CHICAGO JOURNALS

On the Accuracy of Time-Series, Interest Rate, and Survey Forecasts of Inflation
Author(s): R. W. Hafer and Scott E. Hein
Source: *The Journal of Business*, Vol. 58, No. 4 (Oct., 1985), pp. 377-398
Published by: The University of Chicago Press
Stable URL: http://www.jstor.org/stable/2352832
Accessed: 20/06/2014 13:12

Your use of the JSTOR archive indicates your acceptance of the Terms & Conditions of Use, available at
http://www.jstor.org/page/info/about/policies/terms.jsp

JSTOR is a not-for-profit service that helps scholars, researchers, and students discover, use, and build upon a wide range of content in a trusted digital archive. We use information technology and tools to increase productivity and facilitate new forms of scholarship. For more information about JSTOR, please contact support@jstor.org.

The University of Chicago Press is collaborating with JSTOR to digitize, preserve and extend access to *The Journal of Business.*

http://www.jstor.org

This content downloaded from 62.122.79.21 on Fri, 20 Jun 2014 13:12:34 PM
All use subject to JSTOR Terms and Conditions

R. W. Hafer
Federal Reserve Bank of St. Louis

Scott E. Hein
Texas Tech University

On the Accuracy of Time-Series, Interest Rate, and Survey Forecasts of Inflation*

This paper compares the accuracy of three different inflation forecasting procedures. These include a univariate time-series model, an interest rate model based on the methodology of Fama and Gibbons, and the median forecasts derived from the American Statistical Association–National Bureau of Economic Research survey. The evidence presented is based on ex ante forecasts of quarterly inflation rates using the GNP deflator for the period 1970:I–1984:II. Based on the evidence presented, the general conclusion is that the survey forecasts provide the most accurate inflation forecasts.

I. Introduction

There has been much work examining and evaluating different methodologies in forecasting inflation. For example, Fama (1975, 1977) develops an interest rate model to predict the 1-month-ahead rate of inflation using the CPI. Fama and Gibbons (1982, 1984) modify the interest rate model to account for a nonconstant real rate of interest and compare it to a univariate time-series forecasting model and to the Livingston forecasts. Carlson (1977*a*, 1977*b*) and others also analyze the consensus forecasts from the Livingston survey pertaining to multiperiod forecasts of inflation. Pearce (1979) considered the Livingston survey and time-series forecasts.

Our purpose in this paper is to investigate further the relative forecasting ability of three different methodologies. In contrast to previous studies that have generally used the CPI to measure inflation, our analysis uses the implicit GNP deflator. This modification is motivated largely by the fact that calculations of the CPI inflation rate often are distorted greatly by changes in relative prices (e.g., Blinder 1980; Fischer 1981).

* We would like to thank John A. Carlson, Steven Holland, Doug Pearce, and Victor Zarnowitz for their comments and suggestions on an earlier version of this paper. The views expressed are those of the authors and not the Federal Reserve Bank of St. Louis or the Federal Reserve System.

(*Journal of Business*, 1985, vol. 58, no. 4)
© 1985 by The University of Chicago. All rights reserved.
0021-9398/85/5804-0003$01.50

This content downloaded from 62.122.79.21 on Fri, 20 Jun 2014 13:12:34 PM
All use subject to JSTOR Terms and Conditions

This modification requires that the periodicity of the data be quarterly. Thus a univariate time-series model of the GNP deflator is identified, estimated and used to generate ex ante forecasts. Using the methodology of Fama and Gibbons (1984), an interest rate model is developed using the 3-month Treasury bill rate. Finally, the American Statistical Association (ASA) and the National Bureau of Economic Research (NBER) have been conducting a quarterly survey of 30–50 individuals professionally engaged in economic forecasting to obtain ex ante forecasts of inflation and other economic measures since the late 1960s. The existence of this survey allows us to compare ex ante forecasts from a time-series model, an interest rate model, and a survey. The sample studied is 1970–84, a period that encompasses a wide range of inflationary conditions.

The format of the paper is as follows: Section II presents a description of the interest rate model. Section III presents and discusses the univariate time-series model. Both of these models are estimated initially over the 1953–69 period. Section IV briefly discusses the ASA-NBER survey forecasts. Comparison of the three different sets of inflation forecasts is made in Section V. This comparison is made for the period 1970:I–1984:II and three subperiods. Evidence is presented in Section VI testing the bias of each forecast series. In Section VII, we investigate the relative information content of each forecast series in head-to-head contests to explain the actual behavior of prices. Section VIII concludes the paper.

II. Interest Rate Model

The interest rate model used to forecast inflation is based on the so-called Fisher equation:

$$R^t_{t-1} = r^t_{t-1} + I^t_{t-1}, \tag{1}$$

where R^t_{t-1} is the nominal interest rate observed at the end of period $t - 1$ for the holding period $t - 1$ to t; r^t_{t-1} is the expectation, formed in period $t - 1$, of the real interest rate for period t; and I^t_{t-1} is the expectation in $t - 1$ of the rate of inflation for period $t - 1$ to t. Fama (1975) presents evidence suggesting that the rates on U.S. Treasury bills are efficient predictors of short-term inflation. This finding was based on rewriting equation (1) in the form

$$I^t_{t-1} = -r^t_{t-1} + R^t_{t-1} \tag{2}$$

and estimating the regression equation

$$I_t = \alpha_0 + \beta_1 R_{t-1} + \epsilon_t, \tag{3}$$

where α and β are coefficients to be estimated, and ϵ_t is unexpected inflation. Estimates of equation (3) presume that changes in the ex-

This content downloaded from 62.122.79.21 on Fri, 20 Jun 2014 13:12:34 PM
All use subject to JSTOR Terms and Conditions

pected real rate of interest can be subsumed in the constant term α_0. Studies by Hess and Bicksler (1975), Nelson and Schwert (1977), Garbade and Wachtel (1978), and Fama and Gibbons (1982), however, show that there is significant variation in the expected real rate over time.

These latter studies present evidence suggesting that the expected real return behaves as a random walk. This means that changes in the ex post real return may be captured by a moving-average model. To see this, write the ex post real return for period t as the ex ante real rate plus a random disturbance term (η), or

$$R_{t-1} - I_t = r_{t-1}^t + \eta_t. \tag{4}$$

If r_{t-1}^t does behave as a random walk, then changes in r_{t-1}^t and η_t should be white noise processes. Following Fama and Gibbons (1984), this then suggests the following time-series model for period-to-period changes in the ex post real return:

$$(R_{t-1} - I_t) - (R_{t-2} - I_{t-1}) = a_t - \theta a_{t-1}, \tag{5}$$

where θ is the moving average parameter to be estimated. Fama and Gibbons (1984) estimate equation (5) using monthly, ex post real returns based on the CPI measure of inflation and a 1-month T-bill rate observed at the end of month $t - 1$. They find that for the period 1953–77 the change in the ex post real rate is adequately captured by a first-order moving average model. The size of the estimated θ parameter (0.9223) suggests that the variance of η_t in equation (4) is large relative to the change in the expected real rate.

