Survey Measures of Expected Inflation: Revisiting the Issues of Predictive Content and Rationality

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The forecasting accuracy, predictive content, and rationality of survey measures of inflation expectations are important for a number of reasons. In monetary policy deliberations, the Federal Reserve needs a reliable measure of inflation expectations to assess the outlook for future inflation and gauge the stance of current monetary policy. Hence it is important to see if the widely available survey forecasts are accurate and useful in predicting actual future inflation.[1] This reliance on direct measures of inflation expectations has become more critical because of the reduced stability of the short-run relationship between monetary aggregates and GDP expenditures since the early 1980s. Furthermore, during the past two decades the Federal Reserve has conducted policy focusing on the behavior of short-term interest rates. Inflation expectations are important in identifying expected real interest rates that determine real spending in the economy.

The rationality of inflation expectations, namely that economic agents do not make systematic errors in making their forecasts of inflation, is also important. The premise that economic agents may have rational expectations is now widely accepted and employed by macroeconomists in building general

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[1] The forecasting accuracy is measured here by the mean absolute forecast error, or the root mean squared error constructed using prediction errors.

equilibrium models and discussing effects of policy. In such models the effects of monetary policy on output and employment depend in part on whether expectations are rational. It is therefore important to examine whether the popular survey inflation forecasts exhibit rationality.

The most recent work evaluating the forecasting performance of the survey measures of expected inflation appears in Thomas (1999). I extend it in two main directions. In most previous research, the predictive content of survey measures for inflation is not adequately investigated. I examine this issue using the test of Granger-causality, which helps determine whether the survey measures contain additional information about the subsequently realized inflation rates beyond what is already contained in the past history of the actual inflation rates.[2] I allow for the possibility that survey inflation forecasts and actual inflation rates series may be cointegrated (Engle and Granger 1987). If these two series are cointegrated, then such cointegration implies that inflation forecasts and actual inflation series move together in the long run. In the short run, though, these two series may drift apart. This drift property of cointegrated series has important implications for tests of predictive content and rationality. In particular, the forecast error may have serial correlation, suggesting the presence of systematic forecast errors.[3] The fact that in the long run these two series revert to one another—with forecasts adjusting to actual inflation or inflation adjusting to forecasts, or both—implies that the short-run drifts may have predictive content for future movements in inflation. Thus, the presence of serial correlation in forecast errors and the fact that economic agents take these errors into account when they forecast future inflation are not inconsistent with the paradigm of rational expectations.[4]

The other key aspect of the survey measures of inflation examined in previous work concerns their efficiency: whether or not survey respondents employ all relevant information in generating their inflation forecasts. Inflation expectations are said to be efficient if survey respondents employ all relevant information when forecasting. In previous research, this test for efficiency was often conducted using the most recent available information on the past values of the economic variables. But data on some economic variables is subject to significant revisions over time, and so the use of revised data in

[2] This test of predictive content is more rigorous than simply asking whether survey inflation forecasts are more accurate than the naïve inflation forecasts given by the most recent inflation rate known to the respondent at the time forecasts are made. The test for Granger-causality seeks information about the future inflation rate beyond what is already contained in the entire past history of the inflation rate, not just in the most recent inflation rate.

[3] The drift caused by a shock to the fundamentals may be persistent in the short run if economic agents rationally learn the nature of the shock and the resulting true process generating the fundamentals.

[4] A recent paper by Grant and Thomas (1999) uses the cointegration and error-correction methodology in the test for rationality. The authors, however, do not examine the issue of predictive content. Moreover, they consider only the Livingston and Michigan-mean surveys.

the test for efficiency is questionable, since revised data would not have been known to the respondents at the time they made their forecasts. Tests for efficiency conducted using revised data on the relevant economic variables may then yield incorrect inferences on the rationality of survey forecasts. I investigate whether inferences on efficiency reported in previous research are sensitive to the use of real-time data.[5]

In this article, I examine the behavior of three survey measures of one-year-ahead CPI inflation expectations. I evaluate their relative forecasting accuracy and predictive content over a full sample period, from 1961:1 to 2001:3, and two subperiods, 1961:1 to 1980:2 and 1980:3 to 2001:3. The early period is the period of upward-trending inflation, and the later period is the period of downward-trending inflation.[6] The later period also coincides with a major change in the monetary policy regime, when Paul Volcker, appointed Fed Chairman in 1979, put in place a disinflationary policy. In an environment where a central bank must establish credibility for changes in its inflation targets, a rational expectations equilibrium may exist in which inflationary expectations are slow to adjust. Along the transition path, economic agents may continue to expect higher inflation than is actually realized and may thus make systematic forecast errors. In order to assess whether test results for unbiasedness and predictive content for the later period are robust to this phenomenon, I also examine the period that begins with the appointment of Alan Greenspan as Fed Chairman. I assume that the transition to a low inflation environment was credible by the end of the Volcker regime.

The three survey measures considered here are the Livingston Survey of Professional Economists (denoted hereafter Livingston); the Michigan Survey of U.S. households (denoted Michigan-mean or Michigan-median); and the Survey of Professional Forecasters (denoted SPF).[7] The Livingston and Michigan-mean forecasts are available for the full sample period, whereas the Michigan-median and SPF forecasts are available only for the later subperiod.

[5] Zarnowitz (1985) and Keane and Runcle (1989) are among the first to suggest that the use of revised data could affect inferences on rationality. The inference on Granger-causality could also be affected if the price series are revised. However, Consumer Price Index (CPI) inflation data has not been subject to significant revisions, so I focus on the effect of revisions in other economic variables pertinent to the test for efficiency.

[6] Here I follow Thomas (1999) in splitting the sample in the second quarter of 1980, when the CPI inflation rate peaked.

