An interest rate-based indicator of monetary policy

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All policymakers face the problem of determining how changes in the instruments under their control affect the ultimate goals they seek to influence. For the monetary policymaker, or monetary authority, this means that it is necessary to establish how movements in the instruments most directly under its control affect the goals the monetary authority is ultimately interested in influencing. In the United States, the monetary authority, the Federal Reserve, can affect reserve requirements, open market operations, interest rates, and money to influence real income, inflation, and unemployment.

The relationship between the instruments that the Fed controls and the goals of policy has never been known with great accuracy, but the uncertainties recently have been particularly great. Until the 1980s there had been an increasing reliance on money as an indicator that the monetary authority could use to influence the ultimate goals of policy. However, since the early 1980s some of the simple regularities previously believed to exist between money and the goals of policy appear to have deteriorated and the relationship has become more erratic.[1]

This article examines three of the most obvious indicators of monetary policy (two interest rate-based and one monetary aggregate) and then suggests a third interest rate-based indicator of the impact of monetary policy on future real income. All four of these indicators are tested against each other as forecasters of future changes in real income (real GNP). The results indicate that the newly suggested interest rate-based measure—the spread between the long term government bond rate and the federal funds rate—deserves serious consideration as an indicator of the influence of monetary policy on future real GNP. The last section discusses some qualifications to the results, and the implications of an interest rate-based indicator for monetary policy.

The fed funds rate

Monetary policy is implemented through changes in reserves which impact on interest rates. In the first instance, the change in reserves alters the gap between reserves and required reserves and moves the federal funds rate. The change in the federal funds rate transmits the impact of monetary policy to depository institutions. It might seem reasonable, then, that a basic relationship between interest rates and economic activity might be between the federal funds rate and the change in real income.

Figure 1 plots the relationship between the federal funds rate (on a bond equivalent basis) and the level of real GNP. As the figure shows, the level of the federal funds rate behaves over the cycle as would be expected. That is, the rate generally rises before economic activity peaks and falls before economic activity bottoms out. The figure makes it clear, however, that a given level of the federal funds rate may have very different meanings in different economic environments. For example, a *rise* in the federal funds rate to 4.03 percent in 1960 was associated with the economic downturn of 1961 while a *fall* in the federal funds rate to 8.97 percent was associated with the upturn of 1983. This suggests how difficult it is to interpret just the simple level of the federal funds rate as an indicator of monetary policy.

The real fed funds rate

A common adjustment can be applied to the federal funds rate to obtain an indicator

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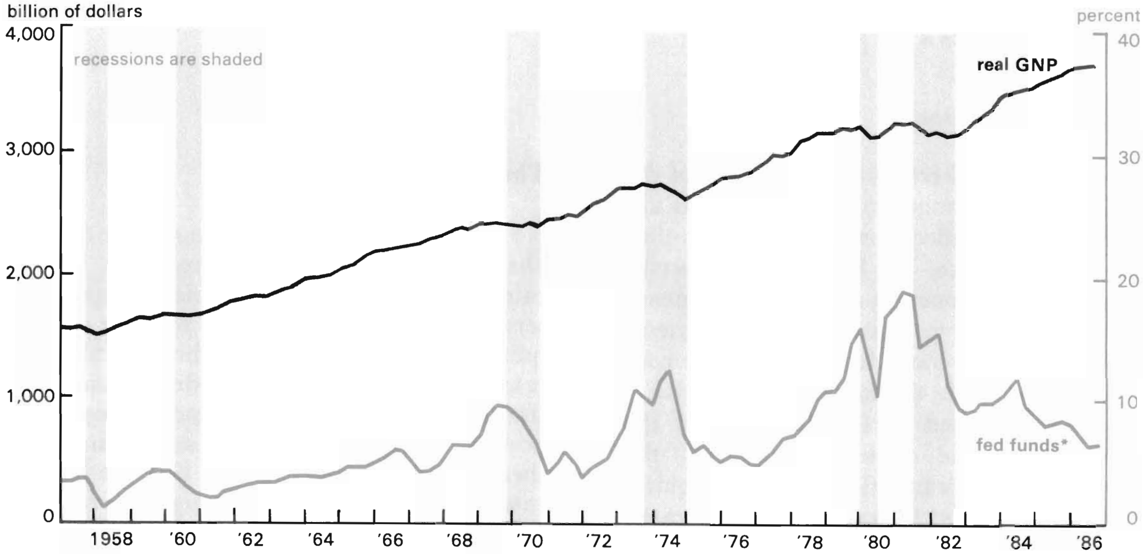
Figure 1
Fed funds rate vs. real GNP



