The Federal Funds Rate and the Channels of Monetary Transmission

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We show that the interest rate on Federal funds is extremely informative about future movements of real macroeconomic variables. Then we argue that the reason for this forecasting success is that the funds rate sensitively records shocks to the supply of bank reserves; that is, the funds rate is a good indicator of monetary policy actions. Finally, using innovations to the funds rate as a measure of changes in policy, we present evidence consistent with the view that monetary policy works at least in part through "credit" (i.e., bank loans) as well as through "money" (i.e., bank deposits). (*JEL* E52)

Does monetary policy affect the real economy? If so, what is the transmission mechanism by which these effects occur? These two questions are among the most important and controversial in macroeconomics. This paper presents some new empirical evidence that bears on each.

Our original motivation for undertaking the research reported here was far more modest than is suggested by the two questions raised above; it was to test a model of monetary policy transmission sketched in Bernanke and Blinder (1988). There we developed an analogue to the simple IS-LM model which embodied an unconventional (but rather old) view of the monetary transmission mechanism: that central-bank policy works by affecting bank assets (loans) as well as bank liabilities (deposits).

The microeconomic justification of this so-called credit view is the observation that, under realistic conditions of asymmetric information, loans from financial intermediaries are "special." Specifically, the expertise acquired by banks in the process of evaluating and screening applicants and in monitoring loan performance enables them to extend credit to customers who find it difficult or impossible to obtain credit in the open market. As a consequence, when the Federal Reserve reduces the volume of reserves, and therefore of loans, spending by customers who depend on bank credit must fall, and therefore so must aggregate demand.[1] This provides an additional channel of transmission for Federal Reserve policy to the real economy, over and above the usual liquidity effects emanating from the market for deposits.[2]

Until now the credit view has been perceived as empirically unsuccessful. One apparently damaging piece of evidence is the finding that bank deposits are better predictors of output changes in unrestricted vector autoregressions than are bank assets (Stephen R. King, 1986). However, it is extremely risky to make structural inferences from unrestricted vector autoregressions, which after all are only reduced forms. If we want to measure the true structural effects of a policy change, there are really only two alternatives.

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[1]The argument is sketched in Blinder and Joseph E. Stiglitz (1983). An assumption of imperfect substitutability of loans for securities in bank portfolios is needed to ensure that a decline in reserves leads to a decline in loans.

[2]Another implication of the theory is that real economic activity will contract if banks reduce the share of loans in their portfolios (e.g., because they fear bank runs). Bernanke (1983) argues that this may have deepened the Great Depression.

First, we can specify and estimate a structural economic model. Thus Bernanke (1986) used a "structural vector autoregression approach" to study the relationships among money, credit, and income and obtained a more optimistic reading on the importance of credit. Unfortunately, inferences drawn from structural models are typically sensitive to the choice of specification and to the identifying assumptions. For example, Bernanke imposed covariance restrictions to get identification.

The second alternative is to try to isolate a direct measure of Federal Reserve policy. Suppose, for example, that we could find a variable whose *innovations* could be interpreted as "policy shocks." (The systematic portion of the variable could depend in any arbitrary fashion on lagged economic variables.) Suppose further that, perhaps because of information lags, these measurable policy shocks could reasonably be assumed to be independent of contemporaneous economic disturbances. Under these assumptions, the reduced-form responses of the economy to observed policy shocks would correctly measure the dynamic structural effects of a monetary policy change. This second strategy is the one we follow in this paper.

Specifically, think of the economy as being represented by the following very general structural model:

$$(1) \quad \mathbf{Y}_t = \mathbf{B}_0\mathbf{Y}_t + \mathbf{B}_1\mathbf{Y}_{t-1} + \mathbf{C}_0\mathbf{P}_t + \mathbf{C}_1\mathbf{P}_{t-1} + \mathbf{u}_t$$

$$(2) \quad \mathbf{P}_t = \mathbf{D}_0\mathbf{Y}_t + \mathbf{D}_1\mathbf{Y}_{t-1} + \mathbf{G}\mathbf{P}_{t-1} + \mathbf{v}_t$$

where $\mathbf{Y}$ is a vector of nonpolicy variables, $\mathbf{P}$ is a vector of policy variables, and $\mathbf{u}$ and $\mathbf{v}$ are orthogonal disturbances. The system (1)–(2) is not identified. Two types of identifying assumptions are most obvious:

The preceding discussion suggests excluding $\mathbf{Y}_t$ from (2), which means assuming that there is no feedback from the economy to policy actions within the period. If $\mathbf{D}_0 = \mathbf{0}$, we can convert this system into a standard vector autoregression (VAR) by substituting (2) into (1) and solving to obtain:

$$(3) \quad \mathbf{P}_t = \mathbf{D}_1\mathbf{Y}_{t-1} + \mathbf{G}\mathbf{P}_{t-1} + \mathbf{v}_t$$

$$(4) \quad \mathbf{Y}_t = (\mathbf{I} - \mathbf{B}_0)^{-1}[(\mathbf{B}_1 + \mathbf{C}_0\mathbf{D}_1)\mathbf{Y}_{t-1} + (\mathbf{C}_0\mathbf{G} + \mathbf{C}_1)\mathbf{P}_{t-1} + \mathbf{u}_t + \mathbf{C}_0\mathbf{v}_t].$$

In this case, the effects of policy innovations on the nonpolicy variables can be unambiguously identified with the impulse response function of $\mathbf{Y}$ to past changes in $\mathbf{v}$ in the unrestricted VAR consisting of (3) and (4), with $\mathbf{P}$ placed *first* in the ordering.

An alternative identifying assumption is to suppose that contemporaneous $\mathbf{P}$ does not enter equation (1), that is, that $\mathbf{C}_0 = \mathbf{0}$, so that policy actions affect real variables only with a lag. In this case, the appropriate VAR has $\mathbf{P}$ *last* in the ordering, viz:

$$(3') \quad \mathbf{Y}_t = (\mathbf{I} - \mathbf{B}_0)^{-1}[\mathbf{B}_1\mathbf{Y}_{t-1} + \mathbf{C}_1\mathbf{P}_{t-1} + \mathbf{u}_t]$$

$$(4') \quad \mathbf{P}_t = (\mathbf{D}_1 + \mathbf{D}_0(\mathbf{I} - \mathbf{B}_0)^{-1}\mathbf{B}_1)\mathbf{Y}_{t-1} + (\mathbf{G} + \mathbf{D}_0(\mathbf{I} - \mathbf{B}_0)^{-1}\mathbf{C}_1)\mathbf{P}_{t-1} + \mathbf{v}_t + \mathbf{D}_0(\mathbf{I} - \mathbf{B}_0)^{-1}\mathbf{u}_t.$$

Here $\mathbf{v}_t$ is still a policy innovation, but $\mathbf{P}_t$ is now also affected by contemporaneous macro shocks $\mathbf{u}_t$.

In this paper, we make some use of each of these two alternatives. In either case, we entertain the idea that the Federal funds rate (or the spread between the funds rate and some alternative open-market rate) is an indicator of Federal Reserve policy—at least before October 1979. If so, the dynamic response of the economy to innovations in the funds rate, or in the funds-rate spread, will measure the true structural response to monetary policy. In particular, we can "see" the monetary transmission mechanism unfold by examining the responses to a Federal-funds-rate shock of bank balance-sheet variables, like deposits and loans, and target variables, like unemployment and inflation.

Before doing this, however, we must defend the idea that the funds rate, or the funds-rate spread, is a measure of monetary policy. This we do in three steps.

First, if the funds rate is a measure of policy and if policy affects the real economy —two conclusions that this paper supports —then the funds rate should be a good reduced-form predictor of major macroeconomic variables. We therefore begin in Section I by studying the information content of the Federal funds rate. The results are striking: the Federal funds rate is markedly superior to both monetary aggregates and to most other interest rates as a forecaster of the economy.[3] This finding is important even to those who are skeptical about the rest of our analysis, because it challenges the argument of Christopher A. Sims (1980), Robert B. Litterman and Laurence Weiss (1985), and other "real-business-cycle" advocates that the predictive power of interest rates is due to real, rather than monetary, factors. Why, under this view, does the Federal funds rate predict real output better than other open-market interest rates?

Second, if the Federal funds rate measures monetary policy, then it should respond to the Federal Reserve's perception of the state of the economy. Our next step (Section II), therefore, is to estimate monetary-policy reaction functions explaining movements in the funds rate or the funds-rate spread by lagged target variables, as in equation (2). As an alternative, we also try a latent-variable approach adapted from Robert B. Avery (1979). In all cases, we obtain plausible results which suggest that the Fed was purposefully manipulating the funds rate during the pre-1979 period—an observation that is consistent with what the Fed claims to have been doing.