We test the assumption that the change in the ex post quarterly real return can be approximated by a first-order moving average process. In our test, the nominal interest rate is measured by the 3-month T-bill rate observed at the midpoint of the quarter.[1] The inflation rate is measured as the annualized log difference between the level of the GNP deflator in quarter t and $t - 1$. The estimation period is 1953–69.[2]

Table 1 presents the sample autocorrelations of the level of the ex post real return (r_t) and the change in the real return ($r_t - r_{t-1}$). The autocorrelations on the level of the real return (row 1) decline relatively slowly, hovering around 0.2 to 0.3 for lags 1–4. Differencing the real return yields autocorrelations (row 2) that are indicative of a first-order moving average model: the first-order autocorrelation (-0.54) is large

1. The reason for using the T-bill rate observed at the midpoint of the quarter is to match the timing of the survey data. Because the survey is taken in the second month of each quarter, taking the T-bill rate from a coincident time provides the financial market participant the opportunity to observe the same amount of data as the survey respondent. The impact of this assumption is examined in the App.

2. The estimation period runs through 1969:IV, allowing us to generate ex ante forecasts for the period 1970:I–1984:II. This forecast period is chosen to coincide with the survey data used in later secs.

This content downloaded from 62.122.79.21 on Fri, 20 Jun 2014 13:12:34 PM
All use subject to JSTOR Terms and Conditions

TABLE 1 Sample Autocorrelations, 1953–69

Variable	1	2	3	4	5	6	7	8	9	10	11	12
r_t	.233	.299	.322	.260	.154	.238	.136	.195	.158	.242	.006	.144
$r_t - r_{t-1}$	−.538	.027	.052	.036	−.133	.128	−.103	.061	−.080	.199	−.244	.153
I_t	.427	.414	.436	.285	.226	.266	.125	.101	.065	.105	.016	.095
$I_t - I_{t-1}$	−.536	−.011	.146	−.058	−.081	.130	−.092	.028	−.069	.151	−.170	.160

NOTE.—r_t is the ex post real return in period t; I_t is the inflation rate in period t, measured as the log difference in the GNP deflator.

This content downloaded from 62.122.79.21 on Fri, 20 Jun 2014 13:12:34 PM
All use subject to JSTOR Terms and Conditions

relative to its standard error (0.12), and the remaining autocorrelations remain well within two standard errors of zero. Moreover, the inverse autocorrelation (not shown) reveals a pattern suggestive of a first-order moving average (MA [1]) process; the correlations exhibit a slow decline over the first nine lags before flattening to a value of approximately 0.20.

Based on the autocorrelations of the change in the ex post real rate in table 1, an MA(1) model on the change in the real rate was estimated for the period 1953:II–1969:IV. The outcome is (absolute value of t-statistics in parentheses)

$$\begin{aligned} (1 - B)r_t &= a_t - \underset{(11.27)}{0.810}\, a_{t-1} \\ \mathrm{SE} = 1.298 \quad & Q(11) = 6.64. \end{aligned} \tag{6}$$

This result is not inconsistent with the hypothesis that changes in the ex post real rate of return are captured by a first-order moving average process. The estimated value for the θ parameter is significantly different from zero at the 1% level, and the reported Q-statistic indicates that we cannot reject the hypothesis of white noise residuals at any reasonable level. The estimated value of θ is relatively large, suggesting that most of the observed variation in the ex post real return comes from changes of the unanticipated component in the real return and not from the expected real return itself.[3]

The estimates from equation (6) are used to generate ex ante forecasts of the level of the real return. More specifically, the forecast of next period's ex post real rate is given by $(R_{t-1} - I_t) = (R_{t-2} - I_{t-1}) - 0.810a_{t-1}$. With these predictions of the real return for period t and the nominal interest rate observed at the end of period $t - 1$, using equation (2) we generate ex ante forecasts of the inflation rate for the current quarter.

III. Time-Series Model

An alternative to the interest rate model's inflation forecast is one derived solely from the information contained in past rates of inflation. To construct such a time-series model, the autocorrelations of the rate of inflation measured using the log difference of the GNP deflator were examined for the sample period 1953–69. These autocorrelations are reported in row 3 of table 1. The behavior of the autocorrelations are

3. Fama and Gibbons (1984) estimate θ to be 0.923 using monthly data for the sample period 1953–77. This indicates that about 8% of the unexpected component of the last period's real rate change is incorporated into this period's forecast. Our estimate of 0.810 suggests about 19% of the unexpected change is reflected in this period's forecast, indicating that unforeseen shocks are more important in altering future forecasts of quarterly movements in the real rate.

This content downloaded from 62.122.79.21 on Fri, 20 Jun 2014 13:12:34 PM
All use subject to JSTOR Terms and Conditions

indicative of a nonstationary series: the reported values decay slowly as the lag increases. Consequently, the inflation series was differenced and the autocorrelations checked.

The autocorrelations of the differenced inflation-rate series, reported in row 4 of table 1, indicate that differencing has reduced the series to stationarity. The first-order autocorrelation coefficient (-0.536) is the only coefficient value significantly greater than its standard error (0.12), suggesting a first-order moving average model of the change in the inflation rate. Such a model selection also is indicated by the partial and inverse autocorrelation functions (not shown).

Given this information, the MA (1,1) model was fitted to the inflation rate for the sample period 1953:I–1969:IV. The estimation results are (absolute value of t-statistics in parentheses)

$$\begin{aligned} (1 - B)I_t &= a_t - \underset{(8.06)}{0.7119}\, a_{t-1} \\ \mathrm{SE} &= 1.336 \quad Q(11) = 7.10. \end{aligned} \tag{7}$$

The estimated MA parameter (0.7119) is significantly different from zero at the 1% level.[4] Moreover, the calculated Q-statistic (7.10) indicates that the simple model has reliably reduced the residuals to white noise. Thus, equation (7) is used to generate ex ante forecasts of the inflation rate for the post-1969 period.

IV. The ASA-NBER Survey

The period from 1970:I through 1984:II is chosen to compare relative forecasting ability because it allows us to compare the interest rate and time-series model forecasts with those that derived from the median survey response to the quarterly ASA-NBER questionnaire.[5] Along with the questionnaire, participants are provided with the preliminary figure of the level of the GNP deflator for the previous quarter. For example, when the first-quarter questionnaire is received, respondents know the fourth-quarter preliminary GNP deflator's value. At each

4. Our quarterly estimates relative to the monthly results of Fama and Gibbons (1982, 1984) suggest that the variance of the expected component of the inflation rate is larger relative to the variance of the unexpected part. Interestingly, their model for the monthly CPI inflation rate also is MA(1, 1).

