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EVALUATING THE EFFICIENCY OF LONG-TERM FORECASTS WITH LIMITED INFORMATION

Revisions in the IEW Poll Responses

Gary W. YOHE

Wesleyan University, Middletown, CT 06457, USA

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An analytical technique based on an adaptive expectations model of incorporating current information into long-term forecast, is developed and applied to IEW respondents' revisions of reported oil price forecasts. Current year weights implicit in their revisions have mean values ranging from 0.27 through 0.67 depending upon the forecast horizons and the assumed base cases. Since the revisions suggest greater perceived importance of current changes for longer forecast, though, some doubt is cast upon the efficiency of their revisions.

1. Introduction

While forecasting into the near term is dominated by the technicalities of statistical techniques and elaborate formulae of prediction errors, forecasting into the medium and long term is more of an art than a science. Short-term forecasters quickly produce observable track records because the events that they forecast are quickly realized. The quality of a given forecast can therefore be anticipated by noting the demonstrated ability of its author to be right more often than not. Particularly for long-term forecasts, however, the luxury of this type of track record evaluation is not available. Much like the subjective criteria of form, composition, use of color, and clarity of expression that must be applied in judging the quality of an artist's painting, indirect criteria must instead be developed and applied if the quality of forecasts into the more distant future is to be evaluated in advance of the observance of the forecasted event. A central issue in assessing the anticipated quality of these forecasts is thus the identification of these criteria.

Efficiency is certainly one such criterion. It can be argued, given a fairly general class of loss functions, that forecasters should try to minimize the mean squared error of their forecasts [see Nordhaus (1985)]. Without knowing how a specific forecast was constructed, however, it is impossible to apply this type of efficiency criterion directly. Nordhaus continued to note, however, that a series of forecasts of the same future event, revised sequentially by an individual forecaster in light of a constant stream of more current information, can provide sufficient information to judge efficiency.

Nordhaus observed, quite simply, that such a series should look like a random walk through time as the present moves forward toward the specified event; i.e., forecast revisions should, in more technical jargon, be a martingale with no statistically significant time trend. To deduce that significance with any power, however, a long time series of revised forecasts is required. Without the requisite number of observations, more subtle and less powerful techniques must be developed and applied.

This note presents such a technique and applies it to the limited number of revised estimates for the real international price of crude oil for 1990 and 2000 reported in the International Energy Workshop polls of 1984 and 1985 [Manne (1984, 1985)]. Section 1 sets forth a simple adaptive expectations model. Manipulation of this model produces (1) an estimation procedure that is efficient, (2) a general mechanism by which current data should be incorporated into forecast revision that is independent of the length of the forecast horizon, (3) the observation that a sequence of these revisions should be a martingale, and (4) a systematic correspondence between (a) the weight attached to the most current data in each revision and (b) the forecaster's subjective judgment about the relative importance of transitory and permanent uncertainties. When the technique is applied to evaluate the efficiency of the IEW poll responses in section 2, points (2) and (4) are employed to inform a less than positive judgment on efficiency.

Unlike the case in judging the quality of art in which failure to meet certain standards of evaluative consistency can be chalked up to 'creative disagreement' with little cause for concern beyond the artistic community, a failure to meet minimum efficiency standards in energy forecasting is extremely troublesome. Policy decisions running the gamut from energy management procedures all the way through macroeconomic policy adjustments and evaluations of international debt conditions depend in no small part on anticipated energy futures. These decisions can affect all of the world's people in one way or another, and it is thus incumbent upon all of us to try to see that they are based on the best evidence that can be provided.

2. A simple model of adaptive expectations

Following Muth (1960), let y_t represent deviation from a time trend. Assume that

$$y_t = \bar{y}_t + \eta_t, \qquad (1)$$

where $\bar{y}_t$ represents a permanent component of the deviation and η_t represents a random transitory component. Assume, further, that the η_t are distributed independently over time with zero mean and σ_η^2 variance. Finally, suppose that the permanent components are defined according to

$$\bar{y}_t = \bar{y}_{t-1} + \varepsilon_t = \sum_{i=-\infty}^{t} \varepsilon_i, \tag{2}$$

with the ε_i independently distributed over time with zero mean and σ_ε^2 variance.