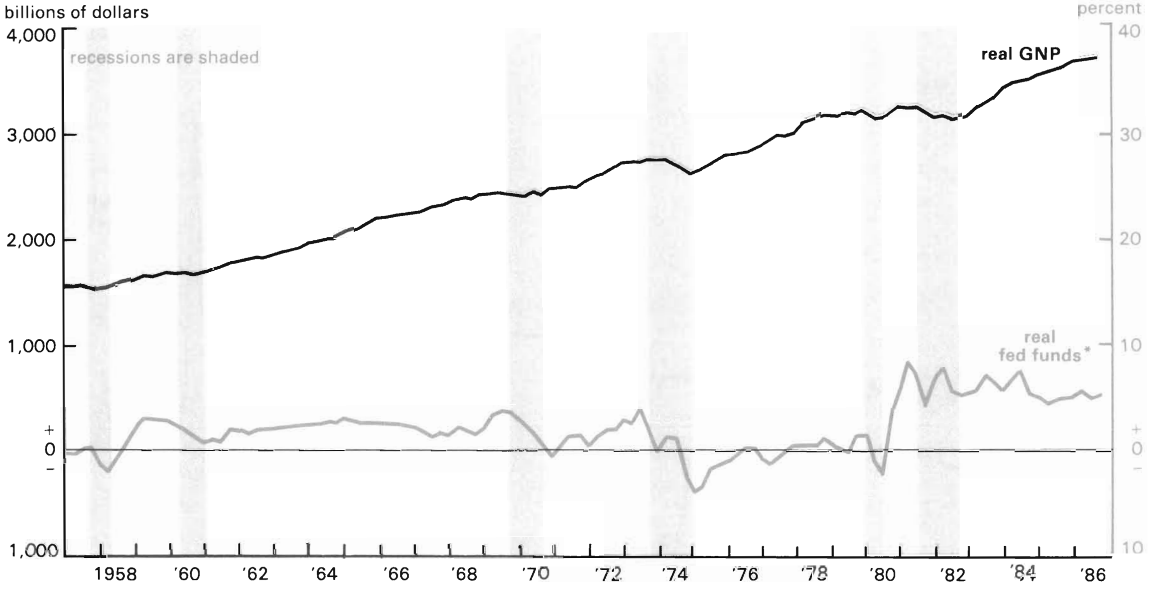
*Fed funds rate is quoted on a bond equivalent basis.

that might be valid across different economic environments. Economists often argue that decisions are based not on mere numbers, or nominal values, but rather on the real values involved. The true cost of credit is not the stated or nominal rate, but rather this rate deflated by the expected rise in prices. As an example, suppose significant inflation is widely expected to occur in the future. Borrowers know that credit allows them to purchase real assets whose prices will appreciate, and that they will repay the lender with depreciated dollars. Lenders are also aware of the situation. Thus lenders demand higher interest rates on loans, and borrowers are willing to pay them. Most importantly, a change in interest rates that results entirely from a change in expected inflation does not change the real cost of credit and is not likely to affect borrowing or economic activity.[2]

Figure 2 plots the level of real GNP and an estimate of the real federal funds rate. The measure of the real federal funds rate used here is approximately equal to the nominal level of the federal funds rate (on a bond equivalent basis) minus the percentage change in the GNP price deflator over the preceding four quarters.[3] This measure implicitly assumes that expectations of future price changes are equal to the behavior of prices over the preceding year. Again, the figure shows that the cyclical behavior of the real rate is as expected. Real rates rise before a peak and fall before a trough in economic activity. Once again, though, it is difficult to use the measure as an indicator of monetary policy across different economic environments because the interpretation of a given real interest rate depends upon the prevailing economic environment. For example, a *rise* to a real interest rate of -0.3 percent in 1979 was followed by a contraction, while a *fall* to a real interest rate of 5.0 percent in 1982 was followed by an expansion.

Indeed, there appear to be extended periods when the "normal" or average equilibrium real interest rate (at least as given by the measure used here) varies substantially. For example, the period from 1958 to 1973 appears to have been one in which the equilibrium or "normal" interest rate was positive but relatively low. This was followed by a period from 1973 to 1979 in which the "normal" real interest rate was very low and perhaps even negative. Finally, there is the period of the 1980s in which real interest rates appear to be at consistently high historical levels.

Figure 2
Real fed funds rate vs. real GNP



*Real fed funds rate is deflated by year-over-year CPI change.