5. For a description of the survey, see Zarnowitz (1969, 1983) and Su and Su (1975). It generally is reported that the survey is mailed to about 50 professional forecasters. It is interesting to note that, although the exact number of surveys mailed is not known to us, we have evidence showing a decline in responses over time. In 1970, e.g., there were 52 responses. By 1975 they had fallen to 44, and in the first two surveys of 1984 the number of responses averaged 32. This reinforces the view that care should be taken in recognizing that these forecasts are not "market" forecasts but forecasts from a number of professionals.

This content downloaded from 62.122.79.21 on Fri, 20 Jun 2014 13:12:34 PM
All use subject to JSTOR Terms and Conditions

survey, participants are asked to forecast (among other series) the level of the deflator for the current quarter and 4 quarters hence. By taking the previous quarter's preliminary number and the respondents' median forecast for the current quarter, we can calculate an ex ante inflation forecast.

Before examining the relative accuracy of the alternative forecasts, some comments about the timing for the different forecasts are appropriate. The survey respondents receive the questionnaire sometime in the second month of the quarter in which they are asked to forecast the current quarter's GNP deflator as well as the level for the next 4 quarters. This means that survey respondents have at their disposal 1 or possibly 2 months of current-quarter information, which may improve their forecast relative to the alternative procedures. As mentioned above (in n. 1), in an attempt to align the forecaster's information set with that of the financial market, the interest rate model uses the Treasury bill rate observed at a point during the quarter's second month. Because we do not know exactly when the respondents form their predictions, selecting the midpoint of the quarter for the interest rate would come close to matching the available information sets.[6]

With regard to the time-series and interest rate model forecasts, our procedure presumes that the previous quarter's actual inflation rate is known. In actuality, because of calculation and publication lags, this information is not available until sometime in the following quarter. Further, our time-series and interest rate model forecasts presume knowledge of the revisions in the data series that are only currently available.

V. Comparing Ex Ante Forecasts

In order to generate ex ante one-step-ahead forecasts for the nonsurvey models, the following procedure was followed: For both the real return and inflation rate models, the original coefficient estimates are taken from the 1953–69 period. These estimates are used to generate the 1970:I forecast. Then the estimation sample is updated to include the actual data for 1970:I, the model is reestimated, and a new ex ante forecast is generated for 1970:II. This updating, reestimation, and forecast procedure is continued throughout the forecast sample until

6. An alternative interest rate model was estimating using the T-bill rate observed at the end of the previous quarter. For example, the forecast of the first quarter would use the interest rate observed in the last week of December. This alignment of the T-bill rate and the inflation rate forecast follows the procedure of Fama and Gibbons (1984). Notice, however, that this provides less information to financial markets relative to the survey respondents. The result of using the end-of-quarter interest rate was to reduce the interest rate model's forecasting accuracy. For purposes of comparison, a discussion of the empirical results using the end-of-quarter interest rate is presented in the App.

This content downloaded from 62.122.79.21 on Fri, 20 Jun 2014 13:12:34 PM
All use subject to JSTOR Terms and Conditions

1984:II, the last available data on the actual inflation rate and the survey forecast.[7]

A. *Full Period Results*

The outcome of forecasting inflation for the 1970–84 period using the time-series, interest rate, and survey methods is summarized in table 2. The results for the full period indicate that the three procedures have mean absolute errors that are all less than 2 percentage points. The Theil forecast decomposition statistics further reveal that the forecast errors from each approach are due mainly to unequal covariation between actual and predicted inflation. In fact, the forecast error due to bias is small for all forecasts and essentially zero for the time-series model.

The ordering of the forecast accuracy indicates that the survey respondents, on average, provided more accurate predictions of the inflation rate than those derived from the time-series or interest rate models. Based on a mean squared error (MSE) criterion, the survey forecasts were more accurate than the interest rate and time-series model by almost 40%. The superiority of the survey differs from the finding of Fama and Gibbons (1984) that the interest rate model dominated the time-series and Livingston survey forecasts. The superiority of the survey is surprising also because we are evaluating the forecasts relative to the revised GNP deflator series. These revisions are part of the time-series and interest rate models, but were not available to survey respondents. Moreover, the full-period statistics indicate that

7. In generating the forecasts, the time-series models for the real return and the inflation rate were estimated 59 times. Although inspection of each estimated equation revealed that we could not reject the continued adequacy of the MA model (the Q-statistics could not reject white noise residuals), it is interesting to note that the estimated coefficients changed somewhat over time. For comparison purposes, we report the model estimates for the full period 1953–84 (absolute values of t-statistics in parentheses):

$$\begin{gathered}(1 - B)r_t = a_t - \underset{(9.82)}{0.662}\, a_{t-1} \\ \mathrm{SE} = 1.749 \quad Q(11) = 7.95;\end{gathered} \tag{i}$$

$$\begin{gathered}(1 - B)I_t = a_t - \underset{(6.60)}{0.5096}\, a_{t-1} \\ \mathrm{SE} = 1.565 \quad Q(11) = 13.08.\end{gathered} \tag{ii}$$

Note that relative to the 1953–69 estimates the MA parameters have declined over time. In terms of the inflation model, the decline in the MA parameter is fairly smooth during the 1970–84 period. The estimated θ coefficient for the real return, however, exhibits more variability across the period. These findings are important because they suggest that basing forecasts on coefficient estimates obtained solely from an earlier sample may provide misleading information. That is, holding the estimated coefficients constant during the forecast period when there is evidence indicating that such constancy is incorrect may bias forecast accuracy comparisons.

This content downloaded from 62.122.79.21 on Fri, 20 Jun 2014 13:12:34 PM
All use subject to JSTOR Terms and Conditions

TABLE 2 **Summary Forecast Statistics: Full Period and Subperiods**

Model	MAE	MSE	RMSE	B	V	CV
			1970:I–1984:II			
ARIMA	1.39	3.27	1.81	.00	.07	.93
T-BILL	1.42	3.38	1.84	.01	.01	.98
ASA-NBER	1.18	2.02	1.42	.07	.06	.87
			1970:I–1974:IV			
ARIMA	1.42	2.67	1.63	.15	.44	.41
T-BILL	1.20	2.15	1.47	.16	.10	.74
ASA-NBER	1.38	2.54	1.59	.59	.03	.38
			1975:I–1979:IV			
ARIMA	1.22	3.78	1.94	.02	.02	.96
T-BILL	1.38	2.91	1.71	.05	.03	.92
ASA-NBER	1.08	1.82	1.35	.00	.21	.79
			1980:I–1984:II			
ARIMA	1.54	3.38	1.84	.06	.07	.87
T-BILL	1.71	5.26	2.29	.12	.08	.79
ASA-NBER	1.06	1.66	1.29	.02	.33	.64

NOTE.—ARIMA is the time-series model; T-BILL represents the interest rate model; and ASA-NBER is the survey result. MAE is the mean absolute error, MSE is the mean squared error and RSME denotes the root mean square error. B, V, and CV are, respectively, the Theil decomposition statistics measuring the degree of error due to bias and the variance and covariance between the actual and predicted series.

the time-series model's forecasts produce an MSE that is as accurate as that of the interest rate model.