Finally, in Section III, we make the case that movements in the funds rate are genuine policy changes, not simply endogenous responses of the Federal funds market to changes in the economy. This boils down to showing that the supply curve of nonborrowed reserves between Federal Open Market Committe (FOMC) meetings is extremely elastic at the target funds rate. Using both monthly and weekly data, we find little effect of reserve demand shocks on the funds rate, which supports the idea that the funds rate is mostly driven by policy decisions.

Given all this evidence, we consider it reasonable to treat either the funds rate or the funds-rate spread as a measure of Federal Reserve policy which, though not statistically exogenous, is at least predetermined within the month. We therefore interpret the estimated dynamic responses of the economy to shocks to these alternative policy measures as reflecting the structural effect of monetary policy in the particular historical period.[4]

In doing this, we reach two main conclusions. First, monetary policy does seem to affect the real economy: a variety of measures of real activity respond to shocks to the Federal funds rate (Section I). Second, there appears to be something to the idea that monetary transmission works through bank loans as well as through deposits (Section IV). Loans seem to respond slowly to monetary policy innovations—which makes economic sense because loans are contractual commitments, and which also explains why loans are not particularly useful in forecasting. However, loans do eventually respond substantially to a change in the funds rate, with a timing that coincides closely to the response of the unemployment rate. This coincidence in time does not prove that loans carry the impact of monetary policy to the real economy; an alternative explanation, which we discuss in Section IV, is that loan volume passively adjusts to economic activity. Nonetheless, the timing seems to us to be strikingly consistent with the credit view.

[3]As will be clear later, its chief competitor is a variable based on the commercial paper rate suggested by James H. Stock and Mark W. Watson (1989).

[4]As we are considering the responses of the economy in a particular historical episode, not contemplating the effects of a change in the policy rule, the Lucas critique does not apply.

I. The Information Content of the Federal Funds Rate

Post hoc ergo propter hoc fallacies notwithstanding, much of the empirical case for the real effects of money is based on the observation that movements in monetary aggregates precede movements in the real economy. Milton Friedman and Anna J. Schwartz (1963) were, of course, the first to document this relationship extensively. Sims (1972) later demonstrated that money Granger-causes nominal GNP in a bivariate system; and Lawrence J. Christiano and Lars Ljungqvist (1988) produced parallel findings for industrial production. If money is at least partly exogenous, these results suggest that changes in nominal money can be used to produce real effects.

In the late 1970's, attention focused on whether it was "anticipated" or "unanticipated" money that leads output. Robert J. Barro (1977, 1978) presented empirical evidence for unanticipated money; Robert J. Gordon (1982) and Frederic S. Mishkin (1982) made rebuttals. The distinction between anticipated and unanticipated money was important for deciding whether *systematic* monetary policy could affect output. However, this debate presumed that the tendency of money to lead output implied some type of causality.

More recent empirical work has questioned precisely this supposition. First Sims (1980) and then Litterman and Weiss (1985) found that interest rates tend to absorb the predictive power of money. Specifically, a nominal interest rate appears to dominate money as a forecaster of output when added to a vector autoregression containing money, output, and prices. These authors interpreted this finding as evidence against the effectiveness of monetary policy, whether systematic or nonsystematic. This interpretation was disputed on empirical grounds by King (1982) and Bernanke (1986) and on theoretical grounds by Bennett T. McCallum (1983). Nevertheless, the apparent fact that money has far less predictive power for output than do interest rates is an important challenge to the traditional "money leads income" argument for monetary-policy effectiveness.

This section picks up and supports a suggestion made by McCallum (1983), who argued that the Sims result need not imply that monetary policy is ineffective. Interest rates might, in fact, be better indicators of policy actions than the monetary aggregates. If McCallum is right, it seems to us that the Federal funds rate should be a better information variable than other open-market interest rates because it is tied so closely to Federal Reserve policy.[5,6] This section shows that this is indeed the case.

In reconsidering the question of predictive power, we take a more comprehensive view of the matter than previous literature has. In particular, we consider nine different real variables one might want to forecast (listed in Table 1), three different interest rates, and two different measures of forecasting power. We also vary the details of the tests in many ways in order to assess the robustness of the results.

We begin with a battery of Granger-causality tests reported in the top panel of Table 1. Each row of the table represents an equation that forecasts some measure of real economic activity[7] by six lags of itself, six lags of the log of the consumer price index (CPI), six lags of the logs of both the M1 and M2 money supplies, and six lags each of three different interest rates: the Federal funds rate (FUNDS), the three-month Treasury bill rate (BILL), and the ten-year Treasury bond rate (BOND).[8] Our focus, of course, is on the predictive power

[5]The discount rate might be thought to be tied even more closely to policy; but it often "follows the market" and, perhaps because of its political sensitivity, is often held fixed for long periods of time.

[6]Litterman (1984) takes more or less the same view in a paper similar in spirit to (but different in details from) this section.

[7]The measures were chosen because the time series are available monthly and because they are popular indicators of economic conditions. We report results for every measure of aggregate activity that was tried.

[8]All interest rates used in this paper are measured as monthly averages of daily figures, expressed at annual rates.

TABLE 1—MARGINAL SIGNIFICANCE LEVELS OF MONETARY INDICATORS FOR FORECASTING ALTERNATIVE MEASURES OF ECONOMIC ACTIVITY: SIX-VARIABLE PREDICTION EQUATIONS

Forecasted variable	M1	M2	BILL	BOND	FUNDS
A. *Sample Period 1959:7–1989:12:*					
Industrial production	0.92	0.10	0.071	0.26	0.017
Capacity utilization	0.74	0.22	0.16	0.40	0.031
Employment	0.45	0.27	0.0040	0.085	0.0004
Unemployment rate	0.96	0.37	0.0005	0.024	0.0001
Housing starts	0.50	0.32	0.52	0.014	0.22
Personal income	0.38	0.24	0.35	0.59	0.049
Retail sales	0.64	0.036	0.33	0.74	0.014
Consumption	0.96	0.11	0.12	0.46	0.0052
Durable-goods orders	0.87	0.22	0.28	0.19	0.039
B. *Sample Period 1959:7–1979:12:*					
Industrial production	0.99	0.084	0.0092	0.61	0.0001
Capacity utilization	0.96	0.40	0.025	0.18	0.0003
Employment	0.57	0.41	0.0005	0.15	0.0004
Unemployment rate	0.56	0.88	0.0006	0.13	0.0000
Housing starts	0.34	0.17	0.73	0.72	0.11
Personal income	0.43	0.095	0.20	0.91	0.037
Retail sales	0.96	0.86	0.27	0.050	0.061
Consumption	0.79	0.017	0.010	0.050	0.0000
Durable-goods orders	0.080	0.030	0.014	0.0071	0.0002

Notes: For each forecasted variable, the entries across each row are the marginal significance levels for omitting six lags of the monetary-policy variable indicated in the column heading from an unrestricted ordinary-least-squares (OLS) prediction equation that also included a constant, six lags of the forecasted variable, and six lags of the CPI. Data are monthly. M1, M2, industrial production, employment, and housing starts are in log levels. Personal income, retail sales, and consumption are deflated and in log levels. The data are from the DRI database; see the Data Appendix for details. FUNDS is the Federal funds rate; BILL is the three-month Treasury bill rate; BOND is the ten-year government bond rate.

of money and interest rates. Lags of the price level are included for comparability with previous literature and because it is presumably *real* money or *real* interest rates that affect real variables.[9]

The table shows the marginal significance levels for the hypothesis that all lags of either a monetary aggregate or a particular interest rate can be excluded from the equation predicting a real variable. A small value thus indicates that the column variable is important for predicting the row variable.[10] All data are seasonally adjusted. The sample period runs from 1959:7 to 1989:12.[11]

Table 1A shows that, according to the Granger-causality criterion, the Federal funds rate is far and away the best predictive variable among the five considered. It is superior to M1, M2, and the Treasury bill rate in predicting every one of the nine macroeconomic variables; in fact, M1 has virtually no predictive power at all. The funds rate is also superior to the bond rate

[9]Once many lags are used, there is little difference between putting the price level or the inflation rate in the equation.

[10]The table has no column for the lags of the dependent variable. Such a column would have 0.0000 everywhere. The table also omits F tests for dropping the CPI. That variable predicts real consumption at the 1-percent level and four other variables at the 10-percent level.

[11]Since money-supply data start only in 1959:1, the first usable observation is 1959:7, given the need for six lags.

in eight of nine cases. FUNDS does well not only relatively, but also on an absolute standard. Even in the presence of M1, M2, two other interest rates, prices, and the lagged dependent variable, the Federal funds rate's predictive contribution is statistically significant at better than the 5-percent level for every variable except housing starts. No other money or interest-rate variable is significant at this level more than twice.