Real M2

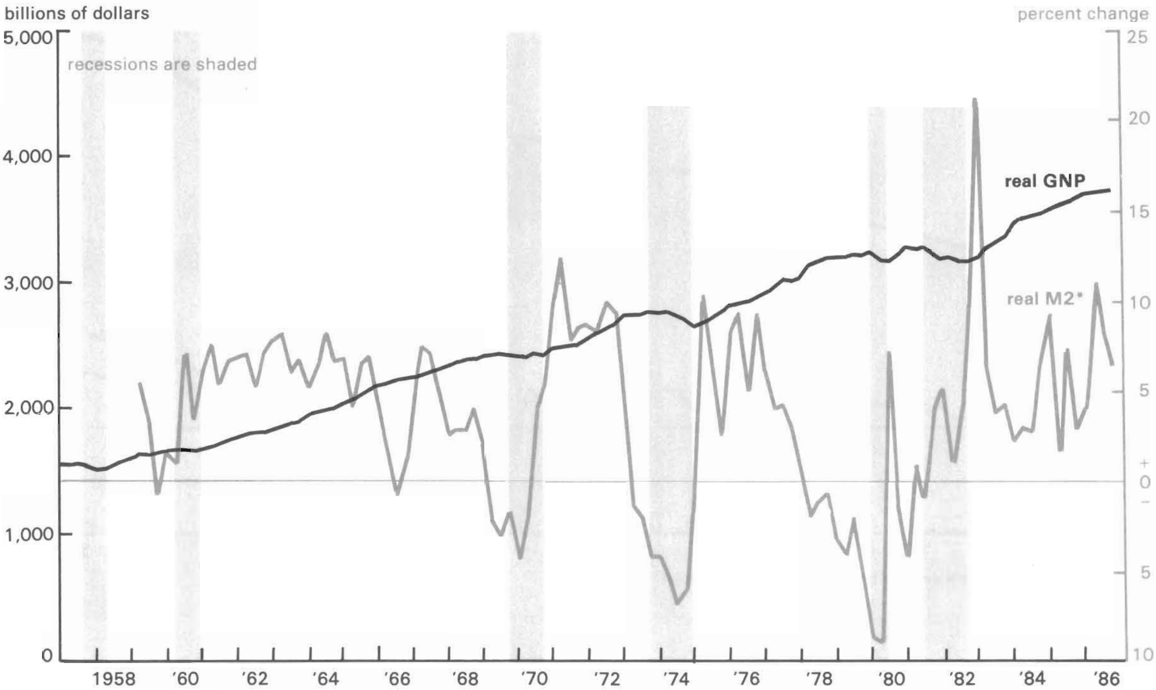
For purposes of comparison, Figure 3 plots the relationship between real economic activity and a measure of the money stock similar to that used in the index of leading economic indicators. The money measure is the percentage change in real M2. This figure is approximately equal to the quarterly percentage change in M2 at an annual rate minus the quarterly percentage change in the consumer price index at an annual rate.[4] This quarterly series roughly approximates the rate of change in the purchasing power of the stock of M2. Once again, the cyclical behavior of this measure roughly corresponds to what would be expected. When growth in the purchasing power of the M2 stock declines, subsequent real economic activity also declines. Conversely, when the purchasing power of M2 increases, real economic activity subsequently increases.

At the beginning of the 1980s when the interest rates on deposits were deregulated, there appears to have been a shift in the relationship between money and income. The effect of deregulation was to make some transaction-type deposits more attractive and cause the public to hold more transactions balances relative to income than it had previously. This increased preference for transactions balances is at least partially responsible for the fact that predictions based on the past history of the relationship between money and income have generally overpredicted the level of real income and inflation in the 1980s.[5] This deterioration in the relationship between money and future income has spurred the search for a more reliable indicator of monetary policy.

"The spread"

An ideal interest rate-based indicator of monetary policy would be immune to contamination by the environment. One possible candidate is suggested by a close examination of the process by which the Fed alters the level of money in the system. The Fed begins by changing the level of reserves in the banking system, which has the effect of moving the federal funds rate. Movements in this rate, which reflects the overnight cost of reserves, cause depository institutions to respond by comparing the new federal funds rate (and expected future federal funds rates) with alternative market re-

Figure 3
Real M2 vs. real GNP



*Annual percent change in M2 is deflated by CPI.