B. *Subperiod Results*

Because the full forecast period encompasses numerous changes in the inflationary environment, it is useful to compare the relative forecasting properties of the alternative models for different subperiods. Table 2 also reports results from three separate subperiods. The first subperiod covers the span 1970:I–1974:IV. This period is characterized by several notable events: the breakdown of the Bretton Woods agreement and the establishment of a floating exchange rate regime; the imposition of wage and price controls beginning in August 1971 and continuing in different forms until April 1974; the OPEC oil boycott in late-1973, which lead to a quadrupling of oil prices; and the increase in the relative price of food in 1973 and 1974.

The forecast statistics in table 2 indicate that the models did fairly well in forecasting inflation during this turbulent period. The MSEs generally are lower than the full-period results. The forecast summary statistics reveal that the interest rate model yields more accurate predictions than the time series or the survey responses. In this regard, the

This content downloaded from 62.122.79.21 on Fri, 20 Jun 2014 13:12:34 PM
All use subject to JSTOR Terms and Conditions

reduction in the MSE for the interest rate model relative to the time-series model is 20% and relative to the survey responses, 15%. The decomposition statistics in table 2 indicate that, unlike the full period, much of the models' forecast errors for this subperiod are due to bias. Indeed, bias accounts for 59% of the forecast error generated from the survey responses. This general increase in bias among the different models results from the tendency to underestimate inflation, as illustrated in figures 1, 2, and 3. This underprediction appears in each of the forecasts between late 1972 and early 1975 and again is most obvious in the case of the survey responses.

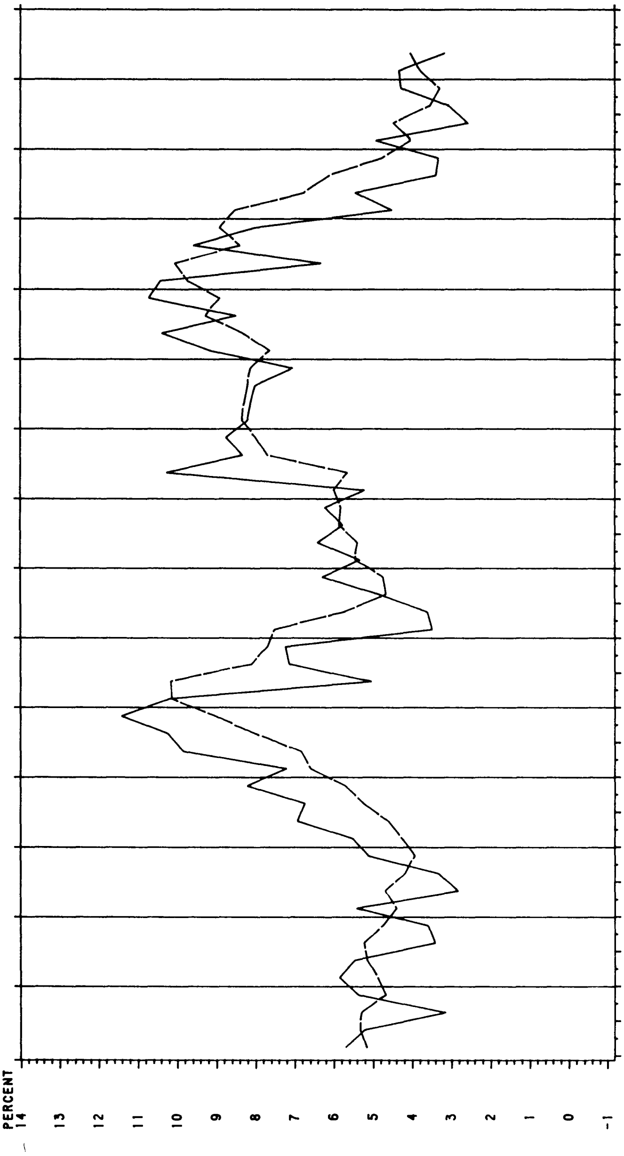
The second subperiod covers 1975:I–1979:IV. In 1979, although the effects of the first oil price shock had dissipated, relative energy prices again began to rise sharply. Moreover, while less severe than in the mid-1970s, the relative price of food increased substantially between 1977:IV and 1979:IV. The forecast summary statistics indicate that the time-series and interest rate models actually did somewhat worse in this period than in the previous one. For example, the MSE of the time series model increased from 2.67% in the 1970–74 period to 3.78% for the 1975–79 sample. A similar decline in accuracy is revealed for the interest rate model. As table 2 shows, this general deterioration in forecast accuracy does not result from further bias. In fact, the general tendency to underestimate inflation in the 1970–74 period was corrected during this subperiod.

In contrast to the time-series and interest rate models, the survey respondents did better in forecasting inflation over the 1975–79 sample than 1970–74 by any statistical criterion reported. Compared with the other models, the survey responses were much more accurate: relative to the time-series forecasts, the survey forecasts yielded a lower MSE by over 50%; compared to the interest rate model forecasts, the reduction is 37%.

The final period covers the post-1979 era. This period is noted for the change in the operating procedures of monetary policy, the brief special credit-control program enacted by the Carter administration in 1980, the deepest postwar recession, falling relative prices of energy, and volatile nominal rates of interest. The statistics again indicate that the survey respondents more accurately forecast inflation than either alternative. The survey forecasts yield an MSE that is 51% lower than that for the time-series model and 68% lower than the interest rate model. Moreover, the statistics show that the time-series model improves on the forecasts from the interest rate model, yielding an MSE that is almost 36% lower. The fact that the interest rate model fares so poorly during this period can be ascribed mainly to the relatively large forecast errors generated from 1980—during the credit-control program—through 1982, as shown in figure 2.

To summarize the results, the statistical evidence indicates that re-

This content downloaded from 62.122.79.21 on Fri, 20 Jun 2014 13:12:34 PM
All use subject to JSTOR Terms and Conditions



ACTUAL INFLATION —
ARIMA FORECASTS — —

FIG. 1

This content downloaded from 62.122.79.21 on Fri, 20 Jun 2014 13:12:34 PM
All use subject to JSTOR Terms and Conditions