The problem of forecasting T periods into the future at time T can now be characterized in this context as one of computing

$${}_t\hat{y}_T \equiv \mathrm{E}\{y_{t+T} | \varepsilon_{t-1}, \varepsilon_{t-2}, \ldots; \eta_{t-1}, \eta_{t-2}, \ldots\};$$

i.e., ${}_t\hat{y}_T$ should be the expected value of y_{t+T} *conditional* upon past experience indexed by the ε_i and the η_i. Expressed in terms of present and past observations, however, one more pragmatic view of efficient forecasting is to determine coefficients ${}_T v_1, {}_T v_2, \ldots$ which minimize the mean squared error:

$$V = \mathrm{E}(y_{t+T} - \hat{y}_T)^2,$$

where

$${}_t\hat{y}_T = \sum_{j=1}^{\infty} {}_T v_j y_{t-j}. \tag{3}$$

In this way, ${}_t\hat{y}_T$ is the expected value of y_{t+T} *conditional* upon past, observed values of the y_i and not the unobserved ε_i and η_i. Noting that (1) and (2) combine to require that

$$y_t = \sum_{i=-\infty}^{t} \varepsilon_i + \eta_t,$$

some algebra reveals that

$$V = \mathrm{E}\left\{\left[\sum_{i=-\infty}^{t+T} \varepsilon_i + \eta_{t+T}\right] - \sum_{j=1}^{\infty} {}_T v_j y_{t-j}\right\}^2$$

$$= 2T\sigma_\varepsilon^2 + \sigma_\eta^2 + \sigma_\varepsilon^2 \sum_{j=1}^{\infty}\left(1 - \sum_{j=1}^{j} {}_T v_j\right)^2 + 2\sigma_\eta^2 {}_T v_k = 0. \tag{4}$$
$$\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad {}_{j=1}$$

To compute the appropriate weights, therefore, one must solve the following system of first-order conditions:

$$\frac{\partial V}{\partial {}_T v_k} = -2\sigma_\varepsilon^2 \sum_{j=k}^{\infty}\left(1 - \sum_{i=1}^{j} {}_T v_i\right) + 2\sigma_\eta^2 {}_T v_k = 0. \tag{5}$$

Comparing (4) and (5), notice that the optimal weights are independent of the forecast horizon (T), even though the mean squared error is expected to increase linearly with that horizon. When applied to forecasts of oil prices in 1990 and 2000, therefore, efficiency requires that the weight applied to the most recent experience be the same for both time horizons.

Muth (1960) has observed that second differences of (5) eliminate the long summations and set the weights forth as solutions to

$$[1+\sigma_\varepsilon^2/\sigma_\eta^2]_T v_1 - {}_T v_2 = \sigma_\varepsilon^2/\sigma_\eta^2 \quad \text{and} \tag{6a}$$

$$-{}_T v_{k-1} + (2+\sigma_\varepsilon^2/\sigma_\eta^2)_T v_k - {}_T v_{k+1} = 0, \quad k=2,3,\ldots \tag{6b}$$

The relevant root constrained to the unit interval then emerges in the form

$$\lambda_1 = 1 + \tfrac{1}{2}K^2 - K[1+\tfrac{1}{4}K^2]^{1/2}, \tag{7}$$

with $K \equiv (\sigma_\varepsilon/\sigma_\eta)$ representing the ratio of the standard deviation of the permanent component of deviation from the time trend to the standard deviation of the transitory component of the same deviation. The solutions to (6) are of the form

$${}_T v_k = c\lambda_1^k, \qquad k=1,2,3,\ldots,$$

where $c=(1-\lambda_1)/\lambda_1$. The appropriate weights can, as a result, finally be summarized given (3) by

$${}_T v_k = (1-\lambda_1)\lambda_1^{k-1}, \qquad k=1,2,\ldots, \tag{8}$$

so that $(1-\lambda_1)$ is the appropriate weight for the most recent observation y_{t-1} in the year t forecast.