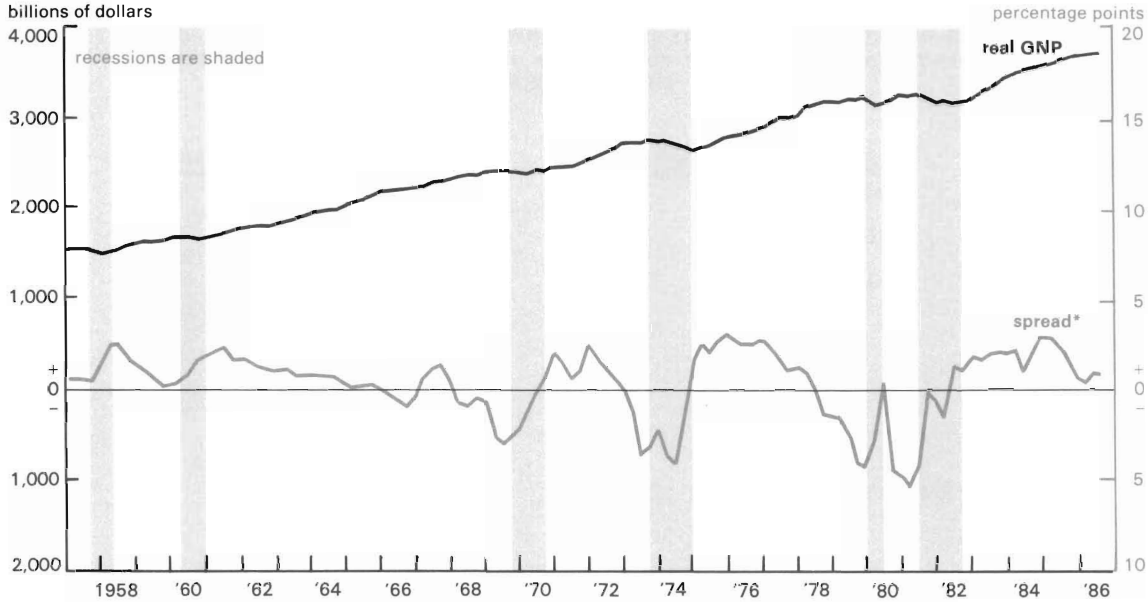
turns available on longer-term securities and loans. If the current federal funds rate drops relative to longer-term rates, depository institutions respond by purchasing securities and making loans, thereby expanding the level of the money stock and stimulating economic activity.[6] While the deregulation of interest rates has affected the relative demand for various components of the monetary aggregates and altered the implications of growth in various aggregates, there is no obvious reason why it should alter the mechanism by which the monetary authority influences the supply of deposits and money or the relationship between interest rates and economic activity. This suggests that the difference (or spread) between some longer-term rate and the federal funds rate, which the Fed directly affects in the conduct of monetary policy, might be a useful indicator of the thrust of monetary policy.

Such a measure has some useful properties. The greater is the rate spread, the more expansionary is monetary policy. Thus, other things being equal, an increase in the federal funds rate is contractionary and a decrease is expansionary. It also indicates that the way to capture the impact of a given federal funds rate across different economic environments is to compare it to longer-maturity interest rates.

The spread also shows, through the money supply mechanism, how a movement in the federal funds rate might not represent a change in monetary policy. Suppose that the monetary authority moved the federal funds rate (and expected future federal funds rates) but that this move was matched by a change in the equilibrium longer-term rate. There would then be no incentive for depository institutions to change their asset holdings or the level of deposits and money. This suggests that a spread between a longer-term rate and the federal funds rate might be superior to the level of an interest rate as an indicator of the thrust of monetary policy.

Another attraction of the spread relative to the level of rates is that it helps to solve a puzzle that occurs when rates move. A movement in the level of rates can be either

Figure 4
The spread vs. real GNP



*Spread between the 20-year Treasury constant maturity and the fed funds rate (bond equivalent basis).

expansionary or contractionary. For example, suppose rates rise because the public's net demand for credit increases. This means that there is either an increase in borrowing (e.g., business sees better investment opportunities) or a reduction in saving (e.g., savers decide to spend more because they are more optimistic about the future). In this case the rise in rates occurs in an expansionary environment. Alternatively, rates can rise because the monetary authority reduces the amount of credit it supplies to the market. This rise in rates occurs in a contractionary environment. Movements in money would be helpful in distinguishing these situations. If the demand for money is disturbed, the spread could help tell which of these situations is causing the rise in rates.

The particular measure of the spread used here is the difference between the longest-term government interest rate available and the federal funds rate. The longest-term interest rate was chosen so as to maximize the contrast between the short-term interest rates, which are strongly affected by monetary policy, and longer-term interest rates, which are most insulated from monetary policy. The longest-maturity government rate available over a sustained recent period was the 20-year constant maturity treasury bond rate. Figure 4 plots the spread between the 20-year bond rate and the federal funds rate (referred to simply as "the spread") and the level of real income. The spread exhibits the cyclical behavior that one would expect, narrowing and usually turning negative before peaks in economic activity. Conversely, the spread turns positive and widens before an upturn in economic activity. Figure 4 seems to indicate that the absolute deviations between the 20-year bond rate and the federal funds rate have been greater in recent years than in the more distant past.

Comparing the four indicators

The figures confirm that all four measures behave in a way that is broadly consistent with expectations based on theory. In order to facilitate comparison, the predictive performance of each measure is quantified by estimating, using ordinary least squares, the relationship between each alternative indicator and subsequent percentage changes in real income. There is wide agreement that the resulting changes in real GNP are temporary and occur with a lag that is commonly thought to average about six to nine months after the monetary

Table 1
Results of regression of percentage change in real GNP on eight lagged terms of each of the four alternative indicators of monetary policy. 1961 II - 1986 IV

	Level of the federal funds rate		Real federal funds rate	
	Coefficient	T value	Coefficient	T value
intercept	6.0964	7.781	3.9468	7.720
lag 1	.2636	.948	.1961	.568
lag 2	−1.5100	−3.459	−1.3926	−2.777
lag 3	.8624	1.911	.8216	1.619
lag 4	−.7358	−1.588	−.7760	−1.523
lag 5	.4451	.961	.6224	1.224
lag 6	−.1333	−.295	−.2203	−.436
lag 7	.3553	.814	.4479	.897
lag 8	.0800	.290	.0034	.010
	−.3727		−.2975	
	RMSE=3.3908	R sq adj = .3234	RMSE=3.8611	R sq adj = .1227

