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FEDERAL RESERVE PRIVATE
INFORMATION AND THE BEHAVIOR
OF INTEREST RATES

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ABSTRACT

Many authors argue that asymmetric information between the Federal Reserve and the public

is important to the conduct and the effects of monetary policy. This paper tests for the existence of

such asymmetric information by examining Federal Reserve and commercial inflation forecasts. We

demonstrate that the Federal Reserve has considerable information about inflation beyond what is

known to commercial forecasters. We also provide evidence that monetary policy actions provide

signals of the Federal Reserve's private information and that commercial forecasters modify their

forecasts in response to those signals. These findings may explain why long-term interest rates

typically rise in response to shifts to tighter monetary policy.

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FEDERAL RESERVE PRIVATE INFORMATION AND
THE BEHAVIOR OF INTEREST RATES

I. INTRODUCTION

Asymmetric information between the Federal Reserve and the public is a phenomenon that is often posited, but rarely tested. Numerous models of central bank behavior, for example, show that the existence of asymmetric information has important implications for the effectiveness of policy and the consequences of dynamic inconsistency (see, for example, Sargent and Wallace, 1975; Barro, 1976; Barro and Gordon, 1983; Canzoneri, 1985; and Cukierman and Meltzer, 1986). Yet there are few studies that test whether the Federal Reserve does indeed possess information about the state of the economy that is not available to the public.

Asymmetric information between the Federal Reserve and the public is also often mentioned as a possible explanation for a puzzling empirical phenomenon: the response of long-term interest rates to monetary policy actions. Standard theories of the effects of monetary policy imply that a shift to tighter policy raises short-term interest rates temporarily by raising real rates, but lowers them in the long run by reducing inflation. When these theories are coupled with the expectations theory of the term structure, they predict that a shift to tighter policy lowers interest rates on bonds of sufficiently long maturities. In fact, however, when the Federal Reserve undertakes contractionary open-market operations, interest rates for securities of all maturities typically rise (Cook and Hahn, 1989a). A common explanation of this behavior is that when the Federal Reserve tightens, market participants infer that it has unfavorable private information about the likely behavior of inflation, and they therefore revise their expectations of inflation upward. It is this upward revision in inflation expectations caused by the revelation of Federal Reserve private information that causes long-term interest

rates to rise.

In this paper we use Federal Reserve and commercial forecasts to test whether the central bank actually does possess private information about the current and future state of the economy. The key idea is that information the Federal Reserve has about the economy that is not known to market participants is likely to be reflected in the Federal Reserve's internal forecasts. Because the Federal Reserve makes its forecasts public only after five years, the forecasts can contain information that is not known contemporaneously to market participants. In this analysis of private information we look primarily at the Federal Reserve's knowledge about inflation, because we then use the results to test the asymmetric information explanation of the response of interest rates to monetary actions. However, to check the robustness of our results, we also look for private information about the path of real GDP.

This analysis of asymmetric information and its implications for the behavior of interest rates proceeds in several steps. Section II describes the forecast data that we use. Section III then investigates whether the Federal Reserve has private information about inflation. Specifically, we ask whether, given commercial forecasts of inflation, the Federal Reserve forecasts are useful in predicting inflation. To do this, we regress commercial forecasters' ex post forecast errors on the difference between the Federal Reserve forecasts and the commercial forecasts.

We find that the difference between the two inflation forecasts is an overwhelmingly significant predictor of the commercial forecast errors. The t-statistic on the difference between the Federal Reserve and commercial forecasts is consistently over two, and in many specifications it is over four. In addition, in most specifications the estimated coefficient on the difference between the two forecasts is approximately equal to one, implying that the optimal forecasting strategy of someone with access to both forecasts would be to put essentially no weight on the commercial forecast. These findings are

robust across forecasting horizons, commercial forecasters, and sample periods. We also find that the Federal Reserve possesses equally important private information about the path of future output. Thus our results provide powerful evidence that the Federal Reserve has important information about the path of the economy beyond that available to market participants.

Sections IV and V turn to the link between Federal Reserve private information and the behavior of interest rates. For the asymmetric information hypothesis to explain why long-term rates rise following a monetary contraction, it is not enough to merely show that the Federal Reserve possesses useful information about future inflation. It is also necessary to show that monetary actions provide signals of this information, and that market participants respond to these signals.

To address the signalling issue, we ask whether it is rational for market participants to infer that the Federal Reserve's inflation forecast is above their own when they observe a contractionary policy action. To do this, in Section IV we regress the difference between the Federal Reserve and commercial forecasts on indicators of Federal Reserve actions. The results of these tests, although not as strong as the results concerning the existence of Federal Reserve private information, support the hypothesis that the Federal Reserve's actions signal its private information. The estimated coefficients on the measures of shifts to tighter monetary policy are almost always positive; typically, however, they are only marginally significant. The point estimates suggest that when the Federal Reserve raises its funds rate target by one percentage point, its inflation forecast for the coming year is on average about a quarter of a percentage point above commercial forecasts.

In Section V, we examine whether market participants actually revise their forecasts in response to Federal Reserve actions. Specifically, we regress the revision in commercial forecasters' predictions of inflation from one forecast date to the next on measures of the change in the funds rate

target, controlling for the arrival of other information about inflation between the two forecast dates. The results of these regressions are broadly similar to the those concerning the information content of the Federal Reserve's actions. The estimates suggest that commercial forecasters raise their expectations of inflation in response to contractionary Federal Reserve actions, but that they do so by slightly less than one would expect given the earlier results. A rise of one percentage point in the funds rate target is associated with an increase in commercial inflation forecasts of between one-tenth and two-tenths of a percentage point.

Section VI concludes by discussing the implications of our results for the response of interest rates to monetary policy actions. We show that our results imply that the information-revelation effect of changes in monetary policy may be more than enough to account for their puzzling impact on long-term rates, and that it also accounts for a substantial fraction of their impact on short-term rates. We also discuss the more general implications of our findings of asymmetric information for a variety of theoretical and empirical studies of monetary policy.

II. DATA

To test whether the Federal Reserve has private information about the state of the economy and to analyze the possible implications of such information for the term structure, we use data on inflation forecasts from both the Federal Reserve and commercial forecasters. The particular indicator of inflation for which we analyze forecasts is the GDP deflator.[1]

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[1] The obvious alternative measure of inflation that could be analyzed is the Consumer Price Index (CPI). We choose to use the GDP deflator for two reasons. First, forecasts for the GDP deflator are available for a much longer sample period: both the Federal Reserve and the Survey of Professional

We focus on commercial forecasts for several reasons. Most obviously, as Keane and Runkle (1990) observe, commercial forecasters have a strong financial incentive to be accurate; thus their forecasts are likely to be more reliable and less subject to random noise than conventional surveys of expectations. Furthermore, many market participants, especially pension fund managers and other large investors, have access to commercial forecasts of inflation. As a result, commercial forecasts are probably particularly relevant for the determination of long-term interest rates.[2]

While our focus on asymmetric information as an explanation for the behavior of interest rates leads us to look primarily at forecasts for inflation, we also consider forecasts for real GDP in a robustness check on the inflation results. This section therefore describes the sources of the Federal Reserve forecasts and the commercial forecasts for both the GDP deflator and real

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Forecasts begin their forecasts of the CPI more than ten years after they begin their forecasts of the GDP deflator. Second, interest rates were included in the CPI until 1983. This greatly complicates the analysis of the link between inflation forecasts and monetary policy.

[2] As Scharfstein and Stein (1990), Lamont (1995), Ehrbeck and Waldmann (1996), and others point out, there may be agency problems between commercial forecasters and their clients that cause forecasters not to report their true expectations of inflation. This is unlikely to be a problem for our investigation, however. To begin with, simple models of agency problems imply that forecasters are concerned about the accuracy of their forecasts and about their forecasts relative to others'. As a result, the models imply that forecasters' predictions are centered around their true expectations, and thus that median forecasts, which are mainly what we consider, reflect forecasters' true expectations (Lamont, 1995). More importantly, the hypothesis that the Federal Reserve's apparent additional information is in fact known to market participants requires that the market participants pay for forecasts that they know to be biased, despite the fact that they possess enough information to produce forecasts incorporating all of the information contained in the forecasts of a large organization (the Federal Reserve) that devotes vast resources to forecasting. Finally, Ehrbeck and Waldmann (1996) find that agency models' predictions are rejected in the data.

GDP.[3] It also discusses issues of consistency and timing related to these data.

Federal Reserve. The Federal Reserve forecasts of inflation and real GDP growth are contained in the "Green Book" that is prepared by the staff of the Board of Governors before each meeting of the Federal Open Market Committee (FOMC). These forecasts are available for the period 1965:11-1991:12.[4] The Green Book typically forecasts inflation and real GDP growth for five or six quarters into the future, though the horizon of the forecast varies over time and with the date of the FOMC meeting.