The preceding results are quite robust. While precise numbers vary as the details of the equations are changed, the clear superiority of the Federal funds rate as a forecaster survives when we use data that are not seasonally adjusted; when we first-difference the nonstationary variables;[12] when we use three, four, or twelve lags in the forecasting equations rather than six; when we add a time trend to the regressions; when we omit one of the M's from the equation; and when we vary the sample. Two examples of the latter are particularly interesting.

First, it is well known—or, rather, widely believed—that the Federal Reserve reduced its reliance on the Federal funds rate as an intermediate target in October 1979. Therefore, it might be surmised that the predictive power of the funds rate would be even stronger in a subsample that ends in September 1979. Panel B of Table 1, which excludes data after September 1979 but is otherwise identical to panel A, shows that this conjecture is generally true. Despite the smaller sample size, FUNDS performs better as a predictor (as measured by F tests) in the pre-Volcker sample (compared to the full sample) in seven cases and worse in only one. More importantly, however, it is once again superior to M1, M2, and BILL in forecasting all nine variables, and it is superior to BOND for eight variables.

Second, the funds rate may have been a less important monetary instrument before 1966, a period during which it was generally below the discount rate.[13] If so, the funds rate should be even more informative in regressions that begin in January 1966. In fact, however, when we ran such regressions (not shown) the funds rate's forecasting ability (as measured by F tests) generally declined compared to that in the full sample. However, that may be due to the smaller sample size. In the 1966–1989 sample, FUNDS remains superior to both M1 and BILL in forecasting all nine variables, and it is superior to BOND in eight of nine cases.

So far we have been using Granger-causality tests to assess predictive power. There is at least one serious drawback to this approach, which arises because the right-hand variables are not orthogonal. A stylized example will illustrate the potential problem. Suppose, say, that M1 were truly an exogenous policy variable which moved the Treasury bill rate (BILL), which in turn moved the real economy. Then M1 might be insignificant in a regression that includes BILL, even though it is the genuine driving force.

This is one reason why Sims (1980) and Litterman and Weiss (1985) focused on a different measure of predictive power, one that is constructed from a VAR with orthogonalized residuals: the percentage of the variance of the forecasted variable attributable to alternative right-hand-side variables at different horizons. This metric also has its drawbacks, including dependence on the ordering of the explanatory variables,[14] dependence on the horizon, and low levels of statistical significance (see David E. Runkle, 1987). Rather than carry on a pointless debate over which measure is superior, however, let us just say that each conveys somewhat different information.

[12]These are: industrial production, employment, housing starts, personal income, retail sales, consumer expenditures, new orders for durable goods, the price level, M1, and M2. If we mechanically first-difference *everything* (including all three interest rates), neither FUNDS nor the other two interest rates has much predictive power left. We do not view the latter as a very sensible procedure, however.

[13]This was suggested to us by a referee.

[14]As we noted in the Introduction, whether the policy variables come before or after the macroeconomic variables depends on which identifying assumption is made.

TABLE 2—VARIANCE DECOMPOSITIONS OF FORECASTED VARIABLES

Forecasted variable	Own lags	CPI	M1	M2	BILL	BOND	FUNDS
A. *Sample Period 1959:7–1989:12:*							
Industrial production	36.6	3.1	15.4	8.7	8.0	0.8	27.4
Personal income	39.7	1.3	21.0	3.5	9.5	1.7	23.3
Employment	38.9	7.0	10.5	0.6	9.8	2.7	30.6
Unemployment rate	31.9	7.2	10.5	0.6	9.9	1.9	37.9
Housing starts	28.8	1.4	3.9	1.8	38.6	14.3	11.2
Personal income	48.2	4.3	20.8	0.1	6.9	3.3	16.3
Retail sales	32.4	15.5	5.1	4.4	27.4	1.1	14.1
Consumption	18.2	13.1	16.0	2.2	28.4	5.3	16.8
Durable-goods orders	41.3	6.8	14.7	5.5	10.3	2.6	18.8
B. *Sample Period 1959:7–1979:9:*							
Industrial production	36.3	2.7	11.8	6.5	11.5	3.3	27.8
Capacity utilization	39.9	2.4	12.4	4.5	10.8	5.6	24.3
Employment	41.4	1.8	5.8	0.2	10.4	3.2	37.9
Unemployment rate	44.9	1.3	4.9	1.3	11.6	2.2	33.8
Housing starts	45.2	9.9	8.3	6.3	11.8	9.6	9.0
Personal income	34.5	17.7	7.0	0.5	11.9	14.9	13.4
Retail sales	49.2	6.0	9.9	2.7	16.7	4.1	11.2
Consumption	18.9	21.1	13.2	3.3	11.7	16.4	15.5
Durable-goods orders	41.9	1.2	16.9	5.8	7.9	7.4	18.9

Notes: Entries are the percentages of the variance of the forecasted variable accounted for by variation in the column variable at a 24-month horizon. Estimates are based on vector autoregressions with six monthly lags of each variable. The ordering of the variables in the variance decomposition is the same as the ordering (left to right) of the columns. M1, M2, industrial production, employment, and housing starts are in log levels. Personal income, retail sales, and consumption are deflated and in log levels. The data are from the DRI database; see the Data Appendix for details. FUNDS is the Federal funds rate; BILL is the three-month Treasury bill rate; BOND is the ten-year government bond rate.

Fortunately, the choice of metric is not terribly important to our conclusions, as Table 2 shows. These results are based on exactly the same data, samples, and specification as Table 1, except that the variance-decomposition exercise requires that we estimate complete vector autoregressions, rather than single equations. Thus, each row in the table summarizes a complete VAR which includes six lags each of the variable to be forecast, the price level, the two M's, and the three interest rates. The entries in the table are the percentages of variance of the row variable attributable to each of the column variables at a 24-month horizon. Variables were ordered in the way they appear in the table; thus, we handicap FUNDS by always placing it last among the five policy variables. The results here are slightly less dramatic than the Granger-causality results, but they still strongly support the view that the Federal funds rate is an informative variable.

Look first at Table 2A, which pertains to the full 1959–1989 sample. Despite its disadvantageous position, FUNDS still contributes more to the 24-month variances of industrial production, capacity utilization, employment, unemployment, and orders for durable goods than any other variable except the forecasted variable itself. If we compare FUNDS to the other four monetary-policy variables, we see that it outperforms M2 in every case (generally by very wide margins) and outperforms M1 and BOND in every case but one. However, by this metric, FUNDS has more predictive power than BILL for only six of the nine variables (vs. eight in Table 1).

Table 2B offers corresponding results restricted to the pre-Volcker sample; it is thus directly comparable to Table 1B. In this shorter sample, the Federal funds rate is the most informative single variable for forecasting the same five real variables as in Table 2A. It outperforms both monetary aggregates in every case, outperforms BILL in seven of nine cases, and outperforms BOND in six of nine cases. For some variables, the superiority of the funds rate over other information variables is slim; but for industrial production, capacity utilization, employment, and unemployment, the percentages of variance at 24 months explained by the funds rate are 28, 24, 38, and 34, respectively. No other monetary indicator records such high numbers anywhere in the table.

Reordering the variables to put the funds rate first among the policy variables generally (but not always) increases its contribution in the variance decompositions, as expected. However, the increases are pronounced in only a few cases.[15] This suggests that, for most variables and most time periods, the information contained in the funds rate is nearly orthogonal to the information in the other forecasting variables.[16] Adding a time trend, changing the sample, and switching to non-seasonally-adjusted data changes these results relatively little and alters the basic message not at all. Differencing the nonstationary variables does cause the predictive performance of FUNDS to deteriorate substantially, but it remains superior to the other four monetary variables in most cases.

Our results so far suggest that much of the information content of interest rates is concentrated in one particular interest rate, the Federal funds rate.[17] This finding is important, since, if it holds up, it suggests a need for macroeconomists to turn their attention to shocks emanating from the market for bank reserves. As we suggested earlier, it is also consistent with McCallum's (1983) view that the real effects of monetary policy may be transmitted directly through interest rates, rather than through monetary aggregates.

However, in the context of work on a new index of leading indicators, Stock and Watson (1989) have called attention to the predictive power of two different interest-rate-based variables: the spread between the six-month commercial paper rate and the six-month Treasury bill rate (henceforth, CPBILL) and the spread between the ten-year and one-year Treasury bond rates (henceforth TERM, for term structure). CPBILL has been found by Stock and Watson and other authors to be particularly informative.[18] How does the Federal funds rate compare with these alternative interest rate variables as predictors of the real economy?