It is now possible to confront directly the issue of how to weight current year experience in amending forecasts of future events. Let

$${}_t\hat{y}_T = \sum_{j=1}^{t} {}_T v_t y_{t-j} = \sum_{j=1}^{t} (1-\lambda_1)\lambda_1^{j-1} y_{t-j}$$

represent, as before, a forecast of y_{t+T} made in period t. Similarly, denote a subsequent forecast of y_{t+T} made in period $t+1$ by

$${}_{t+1}\hat{y}_{T-1} = \sum_{j=1}^{t} {}_{T-1}v_{t+1} y_{t-j} = \sum_{j=1}^{t} (1-\lambda_1)\lambda^{j-1} y_{t+1-j}.$$

The change in the forecast resulting from the efficient incorporation of information generated over the course of period t and embodied in y_t is therefore

$$\{{}_{t+1}\hat{y}_{T-1} - {}_t\hat{y}_T\} = (1-\lambda_1)\lambda_1^0 y_t + \lambda_1 \sum_{j=1}^{t} (1-\lambda_1)\lambda_1^j y_{t-j}$$

$$- \sum_{j=1}^{t} (1-\lambda_1)\lambda_1^j y_{t-j}$$

$$= (1-\lambda_1) y_t + (1-\lambda_1)_t \hat{y}_T. \tag{9}$$

Rearranging (9)

$$(1-\lambda_1) = \frac{{}_{t+1}\hat{y}_{T-1} - {}_t\hat{y}_T}{y_t - {}_t\hat{y}_T}. \tag{10}$$

Eq. (9) reveals explicitly that

$$\mathrm{E}_{t+1}\hat{y}_{T-1} - {}_t\hat{y}_T = 0;$$

i.e., the sequence of forecasts of y_{T+t} should look like a random walk over time thereby displaying the formal properties of a martingale. Eq. (10) reveals implicitly that the appropriate incorporation of current information, y_t, depends isomorphically upon the forecaster's (subjective) view of K – the relative size of permanent and transitory uncertainty measured by the ratio of their standard deviations.

3. IEW poll responses

Turning now to the forecasts of oil prices reported in the IEW polls of 1984 and 1985, the task is not to compare respondent behavior with some optimal forecast. Such a forecast cannot be produced without heroic assumptions about constant market structures and universal information, at the very least. The purpose of the present exercise is, instead, to use the model described above to try to understand how the respondents, in fact, amended their 1983 forecasts. How did they incorporate the 16% decline in real oil prices during 1983 into their 1984 forecasts recorded in the 1985 poll? To what degree did they weight the 1983 experience in their revisions of their 1983 forecasts? What does that weighting reveal about their subjective view of the relative importance of permanent (vs. transitory) uncertainty? Are the forecasts for 1990 and 2000 published by the same respondents based on a consistent weighting of the 1983 experience and thus on a consistent view of the difference between permanent and transitory uncertainty? If the forecasts are efficient, eq. (5) requires that such consistency be apparent.

Quantitative answers to these questions depend, in part, upon the underlying trend in oil prices over the next decade and one half. Each was investigated under three assumptions: (1) the 50th percentile trajectory in Manne (1986), (2) a flat trajectory given 1983 levels, and (3) the 16th percentile trajectory in Manne (1986).[1,2] Qualitative answers, particularly to questions of consistency, appear to be fairly robust across all three assumed environments.

Table 1 shows the implicit weights for the observed 1983 experience incorporated into the adjustments of the indicated respondents given the adaptive expectations model of section 1; the weight for the most current information is, recall, specified in eq. (9). The three assumed underlying trends define the columns. The higher the fraction reported in table 1, the more important is recent history in the formulation of the respondent's

Table 1

Current year weights consistent with oil price forecast revisions cited in the IEW poll results: 1984→1985.