Because the Federal Reserve forecasts are tied to FOMC meetings, there are no forecasts in months when the FOMC does not meet. In the late 1960s and 1970s, there are forecasts almost every month; in the 1980s, there are typically eight forecasts per year. The time of the month when the Federal Reserve forecast is made also varies because the date of the FOMC meeting varies. FOMC meetings more often occur during the first half of the month, but the pattern is not regular.[5]

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[3] Because the Department of Commerce only switched from GNP to GDP accounting in 1991, for most of our sample period the forecast data are for the GNP deflator and real GNP. However, since our analysis focuses solely on the percentage change in these variables, this change in definition is of essentially no importance. Therefore, for convenience we refer to the spliced GNP/GDP forecast series simply as GDP.

[4] The end date is determined by the Federal Reserve's policy of releasing information with a five-year lag. Dean Croushore of the Federal Reserve Bank of Philadelphia provided a machine-readable version of the Green Book forecasts for the GDP deflator. We updated and revised his series using a hard copy provided by the Board of Governors. The real GDP forecasts were obtained from the same documents provided by the Board of Governors.

[5] Occasionally there are two or more Federal Reserve forecasts in a single month. This is especially common in the late 1960s and 1970s. In our analysis we use either the first or last forecast in a given month, depending on whether the particular application calls for a forecast that is early or late in the

Blue Chip. One set of commercial forecasts that we use is from the Blue Chip Economic Indicators (BC).[6] Around the fifth of each month, Blue Chip surveys economic forecasters at approximately 50 banks, corporations, and consulting firms. It then produces a consensus forecast (which is the median of the individual forecasts) for the percentage change in the GDP deflator and real GDP over each of the next six or seven quarters. The Blue Chip forecasts for both inflation and real GDP growth are available starting in 1980:1.

Data Resources, Inc. A second set of commercial forecasts that we consider is that prepared by Data Resources, Inc. (DRI).[7] DRI produces three forecasts each quarter; one early, one late, and one in the middle of the quarter. For comparability with monthly forecasts from other sources, we assign the early forecast to the first month in the quarter, the middle forecast to the second month, and the late forecast to the third month. The early and late forecasts are available starting in the third quarter of 1970; the middle forecast is not available until the first quarter of 1980. Each forecast is made relatively late in the month. The forecast horizon is typically seven quarters.[8]

Survey of Professional Forecasters. The final source for

month.

[6] The historical Blue Chip Economic Indicators were purchased from Capitol Publications, Inc.

[7] The DRI forecasts for both the GDP deflator and real GDP were collated and provided by Stephen K. McNees of the Federal Reserve Bank of Boston. They are used with permission from DRI.

[8] The DRI forecasts are for the level of the GDP deflator and real GDP. Forecasts for the inflation rate and the real growth rate are calculated using the change in the logarithm of the forecasts between a given horizon and a horizon one quarter before (times 400).

commercial forecasts of inflation and real growth that we consider is the Survey of Professional Forecasters (SPF), currently conducted by the Federal Reserve Bank of Philadelphia. This survey continues the American Statistical Association/National Bureau of Economic Research Economic Outlook Survey. The combined survey, which is conducted quarterly, is available beginning in 1968:4 for the GDP deflator and 1981:3 for real GDP.[9]

Like the Blue Chip Economic Indicators, the Survey of Professional Forecasters is based on many commercial forecasts. We again use the median of the individual forecasts.[10] The horizon of the forecasts is four quarters. The SPF is conducted near the end of the second month of each quarter. For comparison with our other forecasts, which are monthly, we treat the Survey of Professional Forecasters as a monthly series available only in February, May, August, and November.

III. DOES THE FEDERAL RESERVE HAVE PRIVATE INFORMATION?

To ascertain whether the Federal Reserve possesses private information, this section compares commercial forecasts of inflation with those of the Federal Reserve. The method of comparison that we use reflects the question we are asking. We are not interested in who is a better forecaster overall, but rather in whether commercial forecasters could improve their forecasting performance by knowing the Federal Reserve forecast. Therefore,

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[9] We use a version of the forecasts compiled by Dean Croushore of the Federal Reserve Bank of Philadelphia.

[10] Like DRI, the SPF forecasts the level of the GDP deflator and real GDP. Forecasts for the inflation rate and the real growth rate are again calculated using the change in the logarithm of the forecasts between a given horizon and a horizon one quarter before times 400.

we do not want to compare the overall accuracy of the commercial and Federal Reserve forecasts. Instead, we want to see if the difference between the Federal Reserve forecast and a given commercial forecast explains some of the commercial forecaster's forecast errors. If it does, then we can conclude that the Federal Reserve possesses information that commercial forecasters would want to have.

A. Specifications

The basic equation that we estimate is:

$$(1) \qquad\qquad E_{it} = \alpha_i + \beta_i C_{it} + \varepsilon_{it} ,$$

where E_{it} is the commercial forecast error at horizon i, and C_{it} is the contemporaneous difference between the Federal Reserve forecast and the commercial forecast at the same horizon. For example, E_{2t} is the difference in month t between actual inflation two quarters ahead of month t and the commercial forecast of inflation two quarters ahead; C_{2t} is the difference between the Federal Reserve forecast of inflation two quarters ahead in month t and the commercial forecast two quarters ahead, also in month t. A positive value of β would indicate that the difference between the Federal Reserve forecast and the commercial forecast helps to explain the commercial forecast errors, and thus that the Federal Reserve has information that would be helpful to commercial forecasters.[11]

As expressed in equation (1), we consider the forecast error for each forecast horizon separately. An alternative that we also consider is to average

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[11] This specification is similar in spirit to that used by Nelson (1972) to test whether the forecasts of the FRB-MIT-PENN model of the U.S. economy contain information not available in a simple ARIMA forecast.

the forecast errors for various horizons and regress them on the average difference between the Federal Reserve forecast and the commercial forecast for the same span of horizons. That is, we estimate

$$(2) \qquad AE_{it} = \alpha_i + \beta_i AC_{it} + \varepsilon_{it} \, ,$$

where AE_{it} is the average forecast error for some commercial forecast up to horizon i, and AC_{it} is the average difference between the Federal Reserve forecast and the commercial forecast up to horizon i.[12] The regressions using averages provide a useful summary of the overall relationship between commercial forecasts and the Federal Reserve forecast. They also provide a check that the relationship is systematic rather than the result of quarter-to-quarter noise.

A final specification issue involves computing standard errors. As the horizons for the various commercial forecasts become longer, the serial correlation of the forecast errors increases. This is true because the forces that drive inflation are themselves serially correlated. Hence a change in one of these forces in the future will cause repeated errors in the forecasts at longer horizons. Because nothing in the dependent variable can deal with this serial correlation, the error terms in these regressions tend to be serially correlated, and the serial correlation tends to be greater the longer the forecasting horizon considered. To deal with this potential problem, we calculate robust standard errors for all of our regressions. Specifically, when we consider forecasts for inflation i quarters ahead, the standard errors are computed correcting for heteroscedasticity and for serial correlation over $i+1$ quarters.

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[12] For example, AE_{3t} is the average of E_{0t}, E_{1t}, E_{2t}, and E_{3t} ; AC_{3t} is the average of C_{0t}, C_{1t}, C_{2t}, and C_{3t} .

B. Results

The estimates of β, the coefficient on the difference between the Federal Reserve and commercial inflation forecasts, for our main specification (equation (1)) are given in Table 1.[13] The results indicate overwhelmingly that the Federal Reserve possesses valuable information about future inflation: the difference between the Federal Reserve forecast and the commercial forecast is an excellent predictor of commercial forecast errors. This is true for all the commercial forecasts that we consider and for virtually all forecast horizons. For all three commercial forecasts, the estimates of β are large and positive. For horizons further ahead than the current quarter, the coefficient estimates are typically between 1 and 1.5. These estimates are almost always significant at the 99% confidence level. For the forecasts for the current quarter, the estimates are smaller, but are still significant for two of the three commercial forecasts.

Taken together, the results indicate that knowing the Federal Reserve forecast would improve the accuracy of the three commercial forecasts we consider, even at fairly short horizons. Indeed, the fact that the coefficient estimates are usually close to one indicates that when the Federal Reserve and commercial forecasts differ, actual inflation on average differs from the commercial forecast by roughly the full amount of the gap between the forecasts. Thus the optimal forecasting strategy of someone who knew both forecasts would be to discard the commercial forecast and use only the Federal Reserve forecast. In sum, the Federal Reserve appears to have a substantial informational advantage.

Table 2 shows the estimated coefficients for equation (2), in which the

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[13] For convenience, the estimates of the constant term, α, are not reported in Table 1. These estimates are split fairly evenly between positive and negative values and are rarely significantly different from zero.

forecast errors and forecast differences are averaged across horizons rather than considered individually. There is remarkably little difference between these results and those in Table 1. It does not appear that quarter-to-quarter noise is driving the basic results. Rather, the difference between the Federal Reserve forecast and the commercial forecast explains commercial forecast errors at almost every horizon for which forecasts are available.

This informational advantage is almost surely due to something other than the Federal Reserve gaining access to data earlier than commercial forecasters. First, the Federal Reserve receives data on economic variables such as unemployment and inflation at most a few days before they are released to the public. Since the Federal Reserve's forecast is typically made well before those of the Survey of Professional Forecasters and DRI, a few days lead time on economic statistics could not give it a net advantage. Furthermore, the Federal Reserve's informational advantage persists for forecast horizons many quarters ahead. One would expect a data advantage to be of most use at very short horizons.