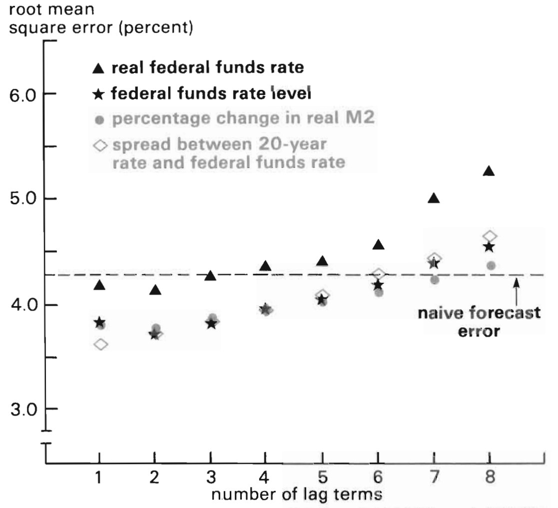
	Spread between the 20-year bond rate and the federal funds rate		Percentage change in real M2	
	Coefficient	T value	Coefficient	T value
intercept	2.9999	8.627	1.1865	2.305
lag 1	.1966	.575	.2529	2.639
lag 2	1.2305	2.619	.1719	1.505
lag 3	−.4356	−.932	.0015	.013
lag 4	.3923	.843	.0975	.854
lag 5	−.2554	−.549	.0175	.152
lag 6	.0787	.169	−.0227	−.200
lag 7	−.1106	−.235	−.0259	−.223
lag 8	.1007	.292	.1011	1.029
	1.1972		.5938	
	RMSE=3.5000	R sq adj = .2791	RMSE=3.5711	R sq adj = .2495

policy action. To capture this relationship, the quarterly percentage change in real GNP at an annual rate is estimated as a linear function of a constant and the eight previous quarters' data for each of the three interest rate measures and the money measure. The regressions cover the period 1961 II through 1986 IV.[7] The results are given in Table 1 which shows the estimated coefficients of the lagged values of the four alternative indicators. The table also gives a summary measure of the error in the forecast of the percentage change in real GNP for each of the measures. This error is measured by the root mean square error.

The results given in Table 1 confirm quantitatively the direction of the relationships observed in Figures 1 through 4. The negative sums of the values of the coefficients show that increases in the level of the federal funds rate and the real federal funds rate are associated with subsequent decelerations in real income growth. For example, a one percentage point increase in the federal funds rate is associated with a 0.37 percentage point decline in real income after eight quarters. The positive sums of coefficients for both the spread and the rate of growth in real M2 indicate that increases in each of these measures are related to subsequent increases in the rate of growth in real income.

The data in Table 1 indicate that when the four measures are each entered with eight quarterly lag terms, the best explanation (as measured by the root mean square error over the period of estimation) is provided by the level of the federal funds rate. The next best

Figure 5
Forecast errors using only previous data
1964 I through 1986 IV



NOTE: The original forecast uses data from Q2 1961 through Q4 1963.

explanations are provided by the spread between the 20-year bond rate and the federal funds rate, followed by the percentage change in real M2. The poorest explanatory power is offered by the measure of the real federal funds rates.

A major shortcoming of the results reported in Table 1 is that they are explanations, or ex post relationships. That is, they are obtained by looking for the values of the constant and the coefficients for the eight-lag variables that best explain the percentage changes in real GNP after all of the data have been observed. Relationships obtained in this way tend to look somewhat better than they actually are in the sense that the errors are smaller than would be obtained in an actual ex ante forecast.

What is desired is a relationship that would be useful in forecasting future real income. A more realistic measure of how well the alternatives could forecast future changes in real income is obtained by estimating a regression with all the data through the quarter prior to the quarter being forecast and using that regression to forecast the change in real income for the next quarter. After all, this is precisely how any indicator obtained in this study would be used.

This method of forecasting was tried for each alternative for the period 1964 I through 1986 IV. For each, stepwise regressions were used to estimate over the entire period, the best model with one lagged term, the best model with two lagged terms, etc., through eight lagged terms. Each of these eight models, for each of these four alternatives, was estimated using only data through the quarter prior to the quarter whose change in real GNP is being forecast.[8] The results are plotted in Figure 5, which gives the root mean square error for each model.

It can be seen that the best models for each measure involve only one or two lagged terms. Figure 5 also shows that the best model over the period 1964 I through 1986 IV was the one-lagged-term model based on the spread between the 20-year bond rate and the federal funds rate. In order, the next best models were those based on the level of the federal funds rate, the percentage change in real M2, and the level of the real federal funds rate. For purposes of comparison, the chart also plots the errors from a very naive model in which the forecast for next quarter's change in real GNP is equal to the average change in real GNP from 1961 I through the preceding quarter.