Tables 3 and 4 provide the comparisons. For the full 1961–1989 sample,[19] these tables show both Granger-causality test results and variance decompositions for five monetary and interest-rate variables: the Federal funds rate (FUNDS); the two Stock-Watson variables (CPBILL and TERM); and the two monetary aggregates.[20]

[15]Most notably, putting FUNDS first (rather than last) increases the percentages of the variance of housing starts, retail sales, and consumer spending it explains from 12.7, 1.0, and 3.2. to 46.2, 40.4, and 45.3, respectively.

[16]Putting the five policy variables before the price level and the lagged dependent variable in the ordering, but keeping FUNDS last among the policy variables, hardly changes its contributions.

[17]Robert D. Laurent (1988), using quarterly data, finds the funds rate superior to real M2 growth in predicting real GNP growth. Oddly, however, he does not include lagged GNP growth in his prediction equations and never uses M2 and the funds rate together in the same equation.

[18]See, in particular, Benjamin M. Friedman and Kenneth N. Kuttner (1992).

[19]Data on the six-month commercial paper rate are available only from 1961.

[20]Some might think this competition unfair since CPBILL and TERM are interest-rate *spreads* while FUNDS is an interest-rate *level*. For this reason, we also ran similar regressions replacing FUNDS by FFBOND, the difference between the Federal funds

TABLE 3—MARGINAL SIGNIFICANCE LEVELS OF MONETARY INDICATORS FOR FORECASTING ALTERNATIVE MEASURES OF ECONOMIC ACTIVITY: SIX-VARIABLE PREDICTION EQUATIONS (SAMPLE PERIOD 1961:7–1989:12)

Forecasted variable	M1	M2	CPBILL	TERM	FUNDS
Industrial production	0.72	0.86	0.0049	0.55	0.86
Capacity utilization	0.50	0.71	0.0008	0.64	0.85
Employment	0.79	0.82	0.032	0.55	0.63
Unemployment rate	0.47	0.54	0.049	0.53	0.28
Housing starts	0.56	0.23	0.21	0.38	0.55
Personal income	0.40	0.29	0.020	0.37	0.76
Retail sales	0.59	0.16	0.48	0.96	0.41
Consumption	0.99	0.53	0.021	0.78	0.41
Durable-goods orders	0.60	0.52	0.021	0.96	0.39

Notes: See notes to Table 1. CPBILL is the difference between the six-month commercial paper rate and the six-month Treasury bill rate. TERM is the difference between the ten-year and one-year government bond rates.

TABLE 4—VARIANCE DECOMPOSITIONS OF FORECASTED VARIABLES

A. *Sample period 1961:7–1989:12:*

Forecasted variable	M1	M2	CPBILL	TERM	FUNDS	OWN	CPI
Industrial production	13.5	19.6	10.7	11.3	6.6	34.3	4.0
Capacity utilization	17.0	8.7	14.2	7.1	18.7	32.5	1.7
Employment	16.1	8.6	13.1	8.0	11.6	37.3	5.3
Unemployment rate	6.8	0.9	14.1	7.9	18.5	45.0	6.8
Housing starts	13.5	3.8	1.3	47.4	2.7	30.5	0.8
Personal income	18.7	0.1	4.1	9.7	1.4	64.3	1.6
Retail sales	8.4	2.7	4.1	33.5	5.7	38.1	7.4
Consumption	24.9	1.4	2.5	36.9	5.6	22.5	6.2
Durable-goods orders	11.9	8.2	11.5	6.4	12.5	43.3	6.3

B. *Sample period 1961:7–1989:12:*

Forecasted variable	M1	M2	FUNDS	TERM	CPBILL	OWN	CPI
Industrial production	13.5	19.6	21.8	0.8	5.9	34.3	4.0
Capacity utilization	17.0	8.7	30.3	0.9	8.9	32.5	1.7
Employment	16.1	8.6	26.7	0.1	6.0	37.3	5.3
Unemployment rate	6.8	0.9	32.9	0.9	6.6	45.0	6.8
Housing starts	13.5	3.8	26.5	22.6	2.3	30.5	0.8
Personal income	18.7	0.1	11.0	2.6	1.6	64.3	1.6
Retail sales	8.4	2.7	30.6	9.8	3.0	38.1	7.4
Consumption	24.9	1.4	33.3	10.9	0.8	22.5	6.2
Durable-good orders	11.9	8.2	22.6	0.7	7.1	43.3	6.3

Notes: See notes to Table 2. CPBILL is the difference between the six-month commercial paper rate and the six-month Treasury bill rate. TERM is the difference between the ten-year and one-year government bond rates.

In addition, we continued to include the price level and lagged values of the dependent variable in every equation.

Table 3 shows that CPBILL is overwhelmingly the best information variable by the Granger-causality criterion, generally wiping out the predictive power of FUNDS.[21] However, Table 4A shows that, even when it is placed last in the ordering, FUNDS is more useful than CPBILL by the

rate and the 10-year bond rate. Results were not affected.

[21]Similar results are obtained in Bernanke (1990), where the comparison of these variables is pursued in greater detail.

variance-decomposition metric.[22] When FUNDS is placed ahead of CPBILL (Table 4B), it not only carries far more information than CPBILL for every variable, but is actually the best single information variable in eight of nine cases.[23]

How should we interpret these disparate results? Much depends on why CPBILL is such an informative variable. A natural hypothesis is that CPBILL is a good predictor because it captures the market's assessment of economy-wide default risk. Bernanke (1990) argues against this view, however, pointing out that the default risk on prime commercial paper is virtually zero[24] and that the correlation of CPBILL with conventional measures of default risk is surprisingly low. Instead, that study finds evidence for a hypothesis, examined earlier by Timothy Q. Cook (1981), that CPBILL tends to rise most sharply during Fed-induced "credit crunches," such as the episodes of disintermediation that occurred during the late 1960's and the 1970's. Bernanke concludes that CPBILL predicts the future of the real economy largely because it indicates the stance of monetary policy.[25]

If this conclusion is correct, then the results we obtained when comparing CPBILL and FUNDS are perfectly sensible. Suppose, for example, that FUNDS is a measure of monetary policy and that monetary policy works largely by inducing "credit crunches," whose occurrences are sensitively recorded in CPBILL. Then FUNDS should lose its marginal forecasting power in regressions that contain CPBILL because the latter already captures the impact of monetary policy. At the same time, however, FUNDS should remain informative in a variance-decomposition sense, because it is the most direct indicator of Federal Reserve policy.[26] Superiority for CPBILL in a Granger-causality sense and for FUNDS in a variance-decomposition sense is precisely what we find in the data. We thus see no conflict between our approach and the Stock-Watson results.

The finding that FUNDS is an excellent predictor is consistent with our thesis that FUNDS measures the stance of monetary policy. However, fluctuations in the funds rate might be caused primarily by variations in the demand for, rather than the supply of, bank reserves. For example, unexpected cash withdrawals increase banks' demands for reserves. In this case, the information content of the funds rate would not imply any effectiveness of monetary policy; it would merely reflect the correlation of the funds rate with surprises in bank deposits, which in turn carry information about future developments in the economy.

A conclusive demonstration that short-run movements in the Federal funds rate are dominated by either demand-side or supply-side forces probably cannot be made, given the difficulties of econometric identification in a context in which expectations and perhaps even game-theoretic considerations are pertinent. Nevertheless, in the next two sections, we present evidence that is at least consistent with the view that short-run variations in the Federal funds rate are mostly attributable to Federal Reserve policy decisions, not to fluctuations in the demand for reserves.

II. The Federal Reserve's Reaction Function

If the Federal funds rate or some related variable is an indicator of the Federal Reserve's policy stance, and if the Fed is purposeful and reasonably consistent in its

[22] FUNDS is the best single predictor for three variables; CPBILL is the best predictor for none. FUNDS carries more predictive power than CPBILL in six of the nine cases.

[23] The ordering underlying the two panels of Table 4 puts the monetary-policy variables (as a group) first, followed by own lags and the CPI. However, the results comparing FUNDS to CPBILL change little if the monetary-policy variables are placed last instead.

[24] According to Moody's Investors Services (1989), the historical probability of P-1 commercial paper defaulting within 270 days is 0.004 percent; there is only one such instance of default.

[25] Bernanke (1990) also argues that TERM, the other Stock-Watson variable, is a monetary-policy indicator.

[26] Note the parallel to our earlier discussion of the relative virtues of the Granger-causality and variance-decomposition metrics.