The Federal Reserve's informational advantage is also probably not due to inside information about monetary policy. Monetary policy appears to have little impact on output and inflation for at least three to four quarters (see, for example, Gordon, 1993, and Romer and Romer, 1994). Yet, the Federal Reserve forecast is a very useful predictor of private forecast errors one or two quarters ahead. The fact that the Federal Reserve continues to have an advantage at fairly distant horizons could indicate that staff members have inside information about the FOMC's commitment to a given policy. However, some evidence presented in the next section contradicts this interpretation.

The most likely explanation for the Federal Reserve's informational advantage is that the Federal Reserve staff is simply better at processing and interpreting information. This is certainly consistent with the fact that the

Federal Reserve commits far more resources to forecasting than even the largest commercial forecasters.

C. Robustness

Outliers. To better understand the regression results in Table 1, it is useful to consider a plot of the individual commercial forecast errors and the difference between the Federal Reserve forecast and the commercial forecast for a typical regression. Figure 1 shows a scatter plot of the two series using the four-quarter-ahead forecast from DRI. Figure 2 shows a time-series plot of the same series.

The scatter plot in Figure 1 makes it clear that the explanatory power of the forecast differences for the commercial forecast errors is not the result of outliers; there is a consistent positive relationship between the two series. The only observations that seem disproportionately important for establishing the estimated relationship are those in the lower left-hand quadrant. It appears that the Federal Reserve forecast is particularly below the commercial forecast when actual inflation is below the commercial forecast.

The time-series graph in Figure 2 shows that these pairs of negative values mainly occur in the early 1980s, the time of the Volcker disinflation. The Federal Reserve correctly predicted that inflation would fall sharply, while commercial forecasters did not. To make sure that these observations are not driving the results, we rerun the regressions in Table 1 with the period 1979:10-1984:12 excluded. While the t-statistics fall somewhat, the coefficient estimates remain around one and are still significant at the 99% level.

Timing Disadvantage. In addition to checking for the presence and contribution of outliers, we also test the robustness of the results to a different specification of the relative timing of the Federal Reserve forecast and the commercial forecasts. In the basic specification, we use the contemporaneous

difference between the two forecasts. Since both the DRI and the Survey of Professional Forecasters forecasts are done near the end of the month, while the Federal Reserve forecasts are done throughout the month, the contemporaneous difference in these cases puts the Federal Reserve at a disadvantage. This is not true for the Blue Chip survey. Because the Blue Chip forecast is done at the beginning of the month, the contemporaneous difference gives the Federal Reserve a potential informational advantage simply because it has more data available.

To correct for this, we do the experiment of putting the Federal Reserve at a deliberate disadvantage in terms of timing. We regress:

$$(3) \qquad\qquad E_{it} = \alpha_i + \beta_i B_{it} + \varepsilon_{it} \,,$$

where E_{it} is again the contemporaneous commercial forecast error at horizon i, and B_{it} is the difference between the Federal Reserve forecast in month t-1 and the commercial forecast for horizon i in month t.

Table 3 shows the estimated coefficients when the forecast differences are calculated so as to put the Federal Reserve at this timing disadvantage. Even when the Federal Reserve is put at such a deliberate disadvantage, the difference between the Federal Reserve forecast and the commercial forecast is a useful predictor of commercial forecast errors. Neither the sizes of the coefficients nor the t-statistics are substantially reduced by this change. Thus, it seems clear that the Federal Reserve does have information about inflation that commercial forecasters would want to have.

Multiple Forecasts. In a third test of the robustness of the results, we examine whether the Federal Reserve's inflation forecast contains useful information beyond that contained in two or more commercial forecasts. It is possible that access to multiple commercial forecasts could eliminate the

apparent informational value of the Federal Reserve's forecast. At the same time, since many market participants presumably do not have access to multiple commercial forecasts, this test is likely to understate the importance of the Federal Reserve's private information.

To consider the value of multiple forecasts, we do the following. Both the Blue Chip and DRI forecasts are available monthly starting in 1980, and there are never multiple forecasts in the same month before 1980. We therefore consider two combinations of commercial forecasts: Blue Chip and DRI, and Blue Chip, DRI, and SPF. We regress DRI's forecast error on the gap between the Federal Reserve's forecast and the DRI forecast, controlling for the difference between the Blue Chip and DRI forecasts and (when we include the SPF forecast) the difference between the SPF and DRI forecasts.[14]

The results of this exercise are only slightly weaker than those based only on a single commercial forecast. For the current quarter, the Federal Reserve's forecast is of essentially no value in explaining commercial forecast errors. For the one-quarter horizon, the estimated weight on the Federal Reserve's forecast is about 0.7, and for all longer horizons it is close to one. The t-statistic on the Federal Reserve forecast variable is over two for all forecast horizons other than the current quarter, and it is usually over three.

Real GDP. The final, and perhaps most important, robustness check that we do is to see if the Federal Reserve's informational advantage for inflation extends to real GDP. Since inflation and real output are simultaneously determined, it would be puzzling if the Federal Reserve had useful information about one variable and not the other. Such a finding might

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[14] The choice of which commercial forecast error to put on the left-hand side has no impact on the coefficient estimate or standard error on the Federal Reserve forecast variable.

suggest that the results for inflation were somehow spurious.

To see if the Federal Reserve possesses additional information about the path of real output, we run equations (1) and (2) using the forecast errors and forecast differences for the various commercial and Federal Reserve forecasts of real GDP. The results for both the individual and average forecast errors are given in Table 4. The table shows that the Federal Reserve certainly possesses information about the course of real output that private forecasters would like to have. The difference between the Federal Reserve forecast and the various commercial forecasts is almost always a significant predictor of the commercial forecast errors.[15]

There are, however, two differences between the results for inflation and the results for real GDP. First, the coefficient estimates are more varied for real GDP. For inflation, the typical coefficient on the difference between the Federal Reserve forecast and the commercial forecast is around one, which implies that the commercial forecasters would typically do better if they could discard their own forecasts and simply use the Federal Reserve's. For real GDP, some coefficients are well below one, suggesting that the commercial forecasters should put some weight on their own forecasts, and some coefficients are well above one, suggesting that the commercial forecasters

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[15] In a related exercise, we also look at the Federal Reserve and commercial forecasts of the rate of change of the CPI. Despite the fact that the sample sizes in these regressions are substantially smaller that those for the GDP deflator because of data limitations, the results are very similar: the Federal Reserve appears to have significant private information about this alternative measure of inflation. This informational advantage is particularly striking at longer horizons. For example, the coefficient on the difference between the Federal Reserve forecast and the commercial forecast in equation (1) is larger than one with a robust t-statistic over two for every forecast four or more quarters out for each of the commercial forecasters. For more contemporaneous forecasts, the coefficients are almost always positive, but only about a third of them are statistically significant.

should not just adopt the Federal Reserve's forecast but should move even farther away from their own forecast.

The other substantial difference is that the Federal Reserve's private information at short horizons is more pronounced for real GDP than for inflation. Even for the contemporaneous quarter the Federal Reserve appears to have a large forecasting advantage over the commercial forecasters. One possible explanation for this advantage is that the Federal Reserve collects and processes the index of industrial production. Therefore, at very short horizons it may actually have more data about real output, rather than just be better at processing widely available information.

IV. DO FEDERAL RESERVE ACTIONS REVEAL PRIVATE INFORMATION?

This section investigates the question of whether the Federal Reserve's actions reveal any of its private information about inflation. The Federal Reserve's private information cannot matter for the effects of monetary policy unless policy actions reveal some of that information. In the specific context of policy's impact on long-term interest rates, even if market participants know that the Federal Reserve possesses private information, it is rational for them to raise their expectations of inflation in response to tighter policy only if a tightening signals that the Federal Reserve's inflation forecasts are above their own.

To investigate this issue, we consider the problem of market participants attempting to infer the information that the Federal Reserve possesses that they do not. We therefore regress measures of the difference between Federal Reserve and commercial forecasts on measures of Federal Reserve actions. As with our examination of the existence of Federal Reserve private information, we focus mainly on information about inflation. At the

end of the next section, however, we briefly examine information about real output as a check on our main results and as a way of learning more about the nature of the Federal Reserve's private information.

Investigating the relationship between the Federal Reserve's actions and its private information is important for another reason. As described in the previous section, one possible reason that the Federal Reserve could have private information is that it has superior information about future monetary policy. As discussed there, the fact that the Federal Reserve has useful information about inflation just one or two quarters ahead already casts strong doubt on this hypothesis. But an additional piece of evidence can be obtained by examining the direction of the relationship between the Federal Reserve's information and its policy actions. If the Federal Reserve has private information about future inflation simply because it knows more about its likely policy actions, then times when the Federal Reserve forecasts of inflation are above commercial forecasts should on average be followed by moves to looser policy. In contrast, if the Federal Reserve has private information about the economy not stemming from its knowledge about future policy, such times should on average be followed by moves to tighter policy. This is true because the difference between the forecasts indicates that the Federal Reserve has received news that inflation will be higher than expected, and it will therefore tighten in order to counteract this development.