The results presented above are for the period 1964 I through 1986 IV. As noted earlier, it is widely believed that the monetary aggregates deteriorated as indicators of the thrust of monetary policy beginning about 1980. It would be interesting to see how the four alternatives compared over the period 1964 through 1979, which excludes the period in which the monetary aggregates are thought to have deteriorated. Table 2 shows the results of the regression estimates for each of the four indicators using all eight lags in each model as was done over the more extended time period in Table 1. Once again, the results indicate that the levels of the real and nominal federal funds rate are negatively related to future growth in real economic activity. Also again, the results indicate that the spread between the 20-year bond rate and the federal funds rate and percentage changes in real M2 are positively related to future changes in real income.

The best models using from one through eight lagged terms are then calculated for each of the four indicators over the period 1961 II through 1979 IV. Each of these is again estimated using only data that would have been available at the time and used to forecast real GNP for each quarter from 1964 I through

Table 2
Results of regression of percentage change in real GNP on eight lagged terms of each of the four alternative indicators of monetary policy. 1961 II - 1979 IV

	Level of the federal funds rate		Real federal funds rate	
	Coefficient	T value	Coefficient	T value
intercept	8.0058	6.679	4.3461	7.733
lag 1	−.1187	−.220	.0233	.042
lag 2	−1.6441	−1.654	−1.2020	−1.416
lag 3	2.0043	1.774	1.0895	1.278
lag 4	−2.3105	−1.961	−1.6680	−1.935
lag 5	1.9328	1.634	1.4049	1.617
lag 6	−1.0094	−.886	−.7944	−.926
lag 7	.4717	.469	.7964	.936
lag 8	−.0755	−.137	−.5647	−1.007
	−.7494		−.9150	

RMSE=3.3677 R sq adj = .2740

RMSE=3.8248 R sq adj = .0569

	Spread between the 20-year bond rate and the federal funds rate		Percentage change in real M2	
	Coefficient	T value	Coefficient	T value
intercept	2.9661	7.173	1.2299	1.745
lag 1	1.1379	1.780	.4438	2.829
lag 2	.5917	.526	−.1448	−.688
lag 3	−.6741	−.521	.4282	2.105
lag 4	1.1408	.827	−.3998	−1.996
lag 5	−1.4426	−1.041	.3198	1.607
lag 6	1.0057	.769	−.1062	−.557
lag 7	−.4193	−.368	−.0081	−.043
lag 8	.5939	.916	.0992	.669
	1.9340		.6321	

RMSE=3.3513 R sq adj = .2809

RMSE=3.3300 R sq adj = .2901

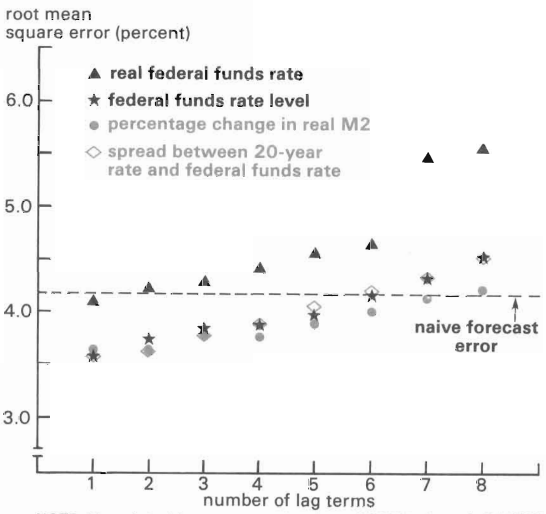
1979 IV. The root mean square errors for the models are plotted in Figure 6. The best predictive model for each of the four alternative indicators contains only one lagged term. The results indicate that a model using the spread does best at predicting future changes in real GNP. A model using this indicator does better than the best model using the level of the federal funds rate, followed in turn by the real M2 model and the real federal funds rate model.

Table 3 shows the forms of the best models for each of the four alternatives and the ex ante errors the models would have produced over each of the two periods. The performance of the spread model is particularly noteworthy because it does best over both periods—even the period ending in 1979 that excludes the time over which the money-income relationship apparently deteriorated. It is important to note that the choice of real M2 was not only based on its similarity to the monetary component of the index of leading indicators. Similar tests to those reported here were run among eight different aggregates and real M2 did better than any other aggregate in forecasting real income over both periods.[9] It follows, then, that the spread does better than any of these other aggregate measures.[10]

Limitations of the results

The results presented above have some interesting implications for the conduct of monetary policy, but before discussing these it is worth noting some limitations concerning the results. The relative performances are obtained using only data available at the time the fore-

Figure 6
Forecast errors using only previous data 1964 I through 1979 IV



NOTE: The original forecast uses data from Q21961 through Q41963.