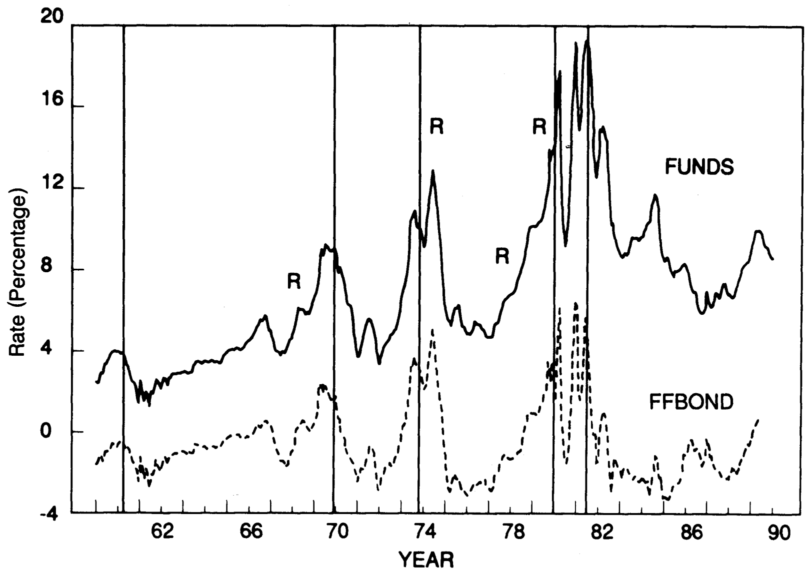

FIGURE 1. INTEREST-RATE INDICATORS OF FED POLICY

policy-making, then the funds rate should be systematically related to important macroeconomic target variables like unemployment and inflation. In this section, we estimate policy reaction functions in the form of equation (2) that show this to be true. We obtain similar results with two very different methodologies, which bolsters our confidence in the conclusion.

First, we must decide what variable to use to represent the tightness or ease of monetary policy. The Federal funds rate itself is the most obvious choice, and for most of our purposes, it is adequate. Therefore, most of the results in the next two sections use FUNDS to measure policy. However, FUNDS has one obvious drawback: a specific value of the funds rate might represent "easy money" when general market interest rates are high (say, because expected inflation is high) but "tight money" when general market interest rates are low. For most of our work, this problem is unimportant because we use *innovations* rather than levels of variables. However, for some purposes, it is useful to have a concrete measure of the level of the policy variable.

Laurent (1988) and others have suggested the spread between the funds rate and a long-term bond rate as a useful monetary indicator, on the grounds that the long rate incorporates the inflationary expectations component of all interest rates but is relatively insensitive to short-run variations in monetary tightness or ease. Indeed, the "tilt" of the term structure is a traditional monetary-policy indicator that is much discussed in the financial press. Thus, as an alternative to FUNDS, we also consider as a monetary indicator the spread between the funds rate and the ten-year bond rate, which we call FFBOND.[27]

Figure 1 displays the behavior of both FUNDS and FFBOND from 1959 through 1989. Readers will immediately notice that the two series behave very similarly; not surprisingly, it is the funds rate, not the bond rate, that dominates movements in FFBOND. Official NBER business-cycle peaks are indicated by vertical lines in the figure. Notice that every cyclical peak since 1959 was preceded by a sustained run-up in

[27]We also tried the spread between the funds rate and the three-month Treasury bill rate (FFBILL), which almost always gave results intermediate between FUNDS and FFBOND.

FFBOND. Furthermore, only one sustained increase in FFBOND was *not* followed by a recession. That episode, which was long and gradual, ended with the 1966 credit crunch, which was followed by a "growth recession." The figure shows, in a very simple way, why the Federal funds rate has so much predictive power.

Figure 1 also calls attention to the four episodes in this period selected by Christina Romer and David Romer (1989) as instances in which the Fed deliberately turned contractionary to fight inflation; these are marked by the letter R. In three of the four cases, decisions by the Fed to fight inflation (as dated by the Romers) were followed by increases in the funds rate and then by recession. The one exception is April 1974, when the funds rate fell after the Fed decided to fight inflation (according to the Romers). This sort of anecdotal evidence leads us to look for a systematic reaction function with FFBOND (or some such measure) on the left and inflation (and perhaps other things) on the right.

As our first way of estimating such a reaction function, we estimated a series of three-variable VAR's using six lags each of one of our measures of monetary policy, the prime-age (25–54) male unemployment rate, and the log of the CPI. The sample period ends in September 1979, before the Volcker de-emphasis of interest rates in the implementation of monetary policy. There is not much point in displaying detailed estimation results; we only note that the hypotheses that either lagged unemployment or lagged inflation can be omitted from the equations predicting FUNDS or FFBOND were always easily rejected. The lagged state of the economy clearly has a great deal of predictive power for any of the three funds-rate-based variables.

Instead, Figure 2 displays the implied impulse-response functions of FUNDS to shocks to unemployment and inflation.[28] The results look like plausible reaction

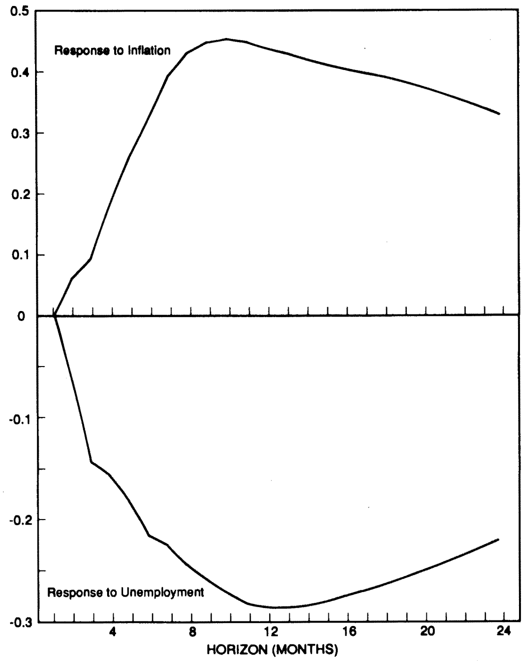

FIGURE 2. RESPONSES OF FUNDS RATE TO INFLATION AND UNEMPLOYMENT SHOCKS

functions. Inflation shocks drive up the funds rate (or the funds-rate spread), with the peak effect coming after 5–10 months and then decaying very slowly. Unemployment shocks push the funds rate in the opposite direction, but with somewhat longer lags and smaller magnitudes.[29] To our surprise, these relationships in the data did not break down in the post-1979 period. Reaction functions estimated in the same way for the 1979–1989 period looked qualitatively similar.

A Latent-Variable Measure of the Fed's Policy.—A clever variation on the reaction-function theme was explored by Avery (1979), who argued that no single indicator can fully measure the Fed's policy stance.

[28] The response of FFBOND is similar in shape, but muted. The ordering is: policy variable, unemployment rate, inflation rate.

[29] Note, however, that the graphs show the impulse responses to *one-standard-deviation* shocks. A one-standard-deviation inflation shock is a much bigger number (215 basis points, at an annual rate) than a one-standard-deviation unemployment shock (18 basis points).

He therefore proposed to measure monetary policy by means of a multiple-indicator multiple-cause (MIMIC) model of policy determination. Specifically, suppose there is some true but unobserved measure of monetary policy, called $\mathbf{y}^*$. The latent variable $\mathbf{y}^*$ is assumed to be a linear function of a vector of causal variables $\mathbf{X}$:

$$\mathbf{y}^* = \mathbf{X}\mathbf{c} + \mathbf{u} \tag{5}$$

where $\mathbf{y}^*$ is $T \times 1$ (T is the sample length), $\mathbf{X}$ is $T \times k$, $\mathbf{u}$ is a $T \times 1$ error vector independent of $\mathbf{X}$, and k is the number of explanatory variables. Equation (5) should be thought of as the true reaction function, so that $\mathbf{X}$ is lagged unemployment, lagged inflation, and so on.

Although $\mathbf{y}^*$ is not directly observed, assume that we have m indicators of $\mathbf{y}^*$, collectively called $\mathbf{Z}$. $\mathbf{Z}$ is a $T \times m$ vector which obeys:

$$\mathbf{Z} = \mathbf{y}^* \mathbf{b}' + \mathbf{v}. \tag{6}$$

Think of $\mathbf{Z}$ as alternative measures of monetary policy, such as various interest rates or growth rates of financial aggregates. The error matrix, $\mathbf{v}$, is $T \times m$ and is independent of $\mathbf{y}^*$ but has an unrestricted covariance matrix.