[7] The Livingston survey currently conducted by the Federal Reserve Bank of Philadelphia covers professional economists in academia, in private financial and nonfinancial corporations, and in government. The Michigan Survey currently conducted by the Survey Research Center at the University of Michigan covers U.S. households and is based on a randomly selected sample of at least 500 households. The respondents are asked to provide forecasts of the inflation rate over the next year in the prices of "things you buy." The survey has been conducted quarterly from 1959 through 1977 and monthly since the beginning of 1978. The Survey of Professional Forecasters covers professional forecasters in the business sector for the most part and is currently conducted by the Federal Reserve Bank of Philadelphia. Consumer Price Index inflation forecasts were initiated in the third quarter of 1981.

As a benchmark, I consider one naïve forecast, which is simply the most recent one-year growth rate of CPI inflation known to the survey respondents at the time forecasts are made.[8]

The empirical work presented here supports the following observations. First, all survey measures considered here are more accurate than the naïve forecast. However, as regards their relative forecast accuracy, the results are sensitive to the sample period. While both the Livingston and Michigan-mean forecasts perform equally well over the full period and the period of rising inflation, the Michigan-mean forecasts are the least accurate over the period of downward-trending inflation. For this later period, the Michigan-median forecasts provide the most relatively accurate forecasts of one-year-ahead CPI inflation.

Second, tests for Granger-causality indicate that survey forecasts considered here contain a forward-looking component and can help predict actual future inflation, with the exception of the Livingston forecasts. The Livingston forecasts do not Granger-cause inflation over the full period, implying they have no predictive content for future inflation.

Third, the Michigan-median forecasts are unbiased, but the results of the others are mixed. The Livingston forecasts are unbiased over the full period, but biased over the early and later periods. The Michigan-mean forecasts are biased over the full and later periods, but unbiased over the early.

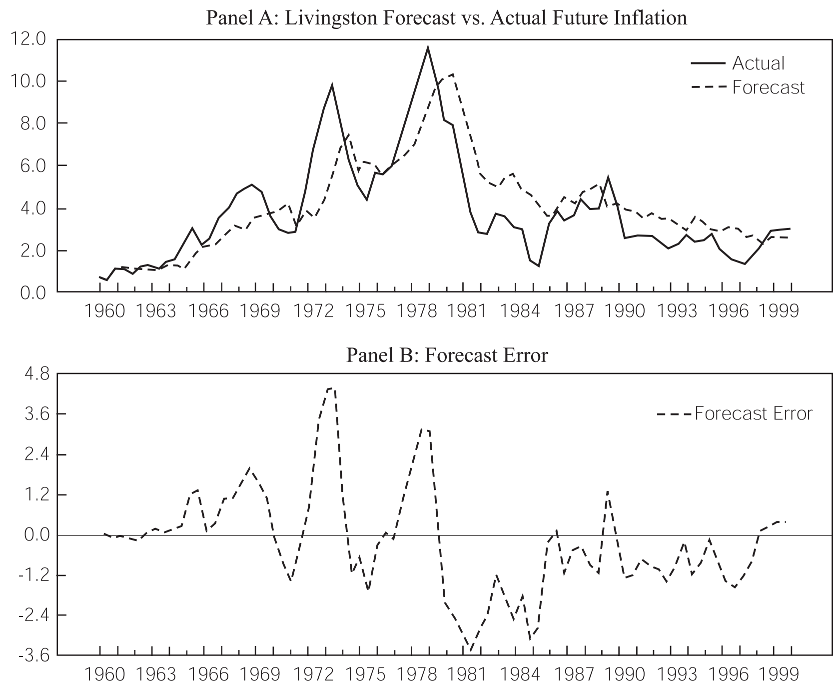
Fourth, tests for efficiency performed using revised data indicate that the forecast error is correlated with past information, including the output gap. This result implies that survey respondents did not take into account past information in making their predictions, a result already reported in Thomas (1999). However, real-time estimates of the output gap differ substantially from those generated using revised data. If tests for rationality are conducted using real-time data, then their results indicate that survey respondents did take into account past information in predicting future inflation.

Finally, excluding the Volcker period from the later period does not dramatically alter the results. There is an increase in forecast accuracy as measured by the mean error or the root mean squared error criterion; however, the Livingston and Michigan-mean forecasts remain biased. The SPF forecasts look much better over this short period, being unbiased and almost as accurate as the Michigan-median forecasts.

Section 1 provides a graphical review of the recent behavior of three survey measures considered here. It also describes the various statistical tests that are

[8] The other benchmark inflation model commonly used in previous work is based on the Fisher model of interest rates. According to the Fisher model, the nominal interest rate at any time can be regarded as the sum of the expected real interest rate and the expected rate of inflation. Given an estimate of the expected real interest rate, one can then recover estimates of the expected inflation rate from the nominal interest rate. This benchmark forecasting model has, however, not done well (see Thomas [1999]).

Figure 1



used to evaluate the survey forecasts. Section 2 presents the empirical results, and concluding observations are in Section 3.

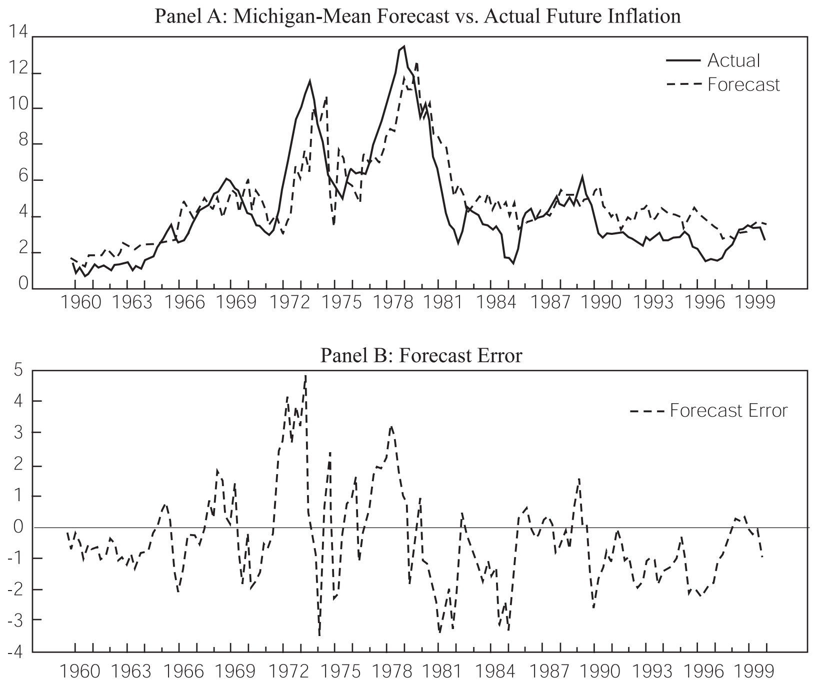
1. EMPIRICAL METHODOLOGY

Various statistical tests are used to assess the forecast accuracy, predictability, and rationality of survey measures. I begin with a graphical review of the recent behavior of these survey measures and then describe the tests themselves.

