of week t, is

$$\underset{i+1}{DR_{it}} = \sum_{i+1}^{7} v_{jt-1} + \sum_{1}^{i} v_{jt}$$

Averaging this equation then yields

$$(*)\ DR = \left[\sum_{1}^{7} (i-1)\, v_{it-1} + \sum_{1}^{7} (8-i) v_{it} \right] / 7$$

Therefore, DR and DR (−1) have the nonzero covariance

$$(**) \left[\sum_{1}^{7} (8-i)(i-1) \mathrm{Var}\, v_{it-1} \right] / 49$$

and DR and DR(−i), i>1, have a zero covariance, it follows that DR is the first-order moving average. Note that DR has the representation

$$DR = U + g\,U(-1),$$

where U is a serially uncorrelated error term and g is a parameter. The parameter g and the variance of U are chosen so that DR has the same variance as (*) implies and DR and DR(−1) have the covariance (**).

11. It is hard to be more specific about when EM(−1) affects the bond markets, because M−1B data may leak out before its official release date. I assume, however, that leakage occurs after the beginning of the week.

12. The sum of the coefficients on EFFR(+1) and EFFR consistently estimates the coefficient that one would obtain using Federal-funds rate data averaged over weeks ending on Saturdays. First, let X_1 be EFFR(+1), X_2 be EFFR, Y be DR, and X be the EFFR that would be used if the right data were available. Next, let Z_1 and Z_2 be the parts of X that X_1 and X_2 give to the bond markets, and let E_1 and E_2 be defined by

$$X_1 = Z_1 + E_1$$
$$X_2 = Z_2 + E_2$$
$$X = Z_1 + Z_2$$

By construction, Z_1, Z_2, E_1 and E_2 are mutually orthogonal and X_1, X_2 and X have the same variance. Then, let be α the fraction of the variance of X contributed by Z_1 and $1-\alpha$ be the fraction contributed by Z_2. Finally, let

$$Y = \beta X' + V,$$

where V is orthogonal to Z_1, Z_2, E_1 and E_2' Then

$$Y = \beta(X_1 + X_2) + V - \beta(E_1 + E_2).$$

Since X_1 and X_2 are orthogonal, the least-squares estimator b_1 of the coefficient on X_1 is

$$\Sigma X_1 Y / \Sigma X_1^2.$$

Its probability limit is therefore

$$\text{plim}\ (\Sigma X_1\ (\beta(X_1 + X_2) + V - \beta(E_1 + E_2))/\Sigma X_1^2)$$
$$= \beta + \beta\ \text{plim}\ (\Sigma X_1 X_2 / \Sigma X_1^2)$$
$$+ \text{plim}\ (\Sigma X_1 V / \Sigma X_1{}^2) - \beta \text{plim}\ (\Sigma X_1 (E_1 E_2)/\Sigma X_1{}^2)$$
$$= \beta - \beta\ \text{plim}\ (\Sigma (Z_1 + E_1)(E_1 + E_2)/\Sigma X_1{}^2)$$
$$= (1 - \text{plim}\ (\Sigma E_1{}^2 / \Sigma E_1{}^2 / \Sigma X_1{}^2))\beta$$
$$= (1 - \text{var}\ E_1 / \text{var}\ X_1)\beta$$
$$= \alpha\beta$$

Similarly, the probability limit of the least-squares estimator b_2 of the coefficient on X_2 is

$$\text{plim}\ (b_2 = (1-\alpha)\beta$$

Hence

$$\text{plim}\ (b_1 + b_2) = \beta$$

13. Strictly speaking, the efficient-markets hypothesis only rules out long lag structures in the equations for long-term interest rates. I therefore conclude that the data support the efficient-markets hypothesis.

14. If the error term V is a first-order moving average, it takes the form

$$V = U + g\ U(-1),$$

where U is a serially uncorrelated error term and g is a parameter. If V is a second-order moving avarage,

$$V = U + gU(-1) + hU(-2),$$

where h is a parameter. The columns labeled **Lag 1** and **Lag 2** provide the estimates of g and h.

15. Since October 6, 1979, the Federal-funds rate has conveyed more information about supply and demand in the market for reserves, even though it has conveyed less information about the aggregate economy.

16. I define the volatility of an interest rate to be the variance of its weekly differences.

17. Some of the equations reported in Tables 1 and 2 have longer lag structures than equation (8) recognizes. For these equations, I have modified equation (8) appropriately.

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