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ON THE PROFITABILITY OF USING FORECASTS*

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ABSTRACT: The conditions on the profitability of using a forecast of real wage is derivided in an adjustment cost model of the firm. With costless information and one period horizon the condition is the same as that derived in econometrics for the usefulness of a forecast as an input to a forecasting model. With costs of obtaining the forecast and in a multiperiod model the condition is more restrictive.

KEY WORDS: Forecast accuracy, labor demand, adjustment costs, information costs

1. Introduction

Casual observations of the behavior of firms suggest that their expectations of the development of costs, demand etc. is often based on public forecasts. Given the cost and effort needed to gather information to form more efficient expectations, the forecasts can be regarded as "economically rational" expectations, as suggested e.g. by Holden and Peel (1983). [The term originates from Feige and Pearce (1976) who used it to justify the use of autoregressive expectations.]

It may not be profitable to the firm to use a forecast, which is too biased and inefficient. In econometrics a closely related problem has been studied: under what conditions is it optimal to use a forecast of a variable for forecasting another variable. For example, forecasts of macro variables can be used as inputs in a company's sales forecasting model. If the forecast is optimal, it is always useful. However, it may be suboptimal and have too large errors to be of use as an input to a forecasting model. The conditions under which this holds have been studied e.g. by Ashley (1983) and Ilmakunnas (1987).

The econometric literature defines loss in terms of mean squared error of forecasts. However, from the point of view of the firm, the relevant question is whether expected profits can be increased. The econometric studies also ignore the cost of obtaining the forecasts, which may in practice be an important determinant of forecast use. It affects both the choice of the types and amounts of information used. [see Feige and Pearce (1976), Kihlstrom (1976), Darby (1976) and Paroush (1981) for examples of models where cost of information is included.]

In all, whether use of forecasts is profitable, depends on the benefits and costs of information obtained from them, and on the accuracy of the forecasts. In this paper the last aspect is studied. The results on the usefulness of forecasts for a firm are contrasted to the corresponding econometric results. It is shown that in a static (one period) model without information costs the conditions are the same, but cost of information leads to a requirement of more accurate forecasts. However, the conditions are more complicated in a multiperiod setting where choices made today, based on currently available forecasts, affect expected profits tomorrow. This kind of situation does not arise in the econometric studies where a static loss function is used.

2. Usefulness of forecasts in a one period case

Consider a labor demand model used e.g. in Sargent (1979). The production function is a quadratic function of the only input, labor, and the costs of the firm consist of wages and adjustment costs. Period t profits, scaled by the price, are

$$\pi(t) = -\tfrac{1}{2}f_1 n(t)^2 + (f_0+a)n(t) - w(t)n(t) - \tfrac{1}{2}c[n(t)-n(t-1)]^2 \quad (1)$$

where w_t is real wage and a is a random error in production. The firm is assumed to choose n before real wage and a are observed. The objective is to maximize the expected present value of future profits $E\Sigma_j R(t+j)\pi(t+j)$, where $R(t+j)$ is the discount factor for period t+j. In this section a one period model is studied, so that it is assumed that $R(t+j)=0$ for $j=1,\dots,\infty$. This implies that a very high discount rate is applied to all future profits beyond the current period.

The choice of $n(t)$ that maximizes $E\pi(t)$ is $n(t) = \phi f_0 - \phi Ew(t) + \phi cn(t-1)$, where $\phi=1/(f_1+c)$. It is assumed that forming expectations of $w(t)$ using all available information is costly. Consider decision rule A, which uses a forecast of the real wage, $w^*(t)$, which is available from outside of the firm at time t-1. The choice of $n(t)$ is $n_A(t) = \phi f_0 - \phi w^*(t) + \phi cn(t-1)$. In this case the possible cost of obtaining the forecast, p, has to be taken into account. An alternative decision rule B, which ignores the influence of the real wage, is $n_B(t) = \phi f_0 + \phi cn(t-1)$. It can be assumed that the variables are expressed as differences or deviations from trend, so that rule B corresponds to a "no change" or "no deviation from trend" forecast of the real wage. The decision rules are related through $n_A(t) = n_B(t) - \phi w^*(t)$. Another policy that could be considered is to use the past average change in real wage. However, since the variables can be scaled so that their means are zeros, this case can be included in policy B.