A. Indicators of Federal Reserve Actions

In this analysis we use two indicators of Federal Reserve actions. This first is a simple dummy variable derived from the Wall Street Journal. Cook and Hahn (1989a and 1989b) catalog the dates from September 1974 to September 1979 when the Journal reports that the Federal Reserve deliberately moved the federal funds rate. From this catalog, we construct a dummy variable that is -1 in the months when the Federal Reserve loosened, +1 in

months when the Federal Reserve tightened, and 0 in all other months.

We extend the sample period by replicating Cook and Hahn's procedures for the months between March 1984 and December 1991. In particular, we checked the front page of each issue of the Wall Street Journal for some mention of Federal Reserve action or interest rate change. Very rarely there was more than one funds rate change in a month. However, only in October 1987 was there both a tightening and a loosening in the same month. Therefore, in all but this one month, assigning the dummy variable was straightforward. We dealt with October 1987 by excluding it from the sample.

This simple dummy variable for whether the Federal Reserve acted in a given month may be a particularly useful indicator of monetary actions. It is possible that action of any sort is what reveals information. Thus, having an indicator that does not distinguish between large and small changes could be desirable. Furthermore, because the dates of actions are derived from the press, we are certain that this is information that commercial forecasters and other agents in the economy actually possessed.

An alternative indicator of monetary policy actions that we consider is the change in the Federal Reserve's actual federal funds rate target. These data are available for 1974:8-1979:9 and 1984:2-1992:8.[16] We use the funds rate target in effect at the end of the month as the monthly observation. The change in the target, therefore, reflects the change from the end of the previous month to the end of the current month.

The target series could be useful because it calibrates the size of monetary actions. If commercial forecasters respond differently to changes in

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[16] The funds rate target series is available in Rudebusch (1995). We construct observations for the end of 1974:08 and 1984:02 by combining the earliest observation of the funds rate target in 1974:09 and 1984:03 and the reported change in the target.

the federal funds rate of different magnitudes, then it is useful to know the size of the monetary actions. The target series is also a useful complement to the dummy variable derived from the Wall Street Journal because it reflects what the Federal Reserve was actually doing. Cook and Hahn (1989b) show that while the Journal identifies most changes in the target, it misses some and misjudges the magnitude of others. Particularly in analyzing the information revealed by Federal Reserve actions, it is therefore desirable to work with the Federal Reserve's own target information. At the same time, since most of the target information is revealed in the press, the Federal Reserve series provides a very good and unbiased proxy for what market participants actually knew about the timing and magnitude of target changes.[17]

B. Specifications

As described above, we consider market participants' efforts to infer the Federal Reserve's information about inflation from its actions. Our basic specification is therefore

$$(4) \qquad C_{it} = \phi_i + \gamma_i M_t + \nu_{it} \, ,$$

where C_{it} is again the contemporaneous difference in month t between the Federal Reserve forecast and a given commercial forecast of inflation i quarters later, and M_t is the Federal Reserve's monetary policy action in month t (measured either by our dummy variable or by the change in the funds

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[17] For the 1980s it is quite difficult to derive a synthetic target series from the Wall Street Journal. In many instances the Journal is confident that the Federal Reserve has moved, but it is unsure where the funds rate will come to rest. Furthermore, the Journal often reports the funds rate in comparison to a year ago, so it is unclear how large a short-run change the paper observes.

rate target). In this specification, the coefficient γ_i shows whether, and by how much, a monetary policy action signals that the Federal Reserve forecast differs from the commercial forecast. For example, a coefficient that is large and positive would indicate that contractionary monetary policy actions provide information that the Federal Reserve's inflation forecast is substantially higher than the commercial forecast.

The sample periods used for estimation are determined by the availability of the data. As just described, the dummy variable for policy actions is available for 1974:9-1979:9 and 1984:3-1991:12. The federal funds rate target has the same break in the Volcker era, but continues through 1992:8. The Federal Reserve inflation forecasts are available through the end of 1991. Thus the longest possible sample is 1974:9-1979:9 and 1984:3-1991:12. When we use the DRI and SPF forecasts, we are able to use this entire period. Because the Blue Chip forecasts are available only since 1980, the sample for this case is 1984:3-1991:12.

As before, a convenient way of summarizing the evidence from the different quarters is to examine the average difference between the Federal Reserve and commercial forecasts of inflation over the next i quarters rather than the difference in their forecasts only for the quarter i quarters after month t. Thus, we also estimate

(5) $$AC_{it} = \phi_i + \gamma_i M_t + \nu_{it} ,$$

where AC_{it} is the average difference between the Federal Reserve forecast and the commercial forecast up to horizon i.

Because any information that is publicly available at time t should be incorporated in both the Federal Reserve and commercial forecasts, it is not necessary to include any control variables in the regression. Thus the main issue that arises in the specification is the timing of the inflation forecasts and

Federal Reserve actions. Ideally, we would examine the relationship between Federal Reserve actions and the difference between the two forecasts immediately before the actions. As described in Section II, however, this is not feasible: Federal Reserve and commercial forecasts are not made simultaneously, and they are not made just before Federal Reserve actions.

Any information revealed by policy actions that occur before the commercial forecasts are made should be incorporated in the forecasts. We therefore focus on actions that occur after the commercial forecasts are made. For the DRI and SPF forecasts, which are made late in the month, this means that we examine Federal Reserve actions in the month after the forecasts. For the Blue Chip forecasts, which are made at the beginning of the month, we consider actions in the same month as the forecast.

If the Federal Reserve receives unfavorable information about inflation, it is likely to tighten. This implies that using Federal Reserve forecasts that do not immediately precede its actions is likely to bias the results against finding information revelation: the Federal Reserve's estimates of inflation at the moments that it tightens are likely to be greater than its estimates as of the dates of its most recent formal forecasts. Some of the unfavorable news about inflation is presumably observed by commercial forecasters as well. Thus using commercial forecasts of inflation that do not immediately precede the Federal Reserve's actions introduces a bias in the opposite direction: commercial forecasters' estimates of inflation at the moments that the Federal Reserve tightens are also probably greater than their estimates in their most recent official forecasts.

In addition, the Federal Reserve presumably bases its actions mainly on its own forecasts rather than those of commercial forecasters. Thus times when its estimates of inflation increase after its last official forecast but commercial forecasters' do not are more likely to be followed by tightening than times exhibiting the reverse pattern. To the extent that this occurs, the

actions are signalling a gap between Federal Reserve and commercial estimates of inflation; but our tests, which are based on the official forecasts, will not capture this. As a result, if the Federal Reserve and commercial forecasts were made at the same time, but both preceded the Federal Reserve's actions, the tests would be biased against finding information revelation.

To balance these considerations, we focus on Federal Reserve forecasts that are made slightly after the commercial forecasts. As described in Section II, the Federal Reserve forecasts are made at different times of the month, although the majority of them are made in the first half of the month. For the DRI and SPF forecasts, which come late in the month, we therefore consider the Federal Reserve forecast in the subsequent month. For the Blue Chip forecast, which comes early in the month, we consider the Federal Reserve forecast in the same month. The preceding analysis implies that the bias caused by this choice of timing is ambiguous: the fact that both forecasts generally precede the action creates a bias against finding signalling, but the fact that the Federal Reserve forecast is usually later creates a bias in the opposite direction.[18]

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[18] For completeness, we have also examined the case where the Federal Reserve forecast usually precedes the commercial forecast. For DRI and SPF, this means that we consider the Federal Reserve forecast in the same month as the commercial forecast; for Blue Chip, it means that we consider the Federal Reserve forecast in the preceding month. Our analysis implies that this specification is unambiguously biased against finding a signalling effect of policy actions. Consistent with this analysis, for DRI and SPF -- where the Federal Reserve forecasts typically precede the commercial forecasts by several weeks and the policy actions by over a month -- we obtain results that are qualitatively similar to those from our main specification, but considerably weaker. For Blue Chip -- where the Federal Reserve forecasts usually precede the commercial forecasts by almost a month and the policy actions by more than a month -- we find no relationship between policy actions and the gap between Federal Reserve and commercial forecasts.

C. Results

Table 5 reports the results based on individual forecast differences. In the first three columns, policy actions are measured using the dummy variable; in the second three, they are measured using the change in the funds rate target. As before, the standard errors are computed allowing for heteroscedasticity and for serial correlation over $i+1$ quarters.

The results support the view that shifts to tighter policy signal that the Federal Reserve's forecasts of inflation exceed those of market participants. The vast majority of the estimated coefficients are positive, and a substantial number of them are significantly greater than zero. In contrast, none of the estimates are significantly less than zero.

Table 6 reports the results using the average differences between Federal Reserve and commercial forecasts of inflation at various horizons in place of the differences for individual quarters. The results are very similar to those in Table 5: 30 of the 34 point estimates are positive, and eight of the t-statistics exceed two.