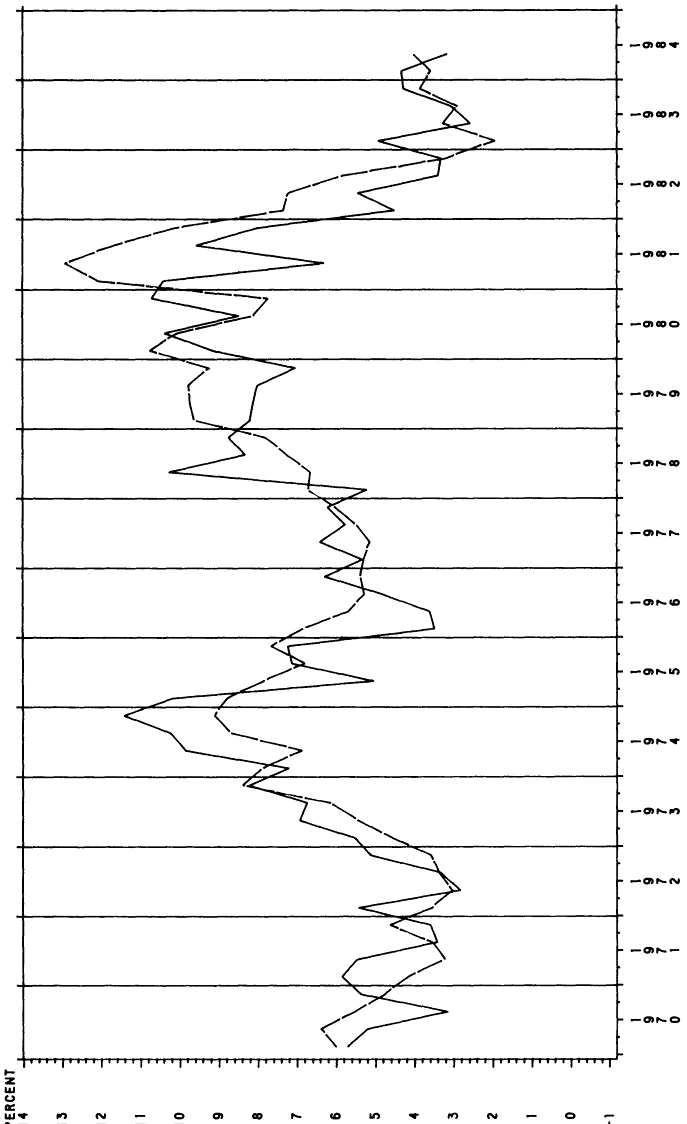
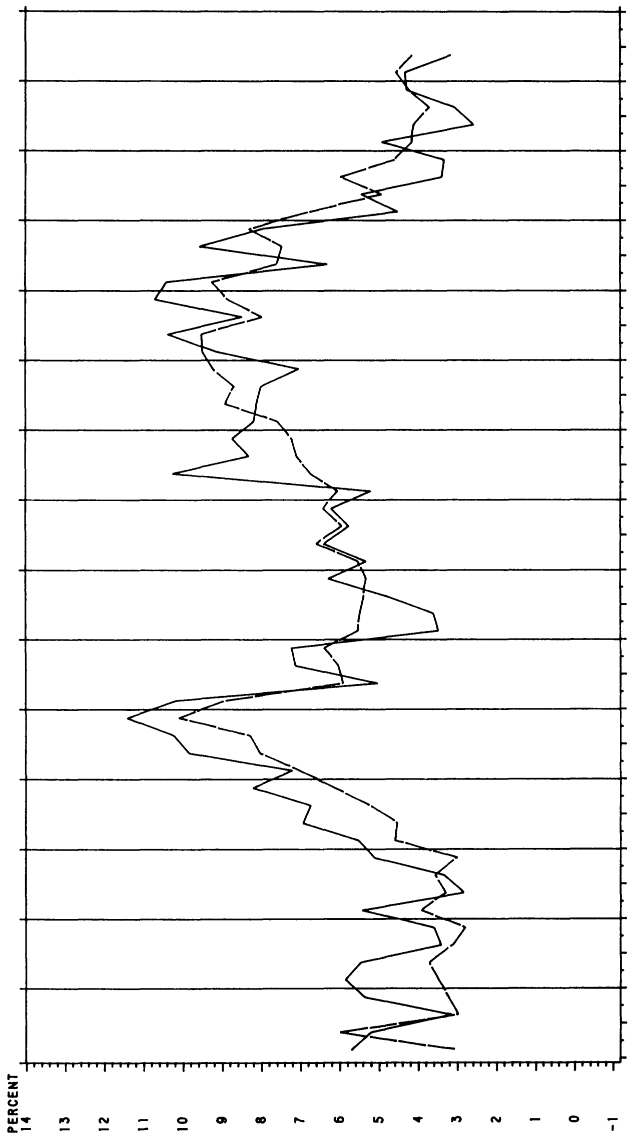


FIG. 2

This content downloaded from 62.122.79.21 on Fri, 20 Jun 2014 13:12:34 PM
All use subject to JSTOR Terms and Conditions



ACTUAL INFLATION —
SURVEY FORECASTS – –

FIG. 3

spondents to the ASA-NBER survey generally provided more accurate forecasts of the quarterly inflation rate from 1970 to 1984 than did the time-series and interest rate models. The evidence from comparing survey and interest rate forecasts indicates that the survey forecasts produced smaller errors in all periods except the 1970–74 subperiod. These results are in contrast to most previous studies, in which survey forecasts (usually the Livingston series) were shown to be consistently inferior to time-series forecasts or predictions derived from interest rates. The comparison of time-series and interest rate model forecasts lends some support the notion that the financial markets yield more reliable forecasts of inflation. In both the 1970–74 and 1975–79 subperiods, inflation forecasts derived from the interest rate model outperformed the univariate time-series model. It is interesting to note, however, that the time-series model forecasts inflation better than the interest rate model for the 1980–84 period. The relative deterioration of the interest rate model forecasts in the 1980–84 sample suggests that these predictions are sensitive to increased volatility in nominal rates. This is especially true during 1980–84 because of the extremely large movements in short-term interest rates over relatively short periods of time, fluctuations that may reflect influences other than inflationary expectations.[8]

VI. Bias Tests

In addition to comparing the different inflation forecast records directly, it is instructive to investigate the rationality of the forecasts. We first test for the necessary condition of unbiasedness.[9] This is done by estimating the regression

$$I_t = \alpha_0 + \beta_1 \hat{I}_t + \epsilon_t, \tag{8}$$

where I_t is the actual rate of inflation in t, $\hat{I}_t$ is the ex ante forecast of inflation, and ϵ_t is an error term with the usual classical properties. This

8. The variability of the ex post real rate during the 1980–84 period was noticeably larger than during the previous samples. For instance, during the 1970–74 period, the standard deviation of the ex post real rate was 1.71%; during the 1975–79 period, it was 2.12%. For the 1980–84 sample, however, the standard deviation rose to 2.80%. It also should be noted that the mean value of the ex post real rate, −0.05% and −0.14% for the 1970–74 and 1975–79 samples, respectively, increased sharply to 4.86% for the recent period. The volatility of interest rates since 1979 is the subject of several recent studies. See, e.g., Bomhoff (1983), Mascaro and Meltzer (1983), and Evans (1984).

9. A complete test of rationality also would require testing for efficiency. Studies examining the rationality of the Livingston data include, among others, Carlson (1977*b*), Brown and Maital (1981), Figlewski and Wachtel (1981), and Hafer and Resler (1982). Comparisons of Livingston and time-series forecasts are found in Pearce (1979). Investigations of the ASA-NBER survey data can be found in Zarnowitz (1983). Note, however, that Zarnowitz, following Figlewski and Wachtel, uses only the median response of a subset of the survey respondents who participated regularly (i.e., 12 or more survey responses).