Figures 1 through 4 chart the Livingston, Michigan-mean, Michigan-median, and SPF inflation forecasts, along with the subsequently realized CPI inflation rates for the pertinent sample periods.[9] Panel B in each figure charts the forecast error, defined as the subsequently realized CPI inflation

[9] The Livingston survey is semiannual and published in June and December of each year. The Livingston survey forecasts actually cover a 14-month period, because respondents who are asked to forecast the level of CPI expected to prevail the following June and December have information about the actual level of CPI for April and October. In contrast, the Michigan survey has been conducted quarterly from 1959 through 1977 and monthly since then. Hence, observations in the Livingston survey are semiannual and cover a 14-month-ahead period, whereas in the Michigan

Figure 2

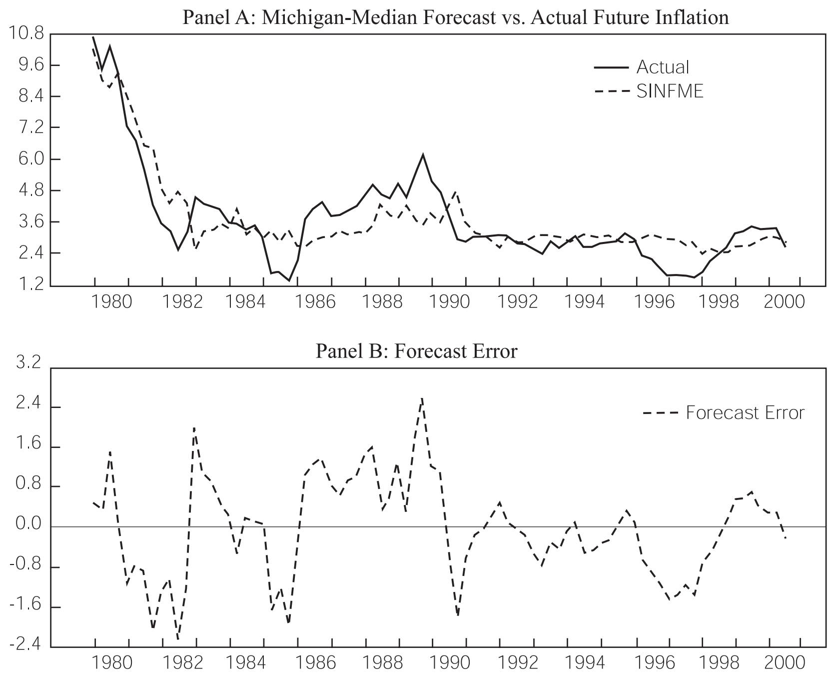


minus its survey forecast. Several observations stand out. First, if we focus on the Livingston and Michigan-mean forecasts that are available over the full period, we see that the turning points in expected inflation appear to lag behind the turning points in actual inflation, suggesting the presence of a backward-looking component in inflation expectations. Furthermore, both Livingston and Michigan respondents appear to underestimate inflation in the early period, when inflation is trending upward, and overestimate inflation in the later period, when it is trending downward (see Figures 1 and 2).

Second, if we focus on the Michigan-median and SPF forecasts available only for the 1980s and the 1990s (see Figures 3 and 4), the SPF respondents also overestimate inflation in periods when inflation is falling. In particular, the SPF respondents seriously underestimated the decline in inflation that occurred in the early 1980s (see Panel B of Figure 4). The Michigan-median inflation forecasts look good in comparison, the extent of overprediction being relatively mild.

survey they are quarterly and cover a one-year-ahead period. See Thomas (1999) for a recent overview of other details.

Figure 3



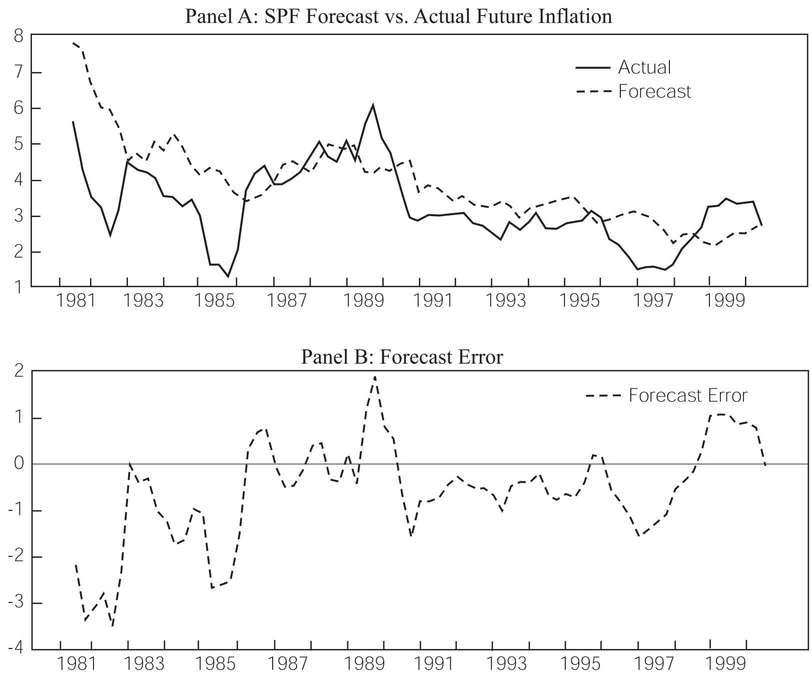
Although Figures 1 through 4 indicate that survey inflation forecasts move together with the subsequently realized inflation rates, it is not clear whether this comovement results from survey respondents adjusting their forecasts in response to past inflation rates or anticipating actual future inflation rates. From a policy perspective, survey measures of expected inflation are useful if they help predict actual future inflation rates. Hence, I examine their predictive content using the test of Granger-causality, allowing for the possibility that survey inflation forecasts and actual realizations of inflation may be cointegrated, as in Engle and Granger (1987). In particular, consider the following regressions:

$$\Delta A_t = g_0 + \lambda_a(A_{t-1} - S_{t-1}) + \sum_{k=1}^{n} g_{1k}\Delta A_{t-s} + \sum_{k=1}^{n} g_{2k}\Delta S_{t-s} + \varepsilon_{1t} \quad (1)$$

and

$$\Delta S_t = g_0 + \lambda_s(A_{t-1} - S_{t-1}) + \sum_{k=1}^{n} g_{3k}\Delta A_{t-s} + \sum_{k=1}^{n} g_{4k}\Delta S_{t-s} + \varepsilon_{2t}, \quad (2)$$

Figure 4



where A is the actual future inflation rate, S is the survey inflation forecast, and ε_s are disturbance terms. Survey measures Granger-cause inflation if $\lambda_a \neq g_{2k} \neq 0$. In that case, survey inflation forecasts provide information about the subsequently realized inflation rates beyond what is already contained in the past history of actual inflation. Similarly, inflation Granger-causes survey measures if $\lambda_s \neq g_{3k} \neq 0$. In that case, inflation has information about future survey measures beyond what is already contained in the past history of survey measures. In the context of these regressions, survey measures are completely backward looking in expectation formation if $\lambda_a = g_{2k} = 0$, but $\lambda_s \neq g_{3k} \neq 0$.

Regressions (1) and (2) include a variable that measures deviations of the actual future inflation rates from their survey forecasts. The hypothesis that actual future inflation rates and survey forecasts may be cointegrated in the long run implies that these two series will move together in the long run.[10] In the short run, they may drift apart, but ultimately they will revert toward

[10] The results here (not reported) are consistent with the evidence in Grant and Thomas (1999) that Livingston and Michigan forecasts are cointegrated with actual inflation.

one another if they are cointegrated. This comovement may, however, occur when survey forecasts revert to actual realization of inflation ($\lambda_s \neq 0$ in (2)), actual future inflation reverts to survey forecasts ($\lambda_a \neq 0$ in (1)), or both adjust in response to such deviations ($\lambda_a \neq 0, \lambda_s \neq 0$). The variable that measures deviations is usually referred to as the error-correction variable, and the coefficients (λ_a, λ_s) are referred to as the error-correction coefficients. From a policy perspective, the most interesting case is the one in which the adjustment occurs mostly through actual realizations of inflation reverting to survey forecasts, so that $\lambda_a \neq 0$ but $\lambda_s = 0$. In that case, survey forecasts have predictive content for future inflation.

Tests of rationality of survey measures have emphasized two key properties of rational expectations. One, they should be unbiased in the sense survey respondents forecast inflation correctly on average. Two, forecasts should be efficient in that survey respondents should consider all information pertinent to the future behavior of inflation. The test for bias is usually implemented by running the following regression:

$$A_t = a_0 + a_1 S_t + \nu_t \tag{3}$$

where A is actual future inflation rate, S is the survey forecast, and ν is the disturbance term. Survey forecasts are unbiased if $a_0 = 0, a_1 = 1$.[11] Similarly, if survey forecasts are efficient, then the forecast error should not be correlated with known, pertinent information. The test for efficiency is often implemented by running the following regression:

$$e_t = b_0 + b_1 I_{t-1} + \eta_t, \tag{4}$$

where e_t is the forecast error $(A_t - S_t)$, I is the information set containing variables pertinent to the behavior of inflation, and η is the disturbance term. Survey forecasts are said to be efficient if the forecast error is uncorrelated with the variables in the information set I, either individually or jointly.[12] This statement implies that the coefficients vector $b_1 = 0$.

The efficiency test brings up two other issues. In previous work, the test for efficiency has generally been performed including the economic variables in (4), one at a time, as in Thomas (1999). But, as noted in Maddala (1990), inferences on efficiency based on the individual consideration of economic

[11] The test for unbiasedness is generally conducted including the constant term, implicitly allowing for the possibility that actual inflation may not at all be correlated with the survey forecasts. Hence, the specification (3) nests this hypothesis.

[12] For rational agents, the question of what variables should be included in the information set depends on costs and benefits. Since past values of a variable being forecast (inflation) are readily available, that variable should be in the information set. But this cannot be said of other variables. The agents will set the marginal cost equal to the marginal benefit of acquiring information. This analysis leads to the distinguishing of weak-form efficiency, where the information set includes only past values of the variable being forecast, from strong-form efficiency, where the information set also includes past values of other variables. A good review appears in Maddala (1990).

variables may change when variables are considered jointly.[13] The empirical work here therefore considers economic variables both individually and jointly. The other issue in the test for efficiency concerns the use of revised as opposed to real-time data. In most previous work, the tests were performed using the revised data on the past values of the economic variables in the information set. But many analysts, including Keane and Runkle (1989) and Maddala (1991), correctly point out that such revised data would not have been known to the survey respondents at the time they made their predictions. It is suggested that real-time data on the past values of the economic variables should be used in the test for efficiency.

In addition to the tests for predictive content and rationality, I also present summary error statistics that measure the overall predictive accuracy of survey forecasts. The summary statistics considered here are the mean error (ME), the mean absolute error (MAE), and the root mean squared error ($RMSE$). The mean error is a simple measure of forecasting bias; a positive mean error implies that survey respondents on average underestimated inflation. The mean absolute error and the root mean squared error are measures of forecasting accuracy. If a string of positive forecast errors is accompanied by a string of negative forecast errors, the survey respondents may issue forecasts with a zero mean error, but large mean absolute errors. The root mean squared error is the other measure of forecast accuracy. Since the root mean squared error is the square root of the mean value of the squares of the forecast errors, large forecast errors have a greater effect on the $RMSE$ than the MAE.