Even though $\mathbf{y}^*$ is unobserved, the parameters of (5) and (6) and, therefore, fitted values of $\mathbf{y}^*$ can be estimated by maximum-likelihood techniques, under the assumption of joint normality (see R. M. Hauser and A. S. Goldberger, 1971; Avery, 1979). Avery estimated a rather complicated version of this model using monthly data from 1955–1975. He used six indicators of monetary policy, and his explanatory variables included lags of the merchandise trade balance and industrial production as well as unemployment and inflation. Although he obtained reasonable estimation results, the overidentifying restrictions imposed by (5) and (6) were strongly rejected.

To obtain alternative estimates of the reaction of monetary policy to the state of the economy, we estimated a simplified version of Avery's model over the 1959–1979 sample. We used three indicators of monetary policy (the $\mathbf{Z}$'s): the spread between the funds rate and the long-term bond rate (FFBOND), the spread between the discount rate and the long-term bond rate (DRBOND), and the annualized real growth rate of nonborrowed reserves, all measured in percentage points.[30] The causal variables (the $\mathbf{X}$'s) were the same as in the previously estimated reaction functions: six lags of prime-age male unemployment and six lags of the CPI.[31] All variables were measured as deviations from means, so no constant term was included.

The parameter estimates are identified only up to an arbitrary scaling factor. As a convenient normalization, we set the coefficient on $\mathbf{y}^*$ of FFBOND in (6) equal to unity. With this metric, the "reaction-function" coefficients of equation (5) are displayed in Table 5.[32] The absolute magni-

TABLE 5—MODIFIED AVERY REACTION FUNCTION, 1959:8–1979:9

Independent variable	Coefficient estimates
$U(-1)$	-5.0
$U(-2)$	-65.9
$U(-3)$	-18.6
$U(-4)$	12.2
$U(-5)$	1.4
$U(-6)$	-13.3
INFL(-1)	7.9
INFL(-2)	5.9
INFL(-3)	4.2
INFL(-4)	4.6
INFL(-5)	4.2
INFL(-6)	2.6
X^2 $(d.f. = 22) = 40.21$ $(p = 0.010)$	

Notes: U and INFL are the unemployment rate and the inflation rate, measured in decimals. The table reports the effects of U and INFL on a latent indicator of monetary policy. The chi-square statistic tests the overidentifying restrictions of the model.

[30] The results changed little when we used the funds rate and the discount rate (rather than the spreads) or used nominal rather than real nonborrowed reserves.

[31] Avery's technique does not readily accommodate lagged values of the policy variable.

[32] Avery's method does not produce standard errors for individual coefficients.

tudes are not meaningful, but the pattern of response is. As can be seen, these patterns are similar to those found in the VAR's: increased unemployment loosens policy, and increased inflation tightens it. However, the long lags implied by the impulse-response functions of our estimated VAR's make us worry that our application of the Avery technique may not allow sufficiently long lags.[33] Indeed, the chi-square statistic for the overidentifying restrictions of the model rejects those restrictions, as was the case in Avery's (1979) study.[34]

Nonetheless, we pause to ask how closely FFBOND corresponds to our estimates of the latent-variable measure of monetary policy, $\mathbf{y}^*$. To answer this question, look at equation (6) and suppose that FFBOND is the first element of the vector $\mathbf{Z}$. If $\mathbf{Z}_1$ is really the proper measure of policy, then $\mathbf{y}^*$ will closely resemble $\mathbf{Z}_1$; that is, the error term $\mathbf{v}_1$ will have small estimated variance; and the same holds for $\mathbf{Z}_2$ and $\mathbf{Z}_3$. Hence, the simple correlations between the fitted values of $\mathbf{y}^*$ and each $\mathbf{Z}$ should indicate how closely related to "policy" (i.e., to $\mathbf{y}^*$) each observable variable is. These correlations, which are readily calculable from the estimates, are 0.80 for FFBOND, 0.64 for DRBOND, and 0.23 for nonborrowed reserve growth. Thus, the two interest-rate indicators, and especially FFBOND, were closely tied to monetary policy in the pre-Volcker period; but real reserve growth was not.

Once again, if this model is actually capturing the reaction function, it should give very different results for the post-1979 period. When estimated over the period October 1979–January 1988, the model in fact gave generally nonsensical results, including many incorrectly signed coefficients.

Overall, the results of this section lend support to the view that (i) the Fed tried to "lean against the wind" during the pre-1979 period, and (ii) the Federal funds rate and related variables (especially, perhaps, the spread between the funds rate and the long-term bond rate) are good measures of the Fed's policy stance before 1979. The evidence that there was a major shift in policy goals or strategy after 1979 is more mixed but is, in any case, less important for our purposes.

III. The Supply of and Demand for Bank Reserves

The fact that reasonable reaction functions can be estimated when the Federal funds rate or a related variable is used as a proxy for the stance of monetary policy is evidence for the validity of these proxies. In this section, we consider a different sort of evidence implied by the behavior of the Federal funds rate and funds-rate spreads within the month.

The thesis of this article is that innovations in FUNDS help predict movements in the economy because they measure policy-induced shocks to the supply of reserves. However, as we noted earlier, the funds rate would not be a good measure of monetary actions if its information content stemmed from shocks to reserve *demand*—arising from changes in the economy—rather than from shocks to reserve *supply*.

For the funds rate to be a good measure of monetary-policy actions, it must be essentially unresponsive to changes in reserve demand within a given month, as assumed in system (3)–(4). This amounts to saying that the Federal Reserve supplies reserves completely elastically, or nearly so, at its target funds rate. In this section, we present three different types of evidence in support of the idea that the within-month supply of reserves was extremely elastic at the target federal funds rate prior to October 1979.

All three are based on the same idea. We think of the Fed as setting a supply curve for nonborrowed reserves for the month or week. With a horizontal curve (Fig. 3A), any development within the period which affects the *demand* for bank reserves, but which

[33] In fact, OLS regressions of the funds rate on six lags of unemployment and inflation (excluding lags of the funds rate) have highly serially correlated residuals.

[34] With a single latent variable, the overidentifying restrictions are just that the responses of indicator variables to any given causal variable be in fixed proportion.

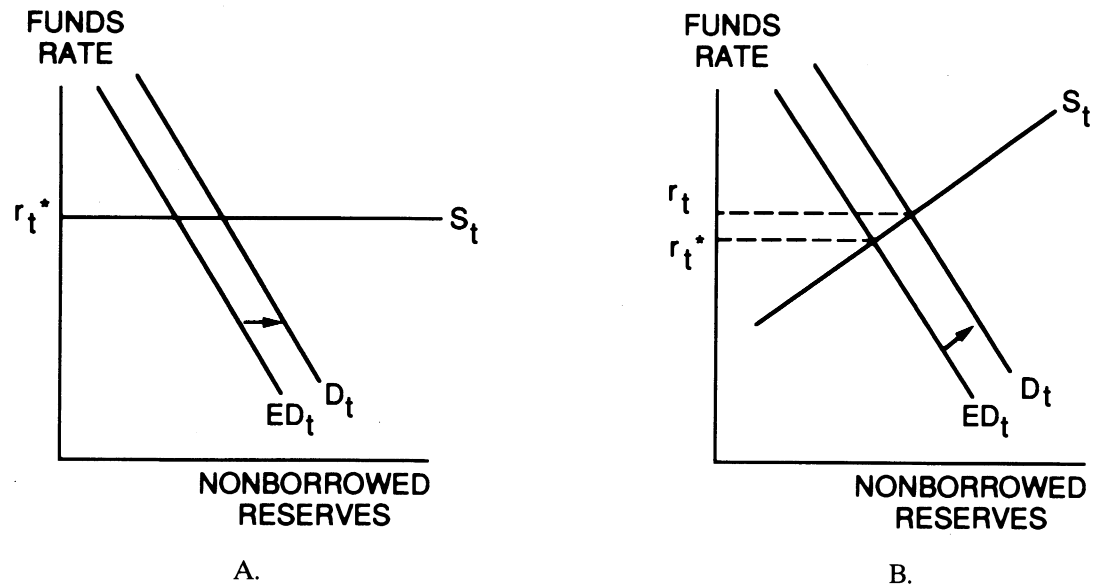

FIGURE 3. SUPPLY OF AND DEMAND FOR NONBORROWED RESERVES

could not have been contemporaneously known by the Fed, will not affect the funds rate. On the other hand, the funds rate will be affected if the supply curve is not horizontal, as in Figure 3B. In econometric terms, innovations in variables that drive the demand for bank reserves are *instruments* for consistent estimation of the slope of the supply curve of nonborrowed reserves.[35]

We implemented this idea first by using as instruments the innovations in the nine macro variables whose predictability was discussed in Section I. Six different five-variable VAR's were run over the period 1959:8–1979:9. Each used three of the nine macro variables,[36] nonborrowed reserves of depository institutions, and either FUNDS or FFBOND as a measure of monetary policy.[37] Innovations from these VAR's were then used to estimate the slope of the supply curve. Specifically, we regressed the innovation in the policy measure on the innovation in nonborrowed reserves, using the innovations in the three macro variables as instruments. If the innovations in the macro variables contain information that the Fed did not have when it set policy for the month, then the instrumental-variables regression should provide an estimate of the slope of the reserve supply function.[38]

[35]This also requires that the instruments not be affected by policy within the month. In terms of equation (1), this means that $\mathbf{C}_0 = \mathbf{0}$.