This content downloaded from 62.122.79.21 on Fri, 20 Jun 2014 13:12:34 PM
All use subject to JSTOR Terms and Conditions

latter condition is important, because if the forecasts are unbiased there should be no autocorrelation in the residuals. More important, rational forecasts do not permit rejection of the joint hypothesis that $\hat{\alpha}_0 = 0$ and $\hat{\beta}_1 = 1.0$. If *any* of these conditions are not satisfied, then the hypothesis of unbiasedness is rejected.

The three forecast series were used to estimate equation (8) for the 1970–84 sample as well as the three subperiods. The calculated F-statistics from testing the joint hypothesis that $\hat{\alpha}_0 = 0$ and $\hat{\beta}_1 = 1.0$ and the Durbin-Watson statistics for each model and sample period are reported in table 3. The outcome for the full period indicates that we cannot reject the joint hypothesis for both the time-series forecasts and the survey responses at the 5% level of confidence. In contrast, the F-value using the interest rate model forecasts (7.21) is well above the 5% critical value. This rejection stems from both the fact that the estimated constant term is 1.90 ($t = 3.16$) and that the slope coefficient is statistically different from unity, taking on a value of 0.68 ($t = 7.92$). For each equation, however, we can reject the hypothesis of no first-order residual serial correlation at the 5% level, suggesting that the forecasts are not unbiased across the full period.

The subperiod results reported in table 3 are used to examine the robustness of the full-period estimates. The evidence using the time-series forecasts indicate that unbiasedness cannot be rejected at the 5% level in any of the sample periods examined. Moreover, the problem of serial correlation does not arise in any of the subperiods. The rejection of unbiasedness for the interest rate model forecasts for the full period stems in large part from the model's performance in the 1980–84 sample. During the 1970–74 and 1975–79 samples, the data do not reject the hypothesis of unbiasedness. Moreover, the evidence indicates no first-order serial correlation. During the 1980–84 period, however, the calculated F-value of 5.94 exceeds the 5% critical value. This result, along with the deterioration documented in table 2 of the interest rate model's forecasting ability during this period, again suggests that this procedure may be very sensitive to relatively large swings in nominal interest rates.

TABLE 3 **Bias Test Results: *F*-Values/D-W Statistics**

Forecast Model	Period			
	1970–84	1970–74	1975–79	1980–84
ARIMA	.96/1.45*	4.06/1.56	2.61/1.65	.61/1.80
T-BILL	7.21*/1.39*	1.74/1.48	1.63/1.69	5.94*/1.53
ASA-NBER	2.10/1.43*	13.03*/2.00	.01/1.41	1.62/2.56

NOTE.—See definitions in table 2 n. The reported F-value is based on testing the joint hypothesis $\alpha_0 = 0$ and $\beta_1 = 1.0$ in the eq. $I_t = \alpha_0 + \beta_1\hat{I}_t + \epsilon_t$.

* Significant at the 5% level of confidence.

This content downloaded from 62.122.79.21 on Fri, 20 Jun 2014 13:12:34 PM
All use subject to JSTOR Terms and Conditions

Finally, the subperiod results for the ASA-NBER survey responses indicate that, contrary to the full-period outcome, we can reject unbiasedness during the 1970–74 subperiod: the F-statistic is 13.03, easily significant at the 5% level. This result occurs because the estimated constant term is relatively large (1.12), undoubtedly stemming from the general underprediction of inflation during the period from late 1973 through 1974. During the post-1974 sample periods, however, the calculated F-statistics are well below the critical value, and the Durbin-Watson statistics indicate no first-order serial correlation.

VII. Combination Results

As a final test concerning the relative forecasting accuracy of the three procedures, the marginal information content of each is investigated. In other words, once we know the information contained in one forecast, can we improve statistically on that by accounting for the information embedded in another forecast? To assess the marginal contribution of each forecast, the following regression is estimated:

$$I_t = \alpha_0 + \beta_1 \hat{I}_t^i + \beta_2 \hat{I}_t^j + \epsilon_t, \tag{9}$$

where $\hat{I}_t^i$ and $\hat{I}_t^j$ are two alternative inflation forecasts. The estimated β_i coefficients provide the marginal contribution for each forecast.[10] Insignificance of the estimated β_2 coefficient indicates that the I^j forecast provides no marginal information in forecasting inflation not already included in the I^i forecast. If both β's are insignificant, this suggests that each contains similar information. If both are significant, then each contributes to the explanation of inflation.

Pairwise combinations of the forecast series are used to estimate equation (9): the outcome for the full period is presented in the upper panel of table 4. The time-series and interest rate model pairing indicates that the information in the time-series forecast is not statistically significant. The calculated t-statistic for the interest rate model's forecast is highly significant, indicating that this model already incorporates the information reflected in the time-series forecasts. This finding is interesting, given the full-period forecast comparison presented in table 2. The results in table 4 indicate that the time-series forecasts could be improved on by including the information contained in the interest rate model forecasts. No significant improvement in the interest rate forecast could be obtained by also including the time-series forecasts, however.

To see how robust the full period result is, the time-series/interest

10. This type of test was suggested originally by Bates and Granger (1969) as a procedure to obtain weighted combinations of forecasts (see also Nelson 1972 and Granger and Ramanathan 1984).

This content downloaded from 62.122.79.21 on Fri, 20 Jun 2014 13:12:34 PM
All use subject to JSTOR Terms and Conditions

TABLE 4 **Combination Results 1970:I–1984:II; Equation Estimated: $I_t = \alpha_0 + \beta_1 \hat{I}_t^i + \beta_2 \hat{I}_t^j + \epsilon_t$**

Combination	α_0	β_1	β_2	$\bar{R}^2$/SE	D-W
		1970:I–1984:II			
ARIMA/T-BILL	1.552	.167	.571	.516	1.44
	(2.00)	(.71)	(3.22)	1.676	
ASA/T-BILL	.566	.846	.111	.663	1.46
	(.99)	(4.98)	(.82)	1.398	
ASA/ARIMA	.627	.983	−.025	.659	1.42
	(.97)	(6.15)	(.15)	1.406	
		1970:I–1974:IV			
ARIMA/T-BILL	−1.450	.810	.571	.700	1.77
	(1.08)	(1.92)	(2.03)	1.320	
ASA/T-BILL	.692	.830	.248	.803	1.97
	(.95)	(3.80)	(1.04)	1.071	
ASA/ARIMA	.805	.961	.112	.791	1.98
	(.59)	(3.65)	(.26)	1.102	
		1975:I–1979:IV			
ARIMA/T-BILL	2.288	−.134	.759	.215	1.63
	(1.25)	(.33)	(1.84)	1.696	
ASA/T-BILL	−.190	1.232	−.190	.425	1.35
	(.11)	(2.52)	(.49)	1.452	
ASA/ARIMA	−.127	1.059	−.036	.418	1.38
	(.07)	(3.24)	(.14)	1.461	
		1980:I–1984:II			
ARIMA/T-BILL	.691	.432	.375	.599	1.72
	(.48)	(.97)	(1.25)	1.848	
ASA/T-BILL	−1.751	1.265	−.021	.806	2.58
	(1.64)	(4.24)	(.12)	1.285	
ASA/ARIMA	−1.658	1.399	−.165	.810	2.53
	(1.71)	(4.47)	(.59)	1.271	