2. EMPIRICAL RESULTS

Table 1 presents the summary error statistics for the full sample period 1961:1 to 2001:3, as well as for two subperiods, denoted as before the early period (1961:1 to 1980:2) and the later period (1980:3 to 2001:3). It also contains results for the Greenspan period and presents the relevant error statistics for the naïve inflation forecasts. The forecasting accuracy of a survey measure relative to the benchmark naïve forecast is assessed by computing the ratio, defined as the $RMSE$ of the survey forecast divided by the $RMSE$ of the naïve forecast. If this ratio is less than unity for a survey forecast, then it means the survey forecast is more accurate than the benchmark forecast.

The results on forecast accuracy reported in Table 1 suggest the following observations. First, the three survey forecasts considered here are more accurate than the naïve forecast, indicating that survey measures contain information about future inflation rates beyond what is already contained in the most recent past inflation rate. Second, the mean error is positive in the early period

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[13] Tests for efficiency based on including variables one at a time would be subject to the biases generated by the omission of other relevant variables.

Table 1 Forecasting Accuracy of Survey Measures of Expected Inflation Ahead CPI

Survey	Mean Error	Mean Absolute Error	Root Mean Squared Error	Ratio
	(1)	(2)	(3)	(4)
	Panel A: Full Period 1961:1–2000:3			
Livingston	−0.22	1.17	1.57	0.73
Michigan-Mean	−0.43	1.21	1.55	0.73
Naïve	0.06	1.53	2.14	
	Panel B: Early Period 1961:1–1980:2			
	(1)	(2)	(3)	(4)
Livingston	0.66	1.11	1.59	0.66
Michigan-Mean	0.17	1.23	1.63	0.67
Naïve	0.75	1.76	2.42	
	Panel C: Later Period 1980:3–2000:3			
	(1)	(2)	(3)	(4)
Livingston	−1.14	1.25	1.55	0.51
Michigan-Mean	−1.00	1.19	1.48	0.81
Michigan-Median	−0.03	0.78	0.98	0.53
Professional Forecasters*	−0.60	0.95	1.24	0.68
Naïve	−0.51	1.29	1.83	
	Panel D: Greenspan Period 1987:4–2000:3			
	(1)	(2)	(3)	(4)
Livingston	−0.65	0.82	0.94	0.94
Michigan-Mean	−0.89	1.00	1.25	1.25
Michigan-Median	0.01	0.66	0.86	0.86
Professional Forecasters*	−0.24	0.69	0.80	0.80
Naïve	−0.08	0.74	1.00	

*For Professional Forecasters, the sample period is 1981:3–2000:3.

Notes: The naïve forecast is simply a backward-looking forecast, measured here by the recent one-year CPI inflation known to the survey respondent at the time the forecast is made. Ratio is the root mean squared error of the survey forecasts divided by the root mean squared error of the naïve forecasts; a value below unity indicates that the survey forecasts outperform the naïve forecasts. The forecast horizon for the Livingston forecasts is the 14-month period.

and negative in the later period for both the Livingston and Michigan-mean forecasts. The SPF forecasts that are available only for the later period have a negative mean error. Those results suggest that survey respondents underestimated inflation in the early period, when inflation was trending upward, and overestimated inflation in the later period, when inflation was trending downward. The exception is the Michigan-median forecasts, which are available only for the later period and have a mean error that is negligible. These results are in line with those in Thomas (1999).

As Table 1 shows, for the later period the forecast bias is generally negative, implying that survey respondents overestimated inflation. There is a substantial reduction in the size of the bias if the Volcker period is excluded, implying that survey respondents probably did not believe in the deflationary nature of Fed policy when it was first put in place in 1979 (see Panels C and D, Table 1).[14] One key aspect of these results is that the negative bias appears in the Michigan-mean forecasts, but not in the Michigan-median forecasts. This difference occurs because a small percentage of the households constituting the Michigan respondents overestimated inflation by a large amount over the period. This feature of Michigan household forecasts has the effect of inflating the mean value of the forecasts but not the median, so the negative bias persists in the Michigan-mean forecasts (Thomas 1999).

The survey forecasts are somewhat more accurate than a benchmark naïve forecast. This result implies that survey forecasts have some information about future inflation beyond that already contained in the most recent past inflation rate. I now consider the results of the test for Granger-causality reported in Table 2, a more rigorous test of predictive content. As the table shows, (see χ^2_1 statistics), with the exception of the Livingston forecasts, survey forecasts considered here Granger-cause inflation, implying that survey forecasts have information about the subsequently realized inflation rates beyond what is already contained in the past history of actual inflation rates. The results for the Livingston forecasts are mixed: the Livingston forecasts do not Granger-cause inflation in the full and later periods. In contrast, inflation Granger-causes all three survey forecasts, implying the presence of a backward-looking component in the formation of inflationary expectations (see χ^2_2 statistics in Table 2).

The error-correction variable is usually significant in equation (1) for explaining changes in the realizations of future inflation rates when the Michigan-mean, Michigan-median, and SPF forecasts are used (see Table 2). This result implies that in the short run a persistent deviation of the survey forecast from inflation is corrected in part through adjustment of actual future inflation rates.

[14] This is consistent with the evidence in Dotsey and DeVaro (1995), indicating the deflation of the early 1980s was not anticipated by economic agents.