Respondent[a]	Manne 50th percentile[b]	Constant price trajectory	Manne 16th percentile[b]
Forecasts for the year 1990			
DRIE	0.54	0.38	0.24
PILOT	0.24	0.16	0.10
IPE	0.51	0.47	0.41
WBK	0.04	0.03	0.02
EIA	0.29	0.18	0.11
CERG	1.00	0.54	0.30
CRIEP	0.67	0.52	0.37
GRI	0.89	0.74	0.58
Mean (standard deviation)	0.52 (0.33)	0.38 (0.24)	0.27 (0.19)
Forecasts for the year 2000			
DRIE	0.68	0.47	0.37
IPE	0.74	0.63	0.57
GRI	0.73	0.53	0.43
DOE	0.78	0.54	0.44
JAERI	0.42	0.30	0.24
Mean (standard deviation)	0.67 (0.14)	0.49 (0.12)	0.41 (0.12)

[a]*Sources*: Manne (1984, 1985).
[b]Manne (1986).

[1]The 85th percentile reported by Manne (1986) implies that the adjustments made by the cited respondents were in the wrong direction and could not, therefore, be explained in terms of an adaptive expectations model. Several respondents are not cited in the tables for the same reason.

[2]Based on a 1980 = 100 index, the Manne (1986) 50th percentile trajectory yields international oil price forecasts of 74.4 and 88.3 for 1990 and 2000, respectively. The 16th percentile trajectory passes through 51.0 and 47.5 in the years 1990 and 2000. The precise values are not recorded in the published note, but are available in a preceding draft.

forecast and the less important is more distant history; i.e., the higher the initial weight, the more rapidly the weights, defined by eq. (8) for subsequent years, decay. Notice that the weights uniformly decline as the assumed trend line moves from 1.7% annual growth (Manne 50th) through zero growth down to a small decline (Manne 16th). This is as it should be because the 16% decline observed in 1983 conforms more closely to the trend displaying the weakest upward pressure on prices. Put differently, closer conformity of observed recent history to an anticipated trend portends a smaller need for adjusting a forecast from one year to the next. Close conformity therefore calls for a larger weight to the momentum of the more distant history and a correspondingly smaller weight to recent experience.

Table 2 records the ratios of the standard deviations of the permanent components of uncertainty over the standard deviations of the transitory components of uncertainty corresponding to the latest year weights of table 1. These are the K parameters in the notation of section 1. They emerge from eq. (7) given the $(1-\lambda_1)$ first year weights of table 2, and they measure the respondents' subjective view of the relative importance of the permanent and transitory components of the noise that is included in the data upon

Table 2

Inferred subjective ratio of the standard deviations of permanent uncertainty and transitory uncertainty consistent with oil price forecast revisions cited in the IEW poll results: 1985→1985.

Respondent[a]	Manne 50th percentile[b]	Constant price trajectory	Manne 16th percentile[b]
Forecasts for the year 1990			
DRIE	0.80	0.43	0.27
PILOT	0.27	0.17	0.10
IPE	0.72	0.65	0.53
WBK	0.04	0.04	0.03
EIA	0.35	0.20	0.11
CERG	all trans.	0.80	0.37
CRIEP	1.15	0.75	0.47
GRI	2.70	1.45	0.90
Mean (standard deviation)	0.86 (0.89)[c]	0.56 (0.46)	0.35 (0.29)
Forecasts for the year 2000			
DRIE	1.20	0.65	0.47
IPE	1.45	1.05	0.87
GRI	1.10	0.82	0.57
DOE	0.92	0.80	0.58
JAERI	0.55	0.37	0.27
Mean (standard deviation)	1.04 (0.34)	0.73 (0.27)	0.55 (0.22)

[a] *Sources*: Manne (1984, 1985).
[b] Manne (1986).
[c] The CERG result is excluded to avoid dominance by one observation.

which they base their forecasts. Notice that these ratios also uniformly decline as the assumed trend lines move from the Manne 50th percentile down to the Manne 16th percentile. The reduced weight to recent experience corresponds, through eq. (7), to a subjective belief that the most recent deviation from the trend is more the result of transitory randomness and less the result of a permanent shock.