cast had to be made. Thus, measures of the errors are more realistic than those obtained from an estimation run over all the data. However the results above are still somewhat too optimistic in that the forms of the best models are initially selected using all the data, even though the forecast estimation uses only data that could have been observed at the time of the forecast.[11]

In addition the results are obtained with very simple models. Percentage changes in real GNP are regressed in an ordinary least squares linear regression on from one to eight lagged terms of each of the alternative indicators of monetary policy. It is quite possible that a non-linear form of the relationship, or the addition of more variables, could change the relative rankings of the various indicators. For example, the results using the measure of the real federal funds rate are particularly disappointing. This model barely beats an extremely naive model in either time period. Yet, this is an indicator for which there is substantial theoretical support in economics.[12] Possible explanations for the poor results are that either the year-over-year price changes are not a good proxy for expectations of future price changes or that some other variable should be added to explain what appear to be sustained variations in the equilibrium real rate. The approach taken in this paper is more in the nature of a search for a single component for the index of leading indicators than an attempt to model completely the determination of future real income.

Finally, even the best results presented above give far from accurate forecasts of future real activity. A root mean square error of 3.6 percentage points for the annual growth rate of next quarter's real GNP is hardly the answer to a forecaster's prayer.[13] Nor would errors of this size encourage a policymaker to attempt to actively manipulate real income.

Policy applications

The spread between a long-term bond rate and the federal funds rate forecasts next quarter's real GNP better than the level of the federal funds rate, a measure of the real federal funds rate, or changes in real M2. This is true not only over the last twenty-five years, but also over the sixteen-year period 1964 – 1979 when increasing reliance was being placed on money as an indicator of monetary policy. The performance of the spread between the long-term bond rate and the federal funds rate raises two obvious questions. Can it be used for policy? And, why does it forecast future real economic activity?

The discussion to this point has not considered the ease with which the monetary authority can control the alternative indicators. Controlling the interest rates guides would seem to be easier for the monetary authority than controlling money. For one thing, money is much more difficult to observe, involving as it does readings taken at least a week apart. In addition, money is heavily influenced by seasonal factors that make it difficult to extract the trend in growth. Interest rates, on the other hand, can be observed continuously through market quotes.

Second, the Fed can influence interest rates much more easily than money. The monetary authority actually affects the aggregates through changes it produces in interest rates. The federal funds rate is particularly easy for the monetary authority to control, and the Fed has, in the past, often implemented policy through a target federal funds rate. The real federal funds rate, requiring only an adjustment to incorporate past price changes,

Table 3
The form and predictive performance of the best model of each of the four alternative guides over the two time periods

1964 I - 1986 IV

Naive model	
PCRGNP = GAC	RMSE = 4.2933 percent
Federal funds rate	
PCRGNP = const. + $c_2 * ffr_{-2} + c_7 * ffr_{-7}$	RMSE = 3.7374 percent
Real federal funds rate	
PCRGNP = const. + $c_2 * rffr_{-2} + c_7 * rffr_{-7}$	RMSE = 4.1510 percent
Interest rate spread	
PCRGNP = const. + $c_2 * r20mffr_{-2}$	RMSE = 3.6059 percent
Percent change in real M2	
PCRGNP = const. + $c_1 * pcrM2_{-1} + c_2 * pcrM2_{-2}$	RMSE = 3.7822 percent

1964 I - 1979 IV

Naive model	
PCRGNP = GAC	RMSE = 4.1748 percent
Federal funds rate	
PCRGNP = const. + $c_1 * ffr_{-1}$	RMSE = 3.5864 percent
Real federal funds rate	
PCRGNP = const. + $c_2 * rffr_{-2}$	RMSE = 4.0971 percent
Interest rate spread	
PCRGNP = const. + $c_1 * r20mffr_{-1}$	RMSE = 3.5668 percent
Percent change in real M2	
PCRGNP = const. + $c_1 * pcrM2_{-1}$	RMSE = 3.6416 percent

PCRGNP	=	Quarterly change in real GNP at an annual percentage rate.
GAC	=	Geometric average growth in real income from 1961 I through the previous quarter.
ffr	=	Federal funds rate (on a bond equivalent basis).
rffr	=	Real federal funds rate, one plus the federal funds rate divided by one plus the percentage change in year-over-year CPI, minus one.
r20mffr	=	Interest rate spread, the 20-year constant maturity treasury bond rate minus the federal funds rate.
pcrM2	=	One plus the percentage change in M2 in the quarter at an annual rate, divided by one plus the percentage change in the CPI over the quarter at an annual rate, minus one.
subscripts	=	The number of lagged quarters.

would be just as easy to control. Controlling the interest rate spread between a long-term bond rate and the federal funds rate would be just slightly more difficult. It would require only monitoring the bond rate while moving the federal funds rate. Since the bond rate will generally move in the same direction as the federal funds rate, but by a smaller amount, the monetary authority can affect the spread through movements in the federal funds rate. This is still much simpler, for the monetary authority, than controlling a money stock measure.