Table 2 Test for Predictive Content

	Panel A: Full Period 1961:1–2000:3					
Survey	λ_a	$S1$	χ_1^2	λ_s	$S2$	χ_2^2
Livingston	−0.02 (0.2)	−0.15 (0.5)	03.4	0.24 (5.5)	0.18 (1.2)	122.9*
Michigan-Mean	−0.10 (1.8)	00.11 (0.9)	16.9*	0.23 (3.5)	0.68 (2.2)	36.6*
	Panel B: Early Period 1961:1–1980:2					
	λ_a	$S1$	χ_1^2	λ_s	$S2$	χ_2^2
Livingston	−0.70 (2.6)	−0.26 (0.5)	67.2*	0.14 (1.1)	0.58 (1.7)	19.9*
Michigan-Mean	−0.10 (2.2)	−0.15 (1.2)	19.3*	0.26 (2.4)	0.86 (1.5)	53.1*
	Panel C: Later Period 1980:3–2000:3					
	λ_a	$S1$	χ_1^2	λ_s	$S2$	χ_2^2
Livingston	−0.21 (1.0)	0.55 (0.9)	07.8	0.14 (2.2)	0.25 (1.4)	71.6*
Michigan-Mean	−0.23 (2.5)	0.37 (1.9)	14.6*	0.17 (2.6)	0.40 (2.3)	101.4*
Michigan-Median	−0.20 (2.8)	0.62 (3.0)	37.8*	0.06 (1.0)	0.60 (4.1)	77.1*
Professional Forecasters	−0.19 (2.3)	0.57 (2.1)	35.3*	0.05 (1.3)	0.37 (2.6)	58.0*
	Panel D: Greenspan Period 1987:4–2000:3					
	λ_a	$S1$	χ_1^2	λ_s	$S2$	χ_2^2
Livingston	−0.52 (2.5)	0.43 (0.5)	94.1*	0.02 (0.1)	0.44 (1.1)	13.4*
Michigan-Mean	−0.13 (1.6)	0.25 (1.2)	20.6*	0.15 (2.0)	0.39 (1.8)	65.1*
Michigan-Median	−0.14 (2.0)	0.59 (2.1)	28.6*	0.05 (1.9)	0.50 (3.1)	35.4*
Professional Forecasters	−0.22 (2.9)	0.52 (1.8)	24.4*	0.02 (0.7)	0.29 (1.5)	65.2*

*Significant at the 5 percent level.

Notes: The coefficients reported above are from regressions of the form
$\Delta A_t = a_0 + \lambda_a(A_{t-1} - S_{t-1}) + \sum_{s=1}^{k} a_{1s}\Delta A_{t-s} + \sum_{s=1}^{k} a_{2s}\Delta S_{t-s} + \varepsilon_1$
$\Delta S_t = a_0 + \lambda_s(A_{t-1} - S_{t-1}) + \sum_{s=1}^{k} a_{3s}\Delta A_{t-s} + \sum_{s=1}^{k} a_{4s}\Delta S_{t-s} + \varepsilon_2$,
where A is actual future inflation, and S is the survey inflation forecast. Parentheses contain t-values. $S1$ is $\sum_{s=1}^{k} a_{2s}$ and $S2$ is $\sum_{s=1}^{k} a_{3s}$. χ_1^2 tests ($\lambda_a = 0; a_{2s} = 0$) and χ_2^2 tests ($\lambda_s = 0; a_{3s} = 0$). The regressions above are estimated by ordinary least squares, the standard errors being corrected for the presence of serial correlation. The parameter k measures the lag length, which is set at 4. The sample period is 1981:3–2000:3 for Professional Forecasters.

Therefore, these survey forecasts have predictive content for actual future inflation.

Table 2 also presents the sum of coefficients that appear on lagged values of realized inflation in forecasting equations of the form (2) (see $S2$ in Table 2). We may interpret this sum coefficient as a measure of the degree of backward-looking behavior in expectation formation of survey respondents. In the later period, this coefficient is usually larger for Michigan-median households than for Livingston or SPF respondents, indicating that Michigan-median households paid more attention to past realized inflation rates when making inflation predictions than did the Livingston or SPF respondents. Since inflation has trended downward in the later period, in part due to change in monetary policy regime, Michigan-median households predict actual inflation well compared to professional economists and forecasters. It appears that Livingston economists and SPF forecasters did not believe the deflation of the early 1980s was there to stay, so they continued to give less weight to lower realized inflation rates.

Tables 3 and 4 present tests for rationality. Table 3 contains test results for unbiasedness and Table 4 for efficiency with respect to past information on economic variables pertinent to the behavior of inflation. If we focus on the results for unbiasedness in Table 3, three observations stand out. First, test results for the Livingston and Michigan-mean forecasts are sensitive to the sample period. The Livingston forecasts are unbiased over the full period, but biased within each period. The Michigan-mean forecasts are biased over the full period and the later period, but unbiased over the early period. Second, for the later period of downward trending inflation, all survey forecasts considered here are biased except the Michigan-median forecasts. Excluding observations pertaining to the Volcker period does not alter results on the biasedness of the Livingston and Michigan-mean forecasts (see Panel D in Table 3).

As I discussed earlier, tests for efficiency in previous research have generally been reported using revised data on the past values of the economic variables. The economic variables that have usually been employed are actual inflation, money growth, increase in oil prices, and the level of the output gap. The empirical work reported in Thomas (1999) indicates that the forecast error in the Livingston and Michigan-mean forecasts is correlated with the level of the output gap but none other of the economic variables. This result implies that survey respondents considered past values of actual inflation, money growth, and energy price inflation, but ignored the behavior of the output gap.