NOTE.—See table 2 n. for definitions. $\bar{R}^2$ is the coefficient of determination adjusted for degrees of freedom; SE is the regression standard error.

rate model pairing was examined for each subperiod: these results also are reported in table 4. The subperiod results indicate that the marginal contribution of the time-series and interest rate model forecasts is small. That is, in no period does one forecast procedure dominate the other. For example, the estimated coefficients on the two forecast series for the 1970–74 subperiod are significant only at the 10% level. This suggests that each series adds little to the information already contained in the other. The outcome for the 1975–79 sample also shows the informational contents of the two series to be closely related. Again, the significance must be reduced to the 10% level before one forecast model (the interest rate forecast) is preferred. Finally, the fact that neither the time-series nor the interest rate model forecasts obtain

This content downloaded from 62.122.79.21 on Fri, 20 Jun 2014 13:12:34 PM
All use subject to JSTOR Terms and Conditions

a significant coefficient in the 1980–84 subperiod indicates a high degree of collinearity between the two series. What this evidence suggests is that the contribution of the information contained in the interest rate model forecasts relative to the time-series model is, in the instances examined, marginally significant.

The equations that combine the survey forecasts with those from either the time-series or interest rate models indicate that there is no marginal improvement over the survey responses. This result, which holds for the full period and in each of the subperiods, is quite different from previous results using the Livingston survey forecasts of inflation.[11] Indeed, as the statistics in table 4 show, the significance of the time-series forecast or that derived from the interest rate model never approaches a reasonable level of significance. This strong result thus indicates that the informational content of the two model forecasts is subsumed into that of the median survey response.

VIII. Conclusion

Our purpose in this paper was to investigate the relative abilities of three alternative approaches to forecasting inflation. The three methods examined include a time-series approach to modeling and forecasting inflation, an interest rate model developed in Fama (1975) and recently extended in Fama and Gibbons (1984), and the responses to the ASA-NBER survey of professional forecasters. The evidence presented is based on ex ante forecasts of inflation measured using the GNP deflator for the period 1970:I–1984:II.

The general conclusion reached from our comparison is that the survey responses provide the most accurate ex ante forecasts of inflation. Although the interest rate model was found to yield relatively more accurate forecasts during the 1970–74 period, the median survey response was much more accurate during the remaining 1975–84 sample. Also, regression tests indicate that for no period studied does the forecast from the interest rate or time-series model yield a significant improvement in forecast accuracy once the survey forecasts are known.

An interesting finding to emerge from our study is the fact that the interest rate model does not dominate the time-series forecasts in all periods. Based on forecast accuracy, the interest rate model's forecasts were better than those derived from the time-series model for the 1970–74 and 1975–79 periods. For the 1980–84 subperiod, however, the time-series model produced the more accurate forecast. Moreover,

11. Fama and Gibbons (1984) found the Livingston survey responses to be statistically inferior to both the time-series and interest rate forecasts of inflation. Pearce (1979) reaches a similar conclusion based on a time-series/survey forecast comparison.

This content downloaded from 62.122.79.21 on Fri, 20 Jun 2014 13:12:34 PM
All use subject to JSTOR Terms and Conditions

when the two forecast series were combined, a clear-cut superiority of one model over the other could not be discerned, although the 1975–79 results do provide the strongest support of the interest rate model vis-à-vis the time-series approach.[12]

Finally, the fact that the accuracy of the interest rate model's forecasts deteriorates significantly during the 1980–84 period suggests that this procedure may be very sensitive to noninflationary impacts on nominal rates. Indeed, recent concerns about the uncertainty of the monetary policy, the impact of the federal deficit, and foreign influences may adversely affect the interest rate–inflation connection so important to the success of this forecasting approach.

Appendix

The purpose of this appendix is to present forecast results based on a timing scheme for the interest rate model that is different from that used in the text. The timing here uses the Treasury bill rate observed at the end of the previous quarter. This approach is similar to that of Fama (1975, 1977) and Fama and Gibbons (1984) where the interest rate at the end of the $t - 1$ month is used to forecast inflation in month t. This procedure clearly reduces the information set in the interest rate forecast relative to the survey, since the survey is taken two months later.

The real rate series generated using the end-of-quarter nominal interest rate produces sample autocorrelations quite similar to those presented in table 1: these autocorrelations are presented in table A1. Again their pattern suggests an MA (1, 1) model. The results of estimating such a model are

$$\begin{aligned} (1 - B)r_t &= a_t - \underset{(10.27)}{0.7831}a_{t-1} \\ SE = 1.328 &\quad Q(11) = 4.27. \end{aligned} \tag{A1}$$

We again find that the MA (1, 1) model is appropriate. The estimated value for θ is significant and the Q-statistic rejects the hypothesis of autocorrelation. The large value of θ again indicates that most of the variation in the real rate is in the unanticipated component.

The real rate forecast from equation (A1) was used to generate ex ante forecasts for the period from 1970 to 1984. Using equation (2) in the text, these forecasts were combined with inflation rates to generate the inflation forecast for the next quarter. The inflation forecast results are presented in table A2. Relative to the results discussed in the text, the evidence in table A2 shows the inflation forecasts from the interest rate model to be inferior to both the time-series forecast and the survey responses. This is true for the full period and the 1970–74 and 1980–84 subperiods. Only during the 1975–79 subperiod does the interest rate model yield more accurate forecasts than the other procedures. Note also that the forecast accuracy of the interest rate model deteriorates

12. This outcome provides some corroboration of the findings presented in Nelson and Schwert (1977), wherein monthly inflation forecasts from time-series and interest rate models are compared.

This content downloaded from 62.122.79.21 on Fri, 20 Jun 2014 13:12:34 PM
All use subject to JSTOR Terms and Conditions

TABLE A1 Sample Autocorrelation, 1953–69: End-of-Quarter Interest Rate Used

Variable	1	2	3	4	5	6	7	8	9	10	11	12
r_t	.268	.273	.324	.154	.133	.200	.121	.154	.123	.167	.005	.101
$r_t - r_{t-1}$	−.495	−.036	.143	−.082	−.079	.108	−.071	.043	−.049	.122	−.176	.126

This content downloaded from 62.122.79.21 on Fri, 20 Jun 2014 13:12:34 PM
All use subject to JSTOR Terms and Conditions

TABLE A2 Summary Forecast Statistics, T-BILL Model, Full Period and Subperiods: End-of-Quarter Interest Rate Used

Period	MAE	MSE	RMSE	B	V	CV
1970:I–1984:II	1.68	4.14	2.04	.01	.05	.94
1970:I–1974:IV	1.38	2.79	1.67	.14	.11	.75
1975:I–1979:IV	1.43	3.16	1.78	.11	.00	.89
1980:I–1984:II	2.29	6.73	2.60	.08	.22	.70

even more dramatically during the 1980–84 sample using the end-of-quarter interest rate.