The results also suggest that the magnitude of the association is substantial. For the one-year horizon, for example, the average point estimate in the first half of Table 6 is 0.16. Thus, the estimates suggest that a move to tighter policy (as measured by the dummy variable) indicates that the Federal Reserve forecast of inflation over the coming year is between one-tenth and two-tenths of a percentage point above commercial forecasts. For the coefficient estimates in the second half of the table, the corresponding figure is 0.25: an increase in the funds rate target of one percentage point signals a gap of about a quarter of a percentage point between Federal Reserve

and commercial inflation forecasts.[19] Thus, Federal Reserve actions appear to be important signals of its private information.

V. DO COMMERCIAL FORECASTERS RESPOND TO FEDERAL RESERVE ACTIONS?

The previous two sections show that the Federal Reserve possesses valuable information about future inflation and that changes in the federal funds rate target reveal some of this information. There remains, however, the question of how commercial forecasters respond to monetary actions. In standard theories, an exogenous monetary tightening should produce lower inflation, and should therefore cause commercial forecasters to reduce their expectations of inflation. Our results in the previous two sections imply, however, that if the commercial forecasters realize the information revealed by Federal Reserve actions, they should raise their forecasts of inflation when the Federal Reserve tightens. This section tests which of these two views of commercial forecasters' responses to monetary policy actions is correct.

A. Specifications

To analyze how forecasters respond to Federal Reserve actions, we look at the revisions in commercial inflation forecasts from one forecast to the next. Paralleling our earlier analysis, we look at both the individual revisions for a specific quarter and the average revisions for a set of quarters. The individual revision, R_{it}, shows the change in a commercial forecast of inflation i quarters after month t between month t and the forecaster's next regular

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[19] Since the average change in the funds rate target is considerably less than one percentage point, the estimates using the funds rate target imply a smaller signalling role of monetary policy actions than do the estimates using the dummy variable.

forecast. The average revision, AR_{it}, shows the average of the changes in the commercial inflation forecast between t and the next forecast in all of the forecasts up to i quarters after month t.

One obvious complication is that monetary actions are not the only thing that could cause commercial forecasters to change their inflation forecasts. In particular, the Federal Reserve actions and the revisions in commercial forecasts could both be responses to information released between the times of the initial forecasts and the Federal Reserve actions. Suppose, for example, that there is unfavorable news about inflation. Then commercial forecasters may raise their forecasts of inflation in response to this news, and the Federal Reserve may tighten. The revision in the commercial forecasts, however, would not be a response to the tightening. Thus in the absence of controls, the coefficient estimate could be biased upward.

To address this possibility, we control for the change in the Federal Reserve's forecast of inflation in the interval between the two forecasts. The change in the Federal Reserve forecast should reflect general information that becomes available during the period between the two forecasts.[20] If commercial forecasters revise their forecasts in response to policy actions

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[20] The change in the Federal Reserve's forecast reflects the arrival not just of new public information, but also of new private information. On the one hand, this means that the change in the Federal Reserve forecast is a noisy measure of new public information. To the extent that the Federal Reserve acts on the basis of the new public information, the fact that we are controlling for this information imperfectly means that the coefficient on the Federal Reserve's action is biased up. On the other hand, to the extent that the Federal Reserve acts on the basis of its new private information and commercial forecasters respond to those actions, by controlling for the change in the Federal Reserve forecast we tend to understate the importance of its actions to commercial forecast revisions. One can show that in the natural baseline case where the Federal Reserve puts the same weight on new public and private information in choosing its action, the two sources of bias just balance.

controlling for the change in the Federal Reserve's forecast, this would imply that they are not just responding to the release of general information. Therefore, we estimate:

(6) $$R_{it} = \eta_i + \theta_i M_t + \delta_i RF_{it} + \omega_{it}$$

and

(7) $$AR_{it} = \eta_i + \theta_i M_t + \delta_i ARF_{it} + \omega_{it} ,$$

where RF_{it} is the change in the Federal Reserve forecast of inflation i quarters after month t and ARF_{it} is the average of the changes in the Federal Reserve forecast in all of the forecasts up to i quarters after month t. A positive value of θ_i would indicate that commercial forecasters raise their forecasts of inflation when the Federal Reserve tightens.[21]

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[21] We have also investigated an alternative way of addressing the problem that both the Federal Reserve's actions and the revisions in commercial forecasts of inflation could be responses to information released between the times of the initial forecasts and the Federal Reserve's actions. The alternative is to control for the main pieces of information released early in the interval between the two commercial forecasts. Relative to our main approach of controlling for the change in the Federal Reserve's forecast, this approach has an advantage and a disadvantage. The advantage is that, because it does not require data on Federal Reserve forecasts, it permits a larger sample. The disadvantage is that, because one cannot control for all publicly available information, it can only partially address the problem.

  The specific information that we control for is the information about the percentage changes in payroll employment, average hourly earnings of production workers, and average weekly hours of production workers, which is released early in the month. The employment report released early in month t concerns month t-1. In looking at the revision of the Blue Chip forecast from the beginning of month t to the beginning of month t+1, we therefore control for the percentage changes in employment, hours, and earnings from month t-2 to month t-1. In looking at the revisions in the DRI forecast from late in month t to late in month t+1, and in the SPF forecast

Once again, timing is very important. Because the Blue Chip forecasts are done at the beginning of each month, R_{it} shows the revision over month t. Our measures of policy actions are therefore measures of actions in month t, and we control for the change in the Federal Reserve forecast from month t to month t+1.

The DRI forecasts are done at the end of each month. Thus R_{it} shows the revision over month t+1. For this forecast, the appropriate explanatory variable is a measure of Federal Reserve actions during month t+1, and the appropriate control variable is the change in the Federal Reserve forecast from month t+1 to month t+2.

The Survey of Professional Forecasters presents even more complicated timing issues. The SPF is only done at the end of the middle month of each quarter. Thus, the forecast revision in terms of monthly data is the change between the end of month t and the end of month t+3, and the control variable is the change in the Federal Reserve forecast from month t+1 to month t+4. In addition, to minimize the possibility that the Federal Reserve actions are responses to information that becomes available between the two forecast dates rather than to its forecast as of the initial forecast date, we consider only actions in month t+1.

The sample periods are again determined by the availability of the data. Since the data are the same as those used Section IV, the sample periods are also the same: 1974:9-1979:9 and 1984:3-1991:12 for DRI and SPF, and 1984:3-1991:12 for Blue Chip. Finally, because the Federal Reserve rarely

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from late in month t to late in month t+3, we control for the percentage changes in employment, hours, and earnings from month t-1 to month t.

Although this change in specification alters the results of many of the individual regressions noticeably, it has virtually no impact on the fraction of the estimates that are positive or their average size. Because of the larger sample sizes, however, the standard errors are generally smaller; as a result, many more of the estimates are significantly larger than zero.

makes long-term forecasts in two consecutive months, the sample sizes for the regressions that consider forecast revisions at the six- and seven-quarter horizons are always less than 20, and sometimes less than 10. We therefore do not consider these horizons.[22]

B. Results

Table 7 presents the coefficient estimates for the effects of monetary actions on individual forecast revisions.[23] It shows the results for both the dummy variable for Federal Reserve actions and the change in the federal funds rate target. For simplicity, the coefficient estimates for the change in the Federal Reserve forecast are not shown. These estimates are positive in the vast majority of cases, but are usually not significantly different from zero.

The results in Table 7 support the hypothesis that commercial forecasters revise their forecasts of inflation upward in response to contractionary monetary actions. A large majority of the point estimates are positive, and a number of them are significant. There is certainly variation in the strength of the finding, however. For the Blue Chip and SPF forecasts, the estimated coefficients are positive in all but one case, and for Blue Chip they are often significant. For the DRI forecasts, in contrast, the estimates are often negative, and only two are significantly larger than zero. Table 8 shows the effect of monetary actions on commercial forecast revisions, averaged over

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[22] Because the SPF forecasts are made at the end of the second month of each quarter, by the time the next forecast is made, the data for the previous quarter are actual rather than forecasted. Thus there is never a contemporaneous forecast revision for the SPF. We therefore consider contemporaneous forecast revisions only for Blue Chip and DRI.

[23] Because theory predicts that forecast revisions should be serially uncorrelated, and because the estimated residuals do not show any consistent pattern of serial correlation, the standard errors in Tables 7 and 8 are corrected for heteroscedasticity but not for serial correlation.

various horizons. This change in the specification has no great effect on the signs, magnitudes, or statistical significance of the estimates.

For the monetary policy dummy variable, the magnitude of the estimated effect is close to what one would expect given the findings in Section IV about the information content of the Federal Reserve's actions. Using the average forecast revision for four quarters ahead, for example, the average point estimate in the first half of Table 8 is 0.12. This implies that following a report in the Wall Street Journal of a rise in the federal funds rate, commercial forecasters raise their forecasts of inflation over the next year by between one- and two-tenths of a percentage point. For comparison, the corresponding figure in Table 6 of Section IV is 0.16. This figure implies that a contractionary monetary action signals that the Federal Reserve forecast is also between one- and two-tenths of a percentage point above the commercial forecast.