Finally, why does the spread forecast future changes in real income? The spread between the long-term bond rate and the federal funds rate is a rough measure of the steepness of the yield curve. A longer-term interest rate may be viewed as an average of expected shorter-term rates over the same time interval, for both borrowers and lenders of longer-term credit could borrow or lend for the same length of time by consecutively rolling over credit of a shorter maturity. The steeper is the term structure, the more the market expects short-term interest rates to rise in the future. Since interest rates tend to be positively associated with economic activity, the steeper the yield curve (and the larger the spread between the bond rate and the federal funds rate), the more likely it is that the market expects economic activity to rise in the future. Conversely, a small or even negative spread between the bond rate and the federal funds rate is indicative (other things being equal) of market expectations that the economy will weaken.[14] So one reason why the spread between the long-term bond rate and the federal funds rate is successful may be that it captures market expectations about the economy.

Conclusion

An apparent recent deterioration in the effectiveness of money as an indicator of the thrust of monetary policy has given increased emphasis to the search for a monetary policy indicator. This paper tests three different interest rate-based indicators and a measure of money as forecasters of future changes in real income. The results suggest that the spread between a long-term bond rate and the federal funds rate would have given better forecasts of future changes in real income than the other potential guides, even over the period when increasing emphasis was being placed on money as an indicator of monetary policy. Coupled with the relative ease of controlling the interest rate spread, these results suggest that the interest rate spread deserves consideration as an indicator of the thrust of monetary policy.

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[1] There is an extensive literature dealing with the nature of the policy problem faced by the monetary authority. Typically, these discussions distinguish at least three different entities—an instrument (or target) that the monetary authority can closely control, an indicator that the monetary authority affects through movements in the instrument, and the goals which experience shows are predicted by movements in the indicator. For a more complete description see Saving (1967). In this paper the analysis is basically simplified by assuming that the instrument and indicator are the same. This is equivalent to assuming that the indicator can be controlled like an instrument. The last section of the paper eases this assumption by discussing the actual degree of control over the different indicators considered in the paper.

[2] For an example of an analysis using real rates as an indicator of monetary policy see Hester (1982).

[3] The real rate is actually calculated by using the equation:

$$\text{Real federal funds rate} = \left\{ \frac{(1 + \text{Federal funds rate})}{\left(\frac{CPI}{CPI(-4)}\right)} \right\} - 1$$

where Federal funds rate is on a bond equivalent basis
CPI is the consumer price index
and (−4) indicates the value from four quarters ago.

[4] The actual estimate used is:

$$\text{Percentage change in real M2} = \left\{ \frac{M2}{CPI} \cdot \frac{CPI(-1)}{M2(-1)} \right\}^4 - 1$$

where CPI is the consumer price index
M2 is the level of M2
and (− 1) indicates the value from the previous quarter.

[5] For a discussion of the deterioration of money as an indicator, see Kopcke (1986), Roth (1987), and Siegel (1986). For a somewhat different view of the relationship, see Christiano (1986).

[6] For a more extensive description of this process see Laurent (1982).

[7] The beginning date is chosen because it is the earliest date on which regressions may be run for all the indicators, given data availability. The ending date is chosen because it is the last date on which the 20-year constant maturity rate is available.

[8] For example, the best one-lagged-term model for the level of the federal funds rate uses the two-quarter lagged term. The best two-term model for the level of the federal funds rate uses the two- and seven-quarter lagged terms. Figure 5 shows that when the one-term model is estimated through each quarter and used to forecast next quarter's real GNP, it produces a root mean square error of 3.82 percent over the period 1964 I through 1986 IV. Figure 5 also shows that the comparable figure for the two-lagged-term model over the same period is 3.74 percent.

[9] The eight different aggregates tested were the real values of (M1-Currency), M1, (M1-Other Checkable Deposits), (M2-Currency), M2, (M2-Other Checkable Deposits), (M3-Currency), and M3. The one exception when another aggregate did better than M2 in forecasting real income

was over the period 1964 I – 1979 IV where M2 minus currency did slightly better than M2 alone.

[10] As noted earlier, the series on the 20-year constant maturity government bond ends at the end of 1986. Since 1977 the longest maturity government bond has been the 30-year bond. Comparing the predictive performance of the spread using alternatively the 20- and 30-year bond over the period that both are available indicates that they are very similar, with the 30-year bond giving slightly superior predictive performance.

[11] Ultimately, the most legitimate test of the predictive power of the models will be performed with data available only after publication of this paper.

[12] For a succinct description of an analysis using movements in the market real rates, see the article by Larry R. Mote in this issue of *Economic Perspectives*.

[13] On the other hand, the results are not inferior to those of other models. For an exposition of other model forecasts see McNees (1986).

[14] It has, in recent times, been assumed that the "normal" term structure of interest rates slopes upward. For some evidence that this assumption may be unwarranted and some of the factors which determine a "normal" slope, see Wood (1983).

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