Having recorded raw numbers contingent upon three trend scenarios in tables 1 and 2, it is now time to investigate efficiency. Eq. (5) has already revealed that the optimal weights, and thus both the weight for the most recent year *and* the corresponding view of the relative importance of permanent uncertainty, should be invariant to changes in the forecast horizon. In the case of oil prices, however, that result might be questioned because the trend itself could depend upon the initial price.

Given, for example, that 1983 saw international oil prices drop by 16%, it could be argued that near-term future oil demand should be expected to climb (for both income and substitution effect reasons), oil reserves should be expected to deplete more quickly, and oil prices should eventually increase for reasons of scarcity more rapidly than originally anticipated. Much like the illustration in fig. 1, in other words, the world might take a different path to the same place. If that were the case, then the recent decline would produce the expectation of lower oil prices through 1990 coupled with the expectation of recovery to previously anticipated levels by the year 2000. Forecasters would, in terms of the present exercise, thus incorporate recent

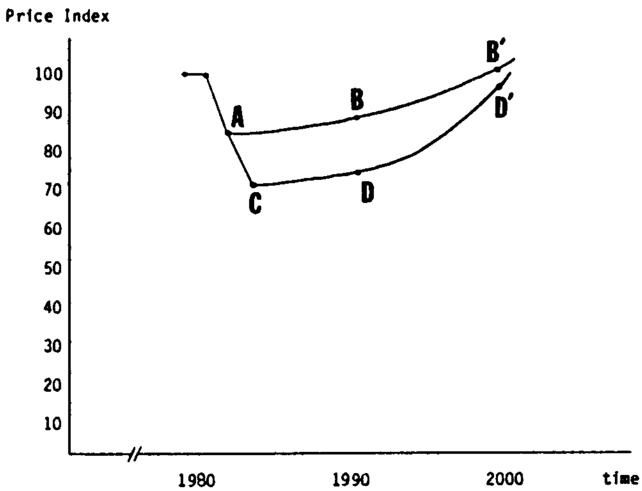

Fig. 1. Along locus *AB*, a forecast trajectory given 1982 = 85 (against a 1980 = 100 index) produces estimates of *B* and *B'* for 1990 and 2000, respectively. A subsequent forecast given 1983 = 71 produces a much lower 1990 estimate at *D*, but later growth is more rapid and produces a 2000 estimate at *D'* close to *B'*.

price reductions more as permanent shocks in making their predictions for 1990 *and* more as transitory shocks in their predictions for 2000. If the relative importance of permanent uncertainty is not found to be invariant to the forecast horizon [as anticipated in Eq. (5)], it should therefore certainly *not increase* as that horizon expands to the more distant future from 1990 to 2000.

Neither the most recent year weights recorded in table 1 nor the uncertainty ratios recorded in table 2 conform to that hypothesis. The mean ratios of permanent to transitory standard deviations for the 1990 forecasts are 0.86, 0.56, and 0.35 for the Manne 50th, flat and Manne 16th trends, respectively. The corresponding means for the 2000 forecasts are, meanwhile, 1.04, 0.73, and 0.55. All three of these numbers climb when, in fact, they should hold fixed on decline. Of the three respondents that report forecasts for both years, IPE and DRIE both show marked increases, and only GRI displays the anticipated decline.

4. Some concluding remarks

While the evidence is sketchy, application of the efficiency criterion of an adaptive expectations model to the IEW poll results casts doubt on the efficiency of recorded adjustments in price forecasts made in the light of recent declines in the price of oil. Adjustments are certainly in order in light of the collapse of oil prices in the mid 1980s, but efficiency requires that recent history be incorporated into forecast revisions in a consistent manner. The weight given to recent history, and thus the subjective judgment of the permanence of its effect, should either be invariant to the forecast horizon or, perhaps, fall as market processes are anticipated. The IEW poll results show the opposite trend, with recent events being given higher weight and thus more presumed permanence in forecast adjustment for the year 2000 than for the year 1990. Consumers of these forecasts should thus be warned, and temper their policy responses accordingly. If, in particular, the consensus adjustment for 1990 turns out to be correct, then the associated forecasts for the year 2000 could easily be too low.

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