[36]We used only three variables, rather than all nine, to conserve on degrees of freedom. Given the use of six lags, these regressions have 30 right-hand-side variables.

[37]Results using the Federal-funds–Treasury-bill spread were not much different.

[38]Although the innovations are estimated from a first-stage VAR, the slope estimates in the second stage are consistent, and the standard-error estimates provided by the instrumental-variables procedure are asymptotically correct. This is because the second-stage parameter estimates and the VAR parameters are asymptotically independent (the information matrix is block diagonal), and the VAR residuals are consistent estimates of the true disturbances.

TABLE 6—ESTIMATED SLOPE OF SUPPLY FUNCTION OF NONBORROWED RESERVES

Instruments	FUNDS	FFBOND
Set A	−0.021	−0.011
	(0.023)	(0.015)
Set B	−0.0068	−0.0072
	(0.0104)	(0.0092)
Set C	−0.014	−0.014
	(0.016)	(0.016)
Personal-income revisions	−0.043	−0.027
	(0.026)	(0.017)

Notes: Entries are the coefficients obtained by regressing the innovation in the column variable against the innovation in unborrowed reserves, using the innovations in the row variables as instruments. Standard errors are in parentheses. Sample periods are 1959:8–1979:9, except for the personal-income revision, which is 1969:2–1979:9. Instrument set A is industrial production, capacity utilization, and employment. Instrument set B is the unemployment rate, housing starts, and real personal income. Instrument set C is real retail sales, real consumer expenditures, and real orders for durable goods.

With two alternative measures of policy and three sets of instruments, we have six estimates in all. Results are given in the first three rows of Table 6 (ignore the fourth row for the moment). Each entry is the number of percentage points the funds rate or funds-rate spread moves in response to a 1-percent innovation in nonborrowed reserves. Notice that all the estimated slopes are negative and statistically insignificant, though measured fairly precisely. This is consistent with the idea that, prior to 1979, the Fed set a target funds rate or funds-rate spread and supplied reserves elastically as required.

One problem with using the VAR innovations of the macro variables is that our information set is presumably smaller than that used by the Fed, so policymakers might have anticipated some of what we call "innovations." In that case, this information might have affected the Fed's decision, and the identification of the supply curve would be lost.

To avoid this problem, we used an instrument that certainly could not have been known to the Fed. Specifically, Peter L. Rathjens (1989) has collected a data set, which he kindly provided to us, consisting of preliminary announcements and successive revisions of economic variables. From these data, we constructed the *difference* between the preliminary announcement of personal income for a given month (issued in the subsequent month) and the second revised estimate of personal income for the given month (issued two months later). The difference between the two announcements embodies information that was unavailable to the Fed during the given month and thus should be a valid instrument.[39]

We calculated innovations to the alternative policy indicators and nonborrowed reserves using bivariate VAR's, then again regressed the innovation in the policy measure on the innovation in nonborrowed reserves, this time using the difference in personal-income announcements as an instrument. Due to data availability, this sample began in 1969. The results are shown in the final row of Table 6. This time the estimated slopes of the reserve supply curves are negative and approach statistical significance. Again, this is inconsistent with the view that the Fed's supply curve of reserves was upward-sloping within the month.

Weekly Data.—As a final way to estimate the elasticity of reserve supply, we went to weekly data. The idea was to try to exploit the lagged reserve accounting system in effect from September 1968 to January 1984, which made banks' demand for reserves completely inelastic within the week.

Suppose that the Fed's supply curve of nonborrowed reserves is extremely elastic at the target Federal funds rate. In such a world, a shock to deposits and, hence, to required reserves (RR) will move the funds rate very little, while nonborrowed reserves (NBR) move virtually one-for-one with RR (see Fig. 3A). Empirically, innovations in

[39]An alternative is the difference between the initial personal-income announcement and the final revision. However, the final revisions reflect such things as new benchmarks that do not represent new information about the particular month.

RR should be highly correlated with innovations in NBR but virtually uncorrelated with innovations in the funds rate. Conversely, if the supply curve of nonborrowed reserves was very inelastic, as would be the case if the Fed were targeting NBR, then the funds rate would take up most of the slack, while NBR would hardly respond. We would thus find a strong correlation between innovations in RR and the funds rate, but a weak correlation between innovations in RR and NBR.

What do we actually find in the data? To see, we ran a VAR on weekly data for required reserves, nonborrowed reserves (both in logs), and the Federal funds rate. Twelve lags of each variable were used, and the sample period was from January 1969 (the beginning of lagged reserve accounting) until the end of September 1979 (when operating procedures changed). We interpret the innovations to this VAR as "shocks" to the variables.

As predicted by the theory for an interest-rate-targeting regime, the correlation between shocks to required reserves and shocks to nonborrowed reserves was fairly high during this period (0.60), while shocks to either required or nonborrowed reserves were almost uncorrelated with innovations to the Federal funds rate (the correlations were 0.14 and -0.02, respectively). Estimating the elasticity of reserve supply by regressing funds-rate innovations on nonborrowed-reserve innovations, using innovations to required reserves as an instrument, revealed that a 1-percentage-point shock to the annual growth of NBR is associated with less than a 0.1-basis-point movement in the funds rate, with a t statistic of 3.2. This is, once again, consistent with the view that the Fed was targeting the funds rate during the pre-Volcker period.

We repeated the above exercise for the three-year period beginning in October 1979 to see if the estimated slope would be much larger under the allegedly "monetarist" operating procedures. The two periods are different in that the standard deviation of the funds rate was about twice as large and the standard deviation of nonborrowed reserves innovations is only about half as large during 1979–1982 as during 1968–1979. Thus, the policy change seems to have made a difference. However, the correlation between innovations in RR and NBR is still 0.45, which is not drastically lower than in the earlier sample; and, the correlation between required-reserve innovations and funds-rate innovations rises to 0.45, which is what would be expected under a nonborrowed-reserve targeting regime. Nonetheless, when we applied our instrumental-variables technique to estimate the slope of the supply curve, the estimate for the 1979–1982 period was 1.3 basis points, or about 13 times as large as during 1968–1979. This seems broadly consistent with both the previous finding and what the Fed was saying.

IV. The Transmission of Monetary Policy

So far we have argued that the Federal funds rate, or perhaps the spread between the funds rate and some other interest rate, is a good indicator of monetary policy. By this we mean that short-run fluctuations in the variable are dominated by shifts in the stance of policy, not by nonpolicy influences. Policy actions might well be influenced by past economic conditions, but it is important for our argument that the policy indicator not be sensitive to current (i.e., within-month) developments in the economy. We have offered evidence that this is so.

As discussed in the Introduction, a variable that is an indicator of policy in this sense would be very useful, since it would allow us to trace out the effects of policy without developing an explicit structural model. If the funds rate measures policy intentions, and if these intentions are predetermined, then the reduced-form responses of economic variables to innovations in the funds rate should measure the effects of policy.