For the federal funds rate target, in contrast, commercial forecasters appear to revise their forecasts in response to Federal Reserve actions by somewhat less than one would expect given the information content of the actions. Using the average forecast revision for four quarters ahead, the average point estimate in the second half of Table 8 is 0.15. In Section IV, we found that a rise of 100 basis points in the federal funds rate target signals a gap of about 25 basis points between Federal Reserve and commercial inflation forecasts. Our results here therefore indicate that commercial forecasters change their forecasts only by about half this amount.

There are at least two reasons why commercial forecasters might not revise their forecasts by the full amount of the information revealed by Federal Reserve actions. First, for the longer horizons, the actions' direct effects tend to offset their information-revelation effects. For example, a contractionary policy action (unless it is fully anticipated by the Federal Reserve at the time of its forecast) tends to reduce inflation below the path forecasted by the

Federal Reserve. Thus commercial forecasters should not revise their inflation expectations by the full amount of the gap between their forecasts and the Federal Reserve's that is signalled by the policy action.

Second, determining what information is revealed by Federal Reserve actions is complicated. It requires obtaining and systematically examining large sets of forecasts that are more than five years old. Given the limited resources that commercial forecasters devote to forecasting, it would not be surprising if they did not do this, and instead made imperfect estimates of the information content of monetary policy actions. Our results about the information content of Federal Reserve and commercial forecasts already suggest that commercial forecasts do not process publicly available information perfectly. Our findings about how commercial forecasters respond to monetary policy actions may just be a specific illustration of this general phenomenon.

C. Results for Real GDP

The information that the Federal Reserve's policy actions reveal about inflation is likely to be much more important to the actions' impact on interest rates than is the information they reveal about real GDP. Nonetheless, to provide a more complete description of the relationship between the Federal Reserve's private information and its actions, we briefly examine the association between monetary policy actions and forecasts of real GDP growth. For simplicity, we discuss only forecasts for individual quarters and do not report the results for average forecasts at various horizons.

Tables 9 and 10 report the results for real GDP. Table 9, which is analogous to Table 5 for inflation, examines the signalling effect of Federal Reserve actions. Specifically, it presents regressions of the gap between Federal Reserve and commercial forecasts of real GDP growth on our measures of policy actions. Table 10, which is analogous to Table 7 for

inflation, examines the response of commercial forecasters to Federal Reserve actions; it reports regressions of the revision in commercial forecasts of real GDP growth from one forecast to the next on the policy measures. Paralleling the regressions in Table 7, the regressions in Table 10 control for the change in the Federal Reserve's forecast of real growth.

The regressions show that contractionary monetary policy actions signal that the Federal Reserve's forecasts of real growth for the current and next quarter are far above commercial forecasts, and that commercial forecasters appear to respond to those signals. A 100-basis point rise in the funds rate target, for example, indicates that the Federal Reserve's growth forecast is in the vicinity of 150 basis points above commercial forecasts for the current quarter, and about 100 basis points above for the next quarter; most of these estimates are highly significant. Commercial forecasters appear to revise their forecasts of near-term growth in response to the actions. The point estimates are considerably less than one would expect given the information content of the actions, however, and they are only sometimes significant.

Once the horizon reaches two quarters, there is no strong pattern to the results. For Blue Chip and SPF, the estimated relationships in Tables 9 and 10 are generally slightly negative; for DRI, they are not consistently of either sign. Few of the estimates are significantly different from zero.

An interpretation that is consistent with these findings about the signalling role of policy actions for inflation and output at different horizons is that the Federal Reserve responds to expected changes in inflation only enough to offset them very gradually. If the Federal Reserve responds slowly,

then a rise in inflation will be very long-lasting.[24] Thus, the gradual response hypothesis can explain why moves to tighter policy signal that the Federal Reserve's forecasts of inflation are above commercial forecasts even at moderately long horizons, and, hence, why commercial forecasters raise their inflation forecasts at all horizons in response to policy tightenings.[25]

This hypothesis also provides a possible explanation of the lack of a clear link between policy actions and the gap between Federal Reserve and commercial forecasts of real growth beyond very short horizons. On the one hand, since policy affects real output with a lag, the Federal Reserve's knowledge that it is likely to tighten policy in response to information about near-term inflation increases implies that contractionary policy will be associated with Federal Reserve medium-term growth forecasts that are lower than commercial forecasts. On the other hand, any information that the Federal Reserve has about likely movements in aggregate demand beyond the short term will be responded to only gradually. Thus, in this case, contractionary policy will be associated with Federal Reserve growth forecasts for the medium term and beyond that are above commercial forecasts. Hence, the hypothesis that the Federal Reserve adjusts rates to gradually offset expected changes in inflation can account for the fact that monetary actions

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[24] Indeed, one type of evidence in favor of this hypothesis are studies showing that inflation is in fact highly persistent (see, for example, Barsky, 1987). The hypothesis is also consistent with the common observation that the Federal Reserve prefers gradual changes in policy to sudden ones.

[25] The point estimates in Table 6 appear to suggest that Federal Reserve actions have little signalling value concerning its inflation forecasts at horizons of six and seven quarters. In fact, however, these results arise only because the observations for which these long-horizon forecasts are available are unusual. Specifically, when the regressions for horizons of one through five quarters in Table 6 are estimated using only the observations for which the long-horizon forecasts are available, those point estimates also do not differ systematically from zero.

provide clear signals about inflation at all horizons, but ambiguous signals about output beyond short horizons.

VI. CONCLUSION

The most important finding of this paper is that the Federal Reserve does appear to possess information about the current and future state of the economy that is not known to market participants. Our estimates suggest that if they had access to the Federal Reserve's forecast of future inflation, commercial forecasters would find it optimal to simply discard their forecasts and adopt that of the Federal Reserve. Furthermore, this informational advantage appears to exist for real output as well as for inflation. The existence of significant asymmetric information between the Federal Reserve and the public has several important implications.

A. Implications for the Impact of Monetary Policy on Interest Rates

One implication concerns the puzzling response of interest rates to monetary policy actions. Consider first the behavior of short-term interest rates. Our estimates in Section IV about the information revealed by policy actions imply that an increase in the funds rate target of one percentage point signals that the Federal Reserve's inflation forecast for the coming year is about 25 basis points above commercial forecasts. And our results in Section III about the value of Federal Reserve forecasts in predicting inflation given commercial forecasts imply that commercial forecasters should raise their forecasts by roughly the full amount of this difference. Our results in Section V suggest, however, that commercial forecasters in fact revise their forecasts by only about half the amount of this difference.

For comparison, Cook and Hahn (1989a) report that an increase of one percentage point in the federal funds rate target is associated with an

increase of roughly 50 basis points in 3-month, 6-month, and 1-year interest rates. Thus our results imply that between a quarter and a half of the impact of monetary policy actions on short-term rates is due to their impact on expected inflation rather than on real rates.

Now consider longer-term interest rates. We do not have any direct evidence about the relative value of Federal Reserve and commercial inflation forecasts at horizons beyond two years, or about what Federal Reserve actions signal about the gap between the two forecasts over such horizons. As a result, we cannot make a precise estimate of how much of the response of long-term interest rates to policy actions is due to the actions' signalling effects. We can say, however, that it is possible that the information-revelation effects are crucial to the response. Cook and Hahn report that an increase of one percentage point in the funds-rate target is associated with increases of about 30 basis points in the 3-year bond rate, 20 points in the 5- and 7-year bond rates, and 10 points in the 20-year bond rate. Thus if the information-revelation effects of monetary policy for the first year carry over to longer horizons, which is consistent with the view that the Federal Reserve acts to undo changes in inflation only very gradually, they account for most of the impact of monetary policy on medium-term rates, and for more than all of the response of long-term rates. And even if the effects for longer horizons are somewhat smaller than the effects over the first year, they can still account for much of the response of medium-term rates and most of the response of long-term rates.

In sum, our results suggest that the keys to understanding the puzzling response of long-term rates to monetary policy are that there is important asymmetric information between the Federal Reserve and the public and that policy actions are often not exogenous. The Federal Reserve has important information about inflation that market participants do not, and its policy actions provide signals about that information. As a result, market

participants' expectations of inflation rise when the Federal Reserve tightens, and fall when the Federal Reserve loosens. Thus, the apparently anomalous behavior of long rates in response to changes in monetary policy is in fact the rational response of markets to valuable information revealed by the Federal Reserve through its actions.

B. Implications for Other Studies

Our finding of substantial asymmetric information between the Federal Reserve and the public may also have implications for a variety of other studies in monetary economics. First, as mentioned before, many models of central bank behavior emphasize the potential importance of an informational advantage for the monetary authority. For example, in models with rational expectations and flexible prices, activist monetary policy can stabilize real output only if the monetary authority has private information about the state of the economy (Sargent and Wallace, 1975; Barro, 1976). To give another example, Barro and Gordon (1983), Canzoneri (1985), and Cukierman and Meltzer (1986) argue that in settings where optimal monetary policy is not dynamically consistent, asymmetric information between the monetary authority and the public about the benefits of expansionary policy has important implications for the conduct of policy, the monetary authority's desire for secrecy, and the relation between economic conditions and policy actions. Our results bear on the importance of all of these models of asymmetric information.