The forecast error may be correlated with the past values of the output gap because of the use of the revised data on the output gap. The recent work in Orphanides and van Norden (2002) shows that real-time estimates of the level of the output gap are generally subject to significant revisions. If this is true, then the revised data on the output gap used in tests for efficiency would not have been available to the survey respondents. This result can be

Table 3 Test for Unbiasedness

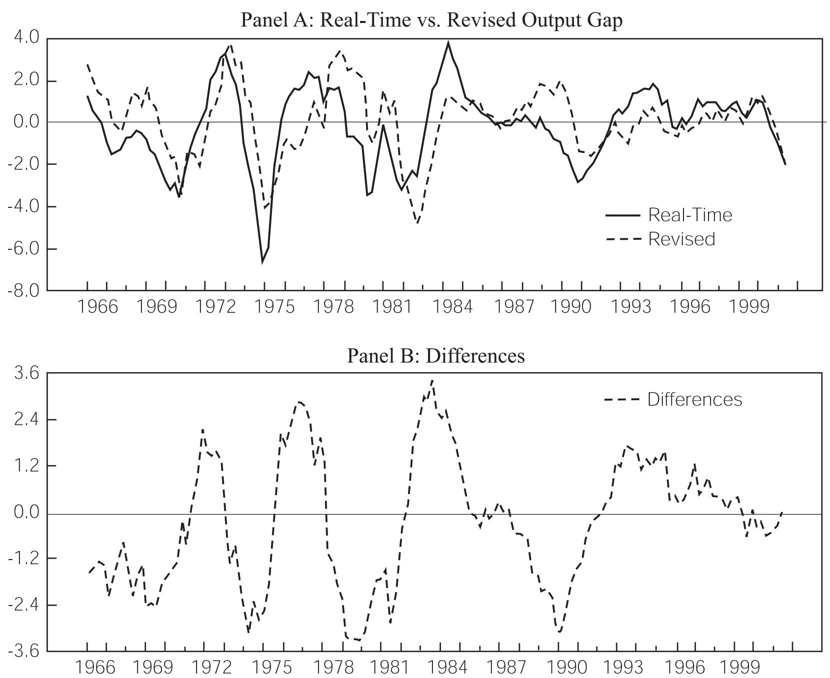
Survey	a	b	R-Squared	χ^2
	Panel A: Full Period 1961:1–2000:3			
	(1)	(2)	(3)	(4)
Livingston	0.26 (0.6)	0.88 (05.6)	0.59	0.91
Michigan-Mean	−0.80 (2.0)	1.00 (11.4)	0.73	9.33*
Naïve	1.40 (3.3)	0.70 (05.8)	0.51	11.20*
	Panel B: Early Period 1961:1–1980:2			
	(1)	(2)	(3)	(4)
Livingston	0.55 (1.5)	1.02 (10.6)	0.76	5.5**
Michigan-Mean	−0.36 (0.8)	1.10 (11.3)	0.79	1.1
Naïve	1.59 (2.4)	0.80 (5.2)	0.56	6.6*
	Panel C: Later Period 1980:3–2000:3			
	(1)	(2)	(3)	(4)
Livingston	0.56 (1.5)	0.58 (7.2)	0.56	59.3*
Michigan-Mean	−0.20 (0.3)	0.81 (5.5)	0.56	30.2*
Michigan-Median	0.37 (0.8)	0.89 (7.5)	0.60	0.9
Professional Forecasters	1.42 (2.7)	0.48 (3.4)	0.26	21.1*
Naïve	1.73 (4.0)	0.44 (4.0)	0.50	26.9*
	Panel D: Greenspan Period 1987:4–2000:3			
	(1)	(2)	(3)	(4)
Livingston	−0.16 (0.3)	0.85 (4.5)	0.45	19.1*
Michigan-Mean	−0.14 (0.1)	0.81 (5.5)	0.30	16.8*
Michigan-Median	−0.90 (0.7)	1.30 (3.1)	0.35	0.5
Professional Forecasters	−0.00 (0.1)	0.96 (3.9)	0.48	1.9

*Significant at the 5 percent level.

**Significant at the 10 percent level.

Notes: The coefficients reported above are from regressions of the form $A_t = a + b P_t + e_t$, where A is the actual future inflation rate and P is its survey forecast. Inflation forecasts are unbiased if $a = 0, b = 1$. χ^2 is the Chi-square statistic that tests the null hypothesis $a = 0, b = 1$. Ordinary least squares are used, and the standard errors are corrected for the presence of serial correlation. Parentheses contain t-values.

Figure 5



seen in Figure 5, which charts real-time and final estimates of the output gap, generated using the historical real-time data in Croushore and Stark (1999).[15] Figure 6 presents real-time and revised data on money growth. It shows that the level of the output gap has been subject to far more significant revisions than has the measure of money growth (compare the revisions charted in Panel B of Figure 5 with that in Figure 6).

Table 4 presents test results for efficiency using both revised and real-time estimates of the output gap. I also use real-time estimates of money growth in tests for efficiency.[16] The forecast error in the Livingston and Michigan-mean forecasts is correlated with the output gap variable when revised data are used, but this correlation weakens or disappears when real-time data are used (compare t-values on the gap variable in Panels A and B of Table 4). Also, the forecast error in the Livingston and Michigan-mean forecasts is correlated

[15] The measure of the output gap used in Thomas (1999) is the Hodrick-Prescott filtered estimate of the output gap. I use the same filter, but employ the real-time historical data available on output to generate estimates of the output gap series.

[16] Since real-time data available in Croushore and Stark (1999) begins in 1966, the sample period covering the tests for efficiency starts in 1966:1.