In this section, we utilize this idea to study the dynamic effects of monetary-policy actions on bank balance sheets and on the economy in general. Monthly data on the balance sheets of commercial banks are published by the Federal Reserve (for a description, see the Data Appendix.) Our

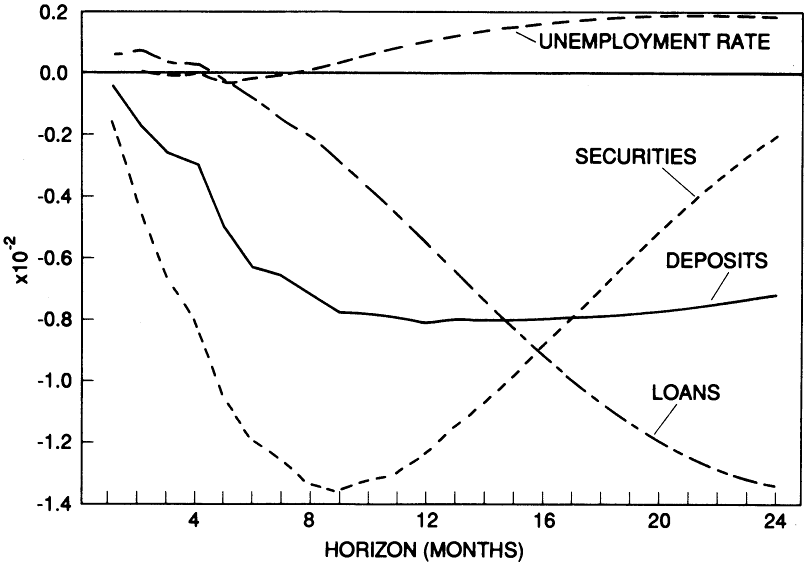

FIGURE 4. RESPONSES TO A SHOCK TO THE FUNDS RATE

sample begins in 1959:1, for comparability with the other results in this paper, and ends in 1978:12, when the Fed changed its definition and the format of its table. This endpoint, however, is not a problem for us, since we want to restrict ourselves to the pre-Volcker period anyway.[40]

We estimated three different VAR's, each including an indicator of monetary policy based on the funds rate, the unemployment rate, the log of the CPI, and the log levels of each of three bank balance-sheet variables (deposits, securities, and loans) all deflated by the CPI.[41] As usual, six lags of each variable were used. From each estimated VAR, we calculated the implied impulse-response functions to a shock to the monetary indicator. Under the assumption that innovations to the indicators represent policy actions, the responses of the other five variables will trace out the dynamic effects of such an action on the banking system and the economy.

The VAR coefficients themselves are not very interesting and so are not reported. Furthermore, since the shapes of the impulse-response functions are almost identical regardless of whether the funds rate or the funds-rate–bond-rate spread is used as a policy measure, we show only the results using the funds rate. Figure 4 displays the responses to a one-standard-deviation (31-basis-point) shock to the funds rate over a horizon of 24 months.[42]

Tight money (a positive innovation in FUNDS) does indeed reduce the volume of deposits held by depository institutions, as we would expect. The effect starts immediately, builds gradually, reaches its peak in about nine months, and appears to be permanent.[43] The other results bear in an interesting way on the money-versus-credit controversy. Naturally, bank assets fall along with bank liabilities; but the composition of the fall is noteworthy. For the first six

[40]The results were basically unchanged when we used an alternative balance-sheet series which the Fed began publishing in 1973 and which is still being maintained (see the Data Appendix).

[41]In alternative regressions, we used the balance-sheet variables in nominal terms. This made little difference. Results were also similar when we differenced the data instead of using levels.

[42]The policy shocks themselves are transitory. They generally build for about four months and then die away rather quickly.

[43]Although the diagram stops at 24 months, we ran all the impulse-response functions out to 48 months.

months or so after the policy shock, the fall in assets is concentrated almost entirely in securities; loans hardly move. However, shortly thereafter, security holdings begin gradually to be rebuilt, while loans start to fall. By the time two years have elapsed (the end of the graph), security holdings have almost returned to their original value, and essentially the entire decline in deposits is reflected in loans.

This pattern is just what we should expect. Loans are quasi-contractual commitments whose stock is difficult to change quickly. Banks therefore react to reduced deposits in the short run by selling off securities. In the longer run, however, portfolios are rebalanced, with the primary effect (according to these results) falling on loans. Similar results have been obtained by Leonard I. Nakamura (1988).

To relate this pattern of portfolio adjustment to developments in the real economy, Figure 4 also displays the impulse-response function of the unemployment rate. As is apparent, the effects of unemployment are essentially zero during the first two or three quarters after the shock to the funds rate; but at about the nine-month point, unemployment begins to rise, building gradually to a peak after about two years, before declining back to zero (the decline is not shown in the graph).

This timing of the unemployment response is interesting, because it corresponds fairly well to the estimated timing of the effect of the policy shock on loans. The fact that unemployment and bank loans move together following a change in the funds rate is consistent with the view that bank loans are an important component of the monetary transmission mechanism, even though loans do not lead real variables and are therefore not useful in forecasting exercises with VAR's.

There is, however, an alternative interpretation of our results: that monetary policy works entirely through the conventional money-demand mechanism, while the observed behavior of loans reflects a purely passive response to a falling demand for credit. One problem with this interpretation is that there is no reason for bank portfolios to bear any systematic relationship to either the stance of monetary policy or the level of real activity if loans, government securities, and corporate bonds are perfect substitutes, as they are under the traditional "money-only" view. However, we have shown here that bank-portfolio composition does respond systematically to monetary policy. Another related problem for the "money-only" view is that the composition of firms' borrowing also seems to be sensitive to monetary policy, with loans falling and other means of finance (like commercial paper) rising during periods of monetary stringency.[44] If the decline in bank loans following a monetary tightening were simply a passive response to falling credit demand, we would expect *all* forms of corporate borrowing to decline.

V. Conclusion

This paper draws three main substantive conclusions. First, the funds rate (or a measure based on it) is a good indicator of monetary policy, even for the period after 1979. The funds rate is probably less contaminated by endogenous responses to contemporaneous economic conditions than is, say, the money growth rate.

Second, the well-known stylized fact that nominal interest rates are good forecasters of real variables should be refined to note that the Federal funds rate is a *particularly* informative variable.[45] In fact, the finding that the Federal funds rate dominates both money and the bill and bond rates in forecasting real variables seems more robust than the oft-cited finding of Sims (1980) and Litterman and Weiss (1985) that the bill rate dominates money. Whether or not one accepts the other arguments of this paper, this result stands as a challenge to the real-business-cycle interpretation of the earlier findings. It needs to be explained.[46]

[44]This point is documented and explored by Anil Kashyap et al. (1991).

[45]The other particularly informative variable is Stock and Watson's (1989) spread between the commercial paper rate and the bill rate.

[46]A simple explanation, of course, is that monetary policy is effective.

Finally, our results are consistent with the view that monetary policy works in part by affecting the composition of bank assets. Tighter monetary policy results in a short-run sell-off of banks' security holdings, with little effect on loans. Over time, however, the brunt of tight money is felt on loans, as banks terminate old loans and refuse to make new ones. To the extent that some borrowers are dependent on bank loans for credit, this reduced supply of loans can depress the economy. The fact that the timing of the responses of loans and unemployment to monetary-policy innovations are so similar is circumstantial evidence that this channel is operative, even though loans do not Granger-cause unemployment.

DATA APPENDIX

Monthly Data.—All data except the consumer price index are from Data Resources, Inc. (DRI), and all variables except interest rates (which do not have significant seasonality) are seasonally adjusted. Variable definitions and DRI code names follow:

Industrial production index, total (JQIND)
Capacity utilization, manufacturing, total (UCAPFRBM)
Employed persons, nonagricultural establishments (EEA)
Housing starts, private, including farms (HUSTS)
Retail sales, 1982 dollars (STR82)
Personal income, 1982 dollars (YP82)
New orders, manufacturing durable goods, 1982 dollars (OMD82)
Personal consumption expenditures (*C*)
M1 money supply (MNY1)
M2 money supply (MNY2)
Effective rate on federal funds (RMFEDFUNDNS)
Average market yield on three-month government bills (RMGBS3NS) and six-month government bills (RMCML6NS)
Rate on prime commercial paper, six months (RMCML6NS)
Yield on Treasury securities at constant maturity of one year (RMGFCM@1NS) and ten years (RMGFCM@10NS).

The unemployment rate is measured as:

HHM25@54/(LCM25@34 + LCM35@44 + LCM45@54)

(i.e., unemployment [male, ages 25–54] divided by the corresponding labor force).

Weekly Data.—Variable definitions and DRI code names are as follows:

Reserves, depository institutions, required, adjusted (RESFRBNANS)
Reserves, depository institutions, nonborrowed, adjusted (RESFRBNBANS)
Effective rate of Federal funds (RMFEDFUNDSNS).

Bank Balance-Sheet Data.—Bank balance-sheet data are from Board of Governors, Federal Reserve System, *Banking and Monetary Statistics, 1941–1970*, and *Annual Statistical Digests*. The following basic data series all come from the table entitled "Principal Assets and Liabilities and Number of All Commercial Banks": total loans and investments, loans, and total deposits.

There are last-Wednesday-of-the-month series. A dummy variable is used to correct for a minor definitional change in June 1969. In the regressions, deposits = total deposits; securities = total loans and investments − loans. All variables are measured in logs.

An alternative set of data was drawn from table 1.25 in the *Federal Reserve Bulletin*, "Assets and Liabilities of Commercial Banking Institutions." Basic balance-sheet components used were investment securities (line 2), loans excluding interbank (line 8), and transactions deposits (line 22). These data begin in 1973 and are not exactly comparable to the principal data set because of differences in definitions and the breakdown of deposits.

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