Second, an even broader literature is concerned with the possibility of asymmetric information in financial markets, and of actions providing signals of that information. In the case of inflation and interest rates, it is easy to identify a participant that may have private information (the Federal Reserve) and one important set of its actions (changes in its funds rate target). Even more important, the Federal Reserve and commercial inflation forecasts

provide a potential record of the informed party's private information. As a result, this setting may be a particularly fruitful one for investigating this general class of models. As we have described, in this case there is overwhelming evidence of the existence of private information, and considerable evidence that actions provide signals of that information and that those signals are important to the actions' effects. This suggests that asymmetric information and signalling deserve serious consideration in financial markets more generally.

Finally, a number of empirical studies have attempted to identify the effects of monetary policy by examining the response of the economy to the component of some policy instrument, such as the federal funds rate, that is orthogonal to some set of publicly available information (see Christiano, Eichenbaum, and Evans, 1996, for a recent example). Our results suggests that there is a fundamental problem with this approach. The component of monetary policy that is orthogonal to publicly available information reflects not just random variations in policy, but also the Federal Reserve's responses to shocks that it observes but the public does not. As a result, the estimates of policy's effects from this approach are contaminated with the effects of the shocks that are causing the changes in policy. Indeed, since the Green Book forecasts are not perfect measures of the Federal Reserve's expectations at the times of its policy actions, even controlling for the information in the Green Book forecasts will not solve the problem. Thus, the existence of significant Federal Reserve private information may have important implications not just for the behavior of interest rates and theoretical analyses of central bank behavior, but for a wide range of empirical investigations of monetary policy.

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TABLE 1

Estimates of Federal Reserve Private Information
(Individual Forecast Errors)

Forecast Horizon	Blue Chip	DRI	SPF
(Q ahead)	(Estimates of β ; robust t-statistics in parentheses)		
0	0.16 (1.44)	0.62 (3.59)	0.59 (4.04)
1	0.60 (3.66)	1.04 (5.66)	1.10 (5.63)
2	0.97 (5.07)	1.01 (4.93)	1.14 (4.86)
3	0.95 (4.20)	1.24 (4.23)	1.45 (5.81)
4	1.00 (3.23)	1.53 (3.66)	1.73 (5.19)
5	0.95 (5.09)	1.64 (3.78)	
6	0.84 (3.52)	1.43 (3.85)	
7		1.53 (4.77)	

TABLE 2

Estimates of Federal Reserve Private Information
(Average Forecast Errors)

Forecast Horizon	Blue Chip	DRI	SPF
(Q ahead)	(Estimates of β ; robust t-statistics in parentheses)		
1	0.43 (2.92)	0.95 (5.38)	1.08 (5.17)
2	0.62 (4.50)	1.00 (5.38)	1.19 (4.42)
3	0.74 (4.02)	1.09 (4.55)	1.29 (4.64)
4	0.79 (3.31)	1.34 (4.23)	1.41 (4.40)
5	1.08 (4.59)	1.47 (4.13)	
6	1.08 (3.40)	1.29 (4.06)	
7		1.16 (4.33)	

TABLE 3

Estimates of Federal Reserve Private Information
(Federal Reserve at a Timing Disadvantage)

Forecast Horizon	Individual Forecast Errors			Average Forecast Errors		
	BC	DRI	SPF	BC	DRI	SPF
(Q ahead)	(Estimates of β ; robust t-statistics in parentheses)					
0	0.22	0.60	0.42			
	(1.84)	(5.27)	(2.78)			
1	0.74	0.91	0.61	0.45	0.79	0.39
	(4.12)	(4.82)	(1.88)	(3.83)	(5.54)	(1.77)
2	0.88	0.73	0.79	0.60	0.70	0.66
	(3.75)	(2.91)	(3.74)	(3.57)	(3.36)	(2.75)
3	0.98	1.15	1.36	0.74	0.85	0.79
	(3.74)	(4.56)	(5.32)	(3.68)	(3.51)	(2.80)
4	1.05	1.27	1.76	0.88	1.15	1.19
	(4.07)	(3.83)	(5.94)	(3.56)	(3.60)	(3.01)
5	0.89	1.32		0.96	1.03	
	(3.71)	(4.31)		(2.63)	(3.59)	
6	0.96	1.11		0.97	1.05	
	(3.29)	(4.89)		(2.76)	(3.33)	
7		1.19			1.04	
		(2.75)			(1.72)	

TABLE 4

Estimates of Federal Reserve Private Information
(Real GDP)

Forecast Horizon	Individual Forecast Errors			Average Forecast Errors		
	BC	DRI	SPF	BC	DRI	SPF
(Q ahead)	(Estimates of β ; robust t-statistics in parentheses)					
0	1.40 (5.73)	0.41 (1.74)	1.26 (3.01)			
1	0.34 (0.55)	0.27 (1.01)	0.74 (1.06)	0.81 (2.64)	0.27 (0.72)	1.10 (2.36)
2	0.72 (1.11)	0.57 (1.87)	1.19 (1.62)	0.72 (1.32)	0.53 (1.19)	1.09 (1.54)
3	0.37 (0.46)	0.69 (1.94)	1.05 (2.78)	0.58 (0.93)	0.67 (1.61)	1.24 (1.78)
4	1.99 (5.54)	1.18 (4.10)	2.40 (3.23)	1.09 (2.31)	0.75 (2.16)	1.64 (2.64)
5	1.60 (9.41)	1.21 (5.86)		1.32 (3.41)	0.73 (1.71)	
6	1.64 (5.70)	1.28 (7.69)		1.41 (5.02)	0.66 (1.60)	
7		1.20 (1.55)			0.95 (3.85)	

TABLE 5

Estimates of Information Revelation
(Individual Forecast Differences)

Forecast Horizon	Dummy Variable			Change in Target		
	BC	DRI	SPF	BC	DRI	SPF
(Q ahead)	(Estimates of γ ; robust t-statistics in parentheses)					
0	0.20 (1.68)	0.14 (1.16)	0.16 (0.90)	0.28 (1.74)	0.03 (0.09)	-0.13 (-0.35)
1	-0.16 (-1.18)	0.23 (1.56)	0.11 (0.62)	-0.38 (-1.76)	0.51 (2.22)	-0.13 (-0.46)
2	0.02 (0.18)	0.25 (2.15)	0.33 (1.96)	0.15 (0.91)	0.61 (3.10)	0.45 (1.18)
3	0.10 (1.63)	0.17 (1.56)	0.24 (2.24)	0.26 (5.41)	0.39 (1.85)	0.28 (1.19)
4	0.14 (4.34)	0.07 (0.62)	0.28 (2.98)	0.40 (4.67)	0.13 (0.70)	0.29 (2.09)
5	0.07 (1.68)	0.11 (1.24)		0.20 (2.44)	0.26 (1.62)	
6	-0.09 (-1.45)	0.03 (0.32)		-0.04 (-0.22)	0.43 (1.69)	
7		0.21 (1.11)			0.43 (1.17)	

TABLE 6

Estimates of Information Revelation
(Average Forecast Differences)

Forecast Horizon	Dummy Variable			Change in Target		
	BC	DRI	SPF	BC	DRI	SPF
(Q ahead)	(Estimates of γ ; robust t-statistics in parentheses)					
1	0.02	0.19	0.14	-0.05	0.27	-0.13
	(0.23)	(1.76)	(0.92)	(-0.39)	(1.58)	(-0.50)
2	0.02	0.21	0.20	0.01	0.38	0.06
	(0.25)	(2.07)	(1.36)	(0.13)	(2.25)	(0.19)
3	0.04	0.20	0.21	0.08	0.39	0.12
	(0.75)	(1.81)	(1.66)	(1.04)	(2.00)	(0.41)
4	0.06	0.17	0.27	0.14	0.32	0.27
	(3.45)	(1.48)	(3.22)	(2.96)	(1.93)	(1.84)
5	0.10	0.13		0.20	0.29	
	(2.51)	(1.36)		(2.16)	(1.80)	
6	-0.00	-0.03		0.06	0.04	
	(-0.01)	(-0.30)		(0.46)	(0.21)	
7		0.01			0.10	
		(0.08)			(0.56)	

TABLE 7

Estimates of Forecast Response to Monetary Policy Actions
(Individual Forecast Revisions)

Forecast Horizon	Dummy Variable			Change in Target		
	BC	DRI	SPF	BC	DRI	SPF
(Q ahead)	(Estimates of θ ; robust t-statistics in parentheses)					
0	0.14 (2.51)	0.22 (1.95)		0.33 (2.30)	0.51 (2.35)	
1	0.05 (1.59)	0.10 (1.30)	0.29 (1.64)	0.13 (1.51)	0.20 (1.45)	0.14 (0.38)
2	0.03 (0.88)	-0.00 (-0.01)	0.08 (0.47)	0.07 (0.92)	-0.24 (-0.58)	-0.01 (-0.03)
3	0.04 (1.75)	-0.02 (-0.18)	0.18 (1.67)	0.12 (1.97)	-0.18 (-0.62)	0.17 (0.59)
4	0.06 (3.00)	0.07 (0.53)	0.28 (2.35)	0.15 (2.65)	-0.16 (-0.55)	0.27 (0.82)
5	0.03 (0.81)	0.12 (1.42)		0.07 (0.81)	0.39 (2.91)	