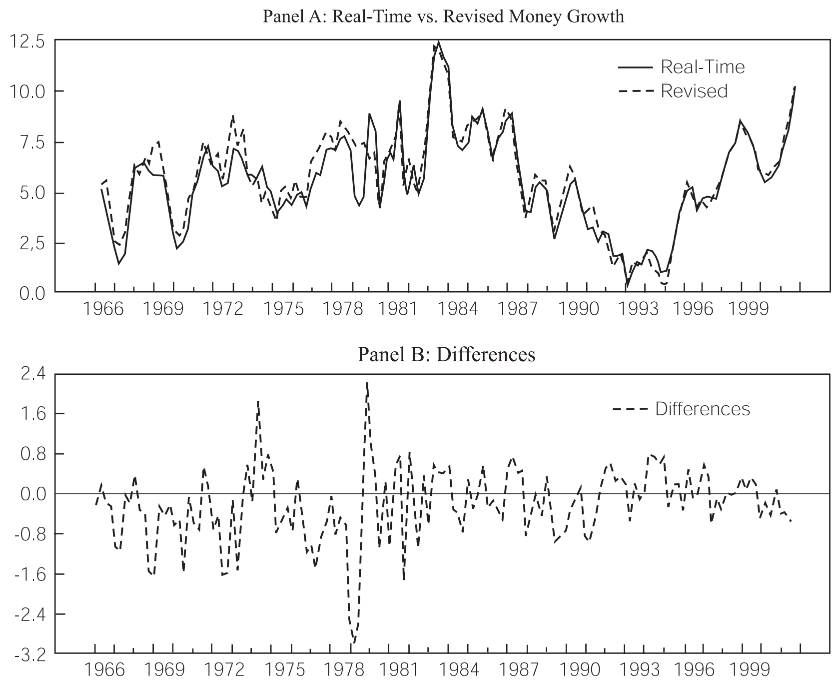
Table 4 Test for Efficiency

	Panel A: Livingston, 1961:1–2000:3					
	Revised Data			Real-Time Data		
Independent Variable (X)	c_o	c_1	χ_1^2	c_0	c_1	χ_1^2
Inflation	−0.07 (0.2)	−0.03 (0.5)		−0.26 (0.5)	0.01 (0.1)	
Gap	−0.24 (0.9)	0.45 (3.4)		−0.26 (0.7)	0.27 (1.4)	
Money Growth	−0.33 (0.7)	0.02 (0.1)		0.17 (0.3)	−0.09 (0.7)	
Oil Prices	−0.23 (0.7)	0.00 (0.1)		−0.31 (0.9)	0.00 (0.1)	
Jointly			21.6*			4.9
	Panel B: Michigan-Mean, 1961:1–2000:3					
	c_o	c_1	χ_1^2	c_0	c_1	χ_1^2
Inflation	0.58 (2.0)	0.03 (0.5)		00.54 (1.4)	0.03 (0.4)	
Gap	−0.42 (2.3)	0.32 (2.4)		−0.36 (1.5)	0.23 (1.5)	
Money Growth	−1.2 (3.9)	0.14 (1.8)		−0.87 (2.4)	0.08 (1.1)	
Oil Prices	−0.42 (1.9)	0.00 (0.7)		−0.40 (1.6)	0.00 (0.7)	
Jointly			8.8*			5.2
	Panel C: Michigan-Median, 1980:1–2000:3					
	c_o	c_1	χ_1^2	c_0	c_1	χ_1^2
Inflation	0.51 (1.4)	−0.15 (1.7)		0.51 (1.4)	−0.15 (1.7)	
Gap	−0.02 (0.1)	0.05 (0.3)		−0.03 (0.2)	0.02 (0.8)	
Money Growth	−0.33 (1.2)	0.05 (1.3)		−0.28 (0.9)	0.04 (0.9)	
Oil Prices	0.03 (0.2)	0.00 (0.9)		−0.03 (0.2)	0.00 (0.9)	
Jointly			5.3			7.2
	Panel D: Professional Forecasters, 1981:3–2000:3					
	c_o	c_1	χ_1^2	c_0	c_1	χ_1^2
Inflation	00.62 (2.0)	−0.34 (4.0)		0.62 (2.0)	0.34 (4.0)	
Gap	−0.58 (2.8)	0.20 (1.7)		−0.61 (2.7)	0.09 (0.5)	
Money Growth	−0.44 (1.9)	0.03 (0.6)		−0.40 (1.5)	0.03 (0.7)	
Oil Prices	−0.60 (2.7)	0.00 (0.3)		−0.60 (2.7)	0.00 (0.3)	
Jointly			37.4*			41.8*

*Significant at the 5 percent level.

Notes: The coefficients reported above are from regression of the form $e_t = c_0 + c_1 X_{t-1}$, where e is the forecast error and X_{t-1} is the lagged yearly growth rate of prices or money or oil prices, or the level of the output gap. Gap is the Hodrick-Prescott filtered estimate of the output gap. The regressions are estimated including one variable at a time as well as all of them together (jointly). Parentheses contain t-values. χ_1^2 tests all variables that when included jointly are not significant in explaining the forecast error.

Figure 6



with lagged inflation, money growth, energy price inflation, and output gap variables when they are jointly included in the pertinent regression estimated using revised data. But this correlation again disappears when real-time data are used (compare χ_1^2 statistics in Panels A and B of Table 4). These results indicate caution is merited when interpreting the results on efficiency derived using revised data.[17]

Another notable result is that for the later period of downward trending inflation, the SPF forecasts are correlated with the past values of inflation, suggesting that professional forecasters ignored the past information in actual inflation rates. In contrast, the forecast errors in Michigan-median forecasts are not correlated at all with any of the economic variables in the information set used here. These results hold even when real-time data are used (see Panels C and D in Table 4).

[17] This result may not be surprising given the results of some recent research. Orphanides and van Norden (2002) present evidence indicating real-time estimates of the output gap do not do as well in predicting inflation, as do the estimates based on the revised data. Amato and Swanson (2001) also report considerable reduction in the predictive content of money for output when real-time data on money growth is used.

3. CONCLUDING REMARKS

I have examined the forecasting accuracy, predictive content, and rationality of three survey measures of one-year-ahead CPI expected inflation: the Livingston forecasts of professional economists, the mean and median forecasts of Michigan households, and the consensus forecasts of the professional forecasters. Three interesting findings emerge from this analysis. First, the median inflation forecasts of Michigan households outperform those of professional economists and forecasters in the period covering the 1980s and 1990s. They are more accurate, unbiased, have predictive content for future inflation, and are efficient with respect to economic variables generally considered pertinent to the behavior of inflation. Second, in the full period the Livingston inflation forecasts appear unbiased and efficient, but those properties do not carry over to the subperiods studied here. Third, the inflation forecasts of professional forecasters are biased and inefficient. The results in the article indicate that Livingston and SPF survey respondents overestimated inflation in the deflationary period of the early 1980s and the 1990s and that they were slow in adjusting their inflation expectations in response to lower realized inflation rates, generated in part by change in the monetary policy regime. The fact that the survey respondents overestimated may explain in part why inflation forecasts of professional economists and forecasters do not perform well relative to those of Michigan households.

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