The bias test results using the end-of-quarter interest rate model again indicate bias for the 1970–84 and 1980–84 periods, as in table 3. Although the calculated F-values are reduced, it again appears that the interest rate model, regardless of the timing of the real rate calculation, produces biased forecasts during the recent period.

Combinations of the new interest rate inflation forecasts with those from a time-series model produce results somewhat different from those reported in table 4. Relative to the survey responses, however, including the interest model forecasts never improve the fit; as in table 4, the interest rate model forecasts never achieve statistical significance when paired with the survey forecast. The subperiod results from combining the time-series forecast and those derived from the interest rate model do change. For example, 1970–74 sample results of combining the time-series and interest rate forecasts when the latter uses the end-of-quarter data is

$$\begin{aligned} I_t &= -2.130 + 1.065 \text{ ARIMA} + 0.446 \text{ T-BILL} \\ &\quad\ (1.61) \quad (3.10) \qquad\qquad\quad (1.84) \\ \bar{R}^2 &= 0.690 \quad \text{SE} = 1.343 \quad \text{D-W} = 2.02. \end{aligned} \tag{A2}$$

Compared with the corresponding result in table 4, using the end-of-quarter interest rate observation reduces the interest rate model's relative forecasting ability. A similar outcome is found for the 1975–79 subperiod. The results of this combination are

$$\begin{aligned} I_t &= 2.718 - 0.219 \text{ ARIMA} + 0.762 \text{ T-BILL} \\ &\quad (1.61) \quad (0.57) \qquad\qquad\quad (2.20) \\ \bar{R}^2 &= 0.268 \quad \text{SE} = 1.638 \quad \text{D-W} = 1.71. \end{aligned} \tag{A3}$$

Compared with the 1975–79 result in table 4, using the end-of-quarter interest rate actually enhances the interest rate model's inflation forecast relative to that from a time-series model.

Finally, the results for the 1980–84 period are

$$\begin{aligned} I_t &= 0.626 + 0.492 \text{ ARIMA} + 0.333 \text{ T-BILL} \\ &\quad (0.50) \quad (1.80) \qquad\qquad\quad (2.10) \\ \bar{R}^2 &= 0.658 \quad \text{SE} = 1.705 \quad \text{D-W } 1.63. \end{aligned} \tag{A4}$$

Although these results indicate that each forecast series is marginally useful in predicting inflation, the degree of collinearity between the two series evident in table 4 is lacking. The 1980–84 results again suggest, as in table 4, that the

This content downloaded from 62.122.79.21 on Fri, 20 Jun 2014 13:12:34 PM
All use subject to JSTOR Terms and Conditions

interest rate model's forecasts do not dominate those derived from a univariate time-series model.

References

Bates, J. M., and Granger, C. W. J. 1969. Combination of forecast. *Operational Research Quarterly* 10, no. 4:451–68.

Blinder, A. S. 1980. The consumer price index and the measurement of recent inflation. *Brookings Papers on Economic Activity*, no. 2, pp. 539–65.

Bomhoff, E. J. 1983. Monetary Uncertainty. Amsterdam: North-Holland.

Brown, B. W., and Maital, S. 1981. What do economists know? An empirical study of experts' expectations. *Econometrica* 49 (March): 491–504.

Carlson, J. A. 1977*a*. Short-term interest rates as predictors of inflation: Comment. *American Economic Review* 67 (June): 469–75.

Carlson, J. A. 1977*b*. A study of price forecasts. *Annals of Economic and Social Measurement* 6 (Winter): 27–56.

Evans, P. 1984. The effects on output of money growth and interest rate volatility in the United States. *Journal of Political Economy* 92 (April): 204–22.

Fama, E. F. 1975. Short-term interest rates as predictors of inflation. *American Economic Review* 65 (June): 269–82.

Fama, E. F. 1977. Interest rates and inflation: The message in the entrails. *American Economic Review* 67 (June): 487–96.

Fama, E. F., and Gibbons, M. R. 1982. Inflation, real returns, and capital investment. *Journal of Monetary Economics* 9 (May): 297–324.

Fama, E. F., and Gibbons, M. R. 1984. A comparison of inflation forecasts. *Journal of Monetary Economics* 13 (May): 327–48.

Figlewski, S., and Wachtel, P. 1981. The formation of inflation expectations. *Review of Economics and Statistics* 63 (February): 1–10.

Fischer, S. 1981. Relative shocks, relative price variability, and inflation. *Brookings Papers on Economic Activity*, no. 2, pp. 381–431.

Garbade, K., and Wachtel, P. 1978. Time variation in the relationship between inflation and interest rates. *Journal of Monetary Economics* 4:755–65.

Granger, C. W. J., and Ramanathan, R. 1984. Improved methods of combining forecasts. *Journal of Forecasting* 3 (April–June): 197–204.

Hafer, R. W., and Resler, D. H. 1982. On the rationality of inflation forecasts: A new look at the Livingston data. *Southern Economic Journal* 48 (April): 1049–56.

Hess, P. J., and Bicksler, J. L. 1975. Capital asset prices versus time series models as predictors of inflation: The expected real rate of interest and market efficiency. *Journal of Financial Economics* 2:341–60.

Mascaro, A., and Meltzer, A. 1983. Long- and short-term interest rates in a risky world. *Journal of Monetary Economics* 12 (November): 485–518.

Nelson, C. R. 1972. The prediction performance of the F.R.B.-M.I.T.-PENN model of the U.S. economy. *American Economic Review* 62 (December): 902–17.

Nelson, C. R., and Schwert, G. W. 1977. Short-term interest rates as predictors of inflation: On testing the hypothesis that the real rate of interest is constant. *American Economic Review* 67 (June): 478–86.

Pearce, D. K. 1979. Comparing survey and rational measures of expected inflation: Forecast performance and interest rate effects. *Journal of Money, Credit and Banking* 11 (November): 447–56.

Su, V., and Su, J. 1975. An evaluation of ASA/NBER business outlook survey forecasts. *Explorations in Economic Research* 2, no. 4:588–618.

Zarnowitz, V. 1969. The new ASA-NBER survey of forecasts by economic statisticians. *American Statistician* 23 (February): 12–16.

Zarnowitz, V. 1983. Rational expectations and macroeconomic forecasts. NBER Working Paper no. 1070. Chicago: NBER, January.

This content downloaded from 62.122.79.21 on Fri, 20 Jun 2014 13:12:34 PM
All use subject to JSTOR Terms and Conditions