TABLE 8

Estimates of Forecast Response to Monetary Policy Actions
(Average Forecast Revisions)

Forecast Horizon	Dummy Variable			Change in Target		
	BC	DRI	SPF	BC	DRI	SPF
(Q ahead)	(Estimates of θ ; robust t-statistics in parentheses)					
1	0.09 (2.21)	0.13 (2.39)		0.21 (1.88)	0.29 (2.48)	
2	0.06 (1.73)	0.08 (1.04)	0.16 (0.85)	0.14 (1.40)	0.24 (1.42)	-0.02 (-0.04)
3	0.05 (1.58)	0.03 (0.31)	0.17 (1.04)	0.11 (1.29)	0.09 (0.45)	0.02 (0.06)
4	0.05 (1.76)	0.01 (0.21)	0.29 (2.59)	0.11 (1.42)	-0.06 (-0.63)	0.38 (1.17)
5	0.02 (0.68)	-0.00 (-0.01)		0.02 (0.21)	-0.09 (-0.86)	

TABLE 9

Estimates of Information Revelation
(Real GDP; Individual Forecast Differences)

| Forecast Horizon	Dummy Variable			Change in Target		
	BC	DRI	SPF	BC	DRI	SPF
(Q ahead)	(Estimates of γ ; robust t-statistics in parentheses)					
0	0.77	0.33	1.01	1.65	0.83	2.31
	(5.26)	(1.86)	(3.45)	(5.43)	(2.34)	(5.48)
1	0.13	0.02	0.51	0.73	0.53	1.55
	(0.70)	(0.10)	(1.54)	(2.22)	(1.22)	(2.98)
2	-0.16	0.18	-0.43	-0.13	0.89	-0.48
	(-0.75)	(0.75)	(-1.41)	(-0.38)	(1.35)	(-0.92)
3	-0.10	0.20	-0.07	-0.10	0.39	-0.12
	(-0.72)	(0.88)	(-0.44)	(-0.43)	(0.94)	(-0.40)
4	-0.12	0.22	-0.26	-0.16	0.49	-0.61
	(-2.21)	(1.14)	(-1.43)	(-2.62)	(1.07)	(-2.06)
5	-0.09	-0.13		-0.12	0.32	
	(-1.05)	(-0.34)		(-2.62)	(0.59)	
6	0.04	-0.28		0.04	-0.44	
	(0.26)	(-0.68)		(0.14)	(-0.74)	
7		-0.59			-0.86	
		(-1.51)			(-1.26)	

TABLE 10

Estimates of Forecast Response to Monetary Policy Actions
(Real GDP; Individual Forecast Revisions)

Forecast Horizon	Dummy Variable			Change in Target		
	BC	DRI	SPF	BC	DRI	SPF
(Q ahead)	(Estimates of θ ; robust t-statistics in parentheses)					
0	0.41	0.46		0.99	0.80	
	(3.52)	(2.97)		(2.90)	(1.86)	
1	0.05	0.14	0.17	0.24	0.42	0.29
	(0.50)	(1.04)	(0.87)	(0.83)	(1.37)	(0.50)
2	0.08	0.29	-0.41	0.14	0.66	-0.67
	(1.41)	(2.11)	(-3.99)	(1.17)	(2.85)	(-2.06)
3	0.02	-0.11	-0.37	0.02	-0.35	-0.74
	(0.33)	(-1.04)	(-3.40)	(0.17)	(-2.36)	(-2.75)
4	-0.07	-0.34	-0.06	-0.17	-0.51	-0.29
	(-1.80)	(-2.90)	(-0.29)	(-1.58)	(-1.17)	(-0.79)
5	-0.04	-0.23		-0.09	-0.24	
	(-0.62)	(-2.92)		(-0.51)	(-1.34)	

FIGURE 1

Scatter Plot of Forecast Errors and Forecast Differences
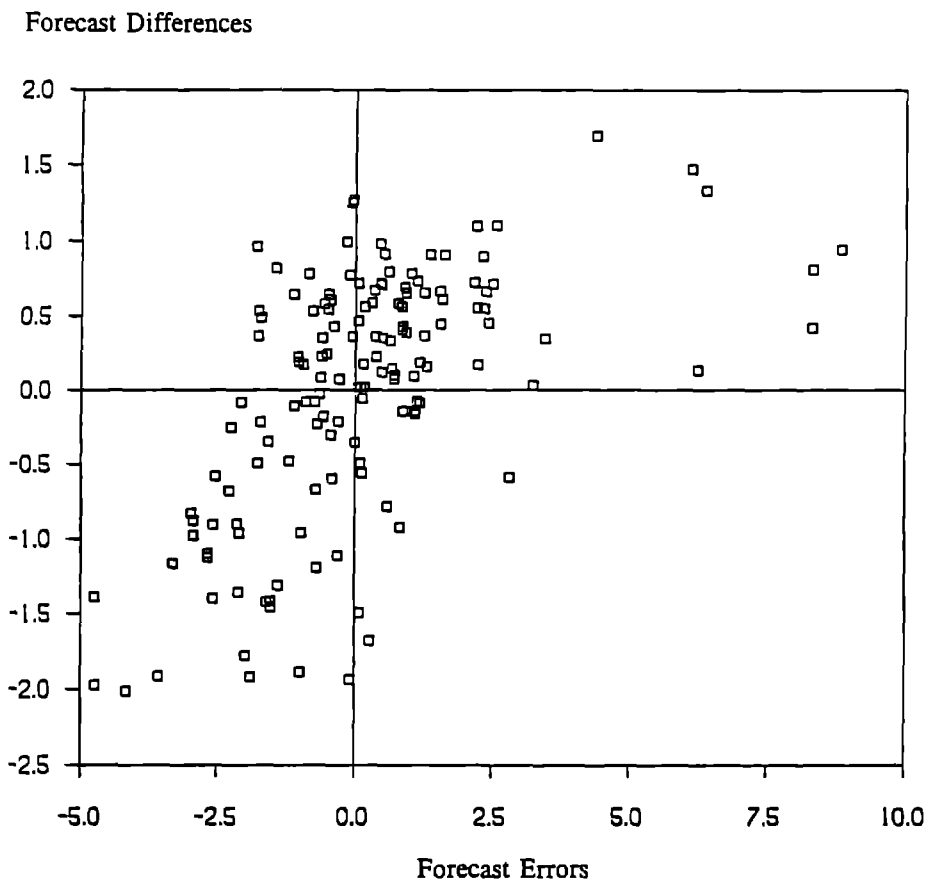
Forecast Differences

Forecast Errors

Note: The forecast errors and contemporaneous forecast differences are
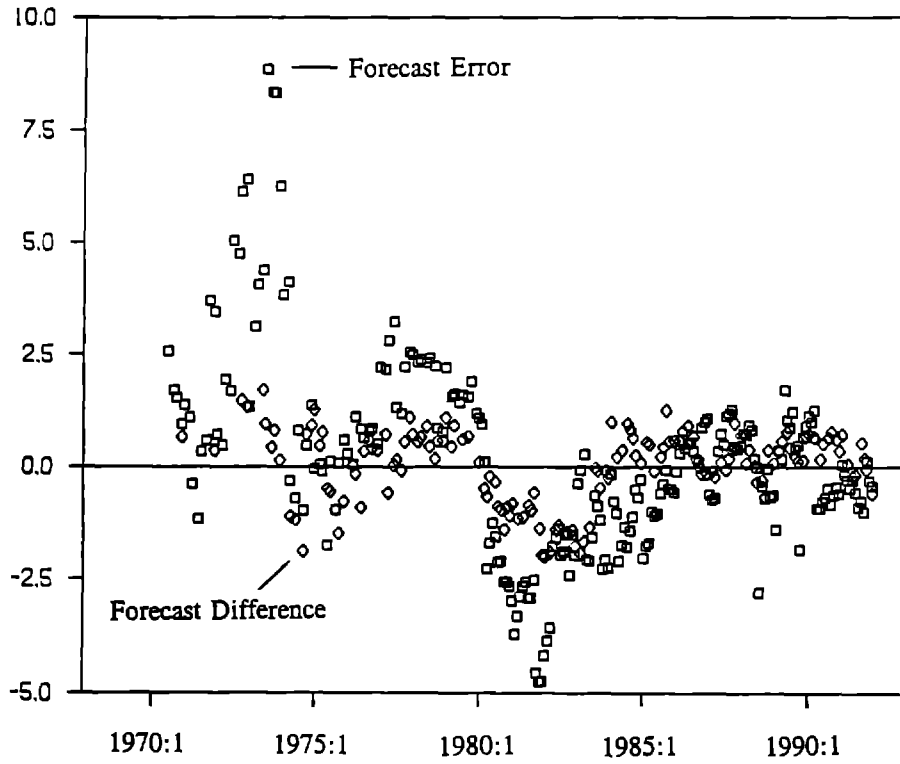based on the DRI forecasts for four quarters ahead.

FIGURE 2

Time-series Plot of Forecast Errors and Forecast Differences

Note: The forecast errors and contemporaneous forecast differences are based on the DRI forecasts for four quarters ahead.