Consider expected profits under the two policies. Under policy A, they are

$$\begin{aligned} E\pi_A(t) &= -\tfrac{1}{2}f_1 E[n_B(t)-\phi w^*(t)]^2 + f_0 E[n_B(t)-\phi w^*(t)] \\ &\quad - Ew(t)[n_B(t)-\phi w^*(t)] - \tfrac{1}{2}cE[n_B(t)-n(t-1)-\phi w^*(t)]^2 - p \\ &= E\pi_B(t) + \phi[Ew(t)w^*(t)-\tfrac{1}{2}Ew^*(t)^2] - p \\ &= E\pi_B(t) + \phi(b-\tfrac{1}{2})Ew^*(t)^2 - p \qquad (2) \end{aligned}$$

where $b = Ew(t)w^*(t)/Ew^*(t)^2$. This can be interpreted as the slope from a regression of w on w^*, which would be available for the firm from past experience of using the forecast. Assume first that the forecast can be obtained costlessly, i.e. $p=0$. Then $E\pi_A(t) > E\pi_B(t)$ if $b > \frac{1}{2}$. A perfect forecast would correspond to $b=1$. If $b<1$ the forecast has a tendency to overestimate. If $1>b>\frac{1}{2}$, this tendency is , however, not too large to make the use of the forecast unprofitable. If $b<\frac{1}{2}$, the overestimation is too large and it is more profitable to use a "no change" forecast. On the other hand, if $b>1$, the forecast tends to underestimate change, but the use of the forecast is still better than using a "no change" forecast, as long as the sign of the change is correctly forecasted. Use of $b>\frac{1}{2}$ as a criterion of forecast usefulness is suggested in Ilmakunnas (1987). [If Theil's (1971) optimal linear correction is used to the forecast, as in the model of Johansen (1972,1978) and Granger (1973), the slope of the regression of real wage on the adjusted forecast is equal to 1.]

Another interpretation of the condition is the following. Write $E[w(t)w^*(t)-\frac{1}{2}w^*(t)^2]$ as $-\frac{1}{2}E[w^*(t)^2-2w(t)w^*(t)+w(t)^2-w(t)^2]$ = $-\frac{1}{2}[E[w(t)-w^*(t)]^2-E[w(t)-0]^2]$ = $-\frac{1}{2}[MSE(w^*)-MSE(0)]$ = $-\frac{1}{2}MSE(0)(U^2-1)$, where $U = \sqrt{MSE(w^*)}/\sqrt{MSE(0)}$ is Theil's (1971) U-statistic. If $U<1$, use of decision rule A is profitable compared to using a "no change" forecast. It the mean of w is zero, the criterion is $MSE(w^*)/var(w) < 1$, which was suggested by Ashley (1983).

In the remainder of the paper it is assumed that all variables have zero mean and w^* is an unbiased forecast, so that $b = r\sigma/\sigma^*$ where r is the correlation coefficient of w and w^* and σ^2 and σ^{*2} are the variances of w and w^*, respectively. If there is a fixed cost p for using the forecast, the criterion for forecast accuracy becomes $b > \frac{1}{2} + p/\phi\sigma^{*2}$. This shows that the slope of the regression line has to be steeper (closer to 1) than in the case of costless information.

It could be imagined that there are alternative forecasts available, which can be ranked according to the correlation between w and w^*. On the other hand, the cost of information could be an increasing function of r, $p(r)$, with $p'>0$, $p''>0$ and p approaches infinity when r approaches 1. [Actually, even for optimal forecasts r is never equal to 1. In that case $b = 1$, $\sigma>\sigma^*$ and $\text{cov}(w,w^*)= \sigma^{*2}$ so that $r = \sigma^*/\sigma < 1$.] The forecast (or r) to be chosen is determined from the condition $\phi\sigma\sigma^* - p'(r) = 0$. It is easily shown that optimal r varies inversely with c, the slope of marginal costs, and f_1, the negative of the slope of marginal revenues. Hence if the benefit from forecast accuracy increases (c or f_1 falls), more forecast information is demanded. On the other hand, any upward shifts in the marginal price of forecast p' would reduce optimal r. This is in line with Kihlstrom's (1976) result that information is not a Giffen good.

3. Usefulness of forecasts in a multiperiod case

Above it was assumed that the discount rate is so high that future periods can be ignored. Consider now a multiperiod case. For analytical tractability the simplifying assumption is made that $R(t)=1$, $R(t+1)=R$ and that $R(t+j)=0$ for $j>2$. Hence only periods t and $t+1$ need to be taken into account. The first policy to be considered, A, is such that in periods t and t+1 the real wage is assumed to be equal to the one period ahead and two periods ahead forecasts $w^*(t)$ and $w^*(t+1)$, respectively. Policy B is such that for period t the forecast $w^*(t)$ and for period t+1 a "no change" forecast is applied.

The firm now maximizes $E(\pi(t) + R\pi(t+1))$. The optimal labor input for period t is $n(t) = \mu f_0 - \mu Ew(t) + \mu cn(t-1) + \mu cREn(t+1)$, where $\mu = 1/(f_1+c+Rc)$. To obtain the expected next period labor input, expected profits are differentiated with respect to $n(t+1)$. This yields $En(t+1) = \phi f_0 + \phi cn(t) - \phi Ew(t+1)$. Combining these results gives $n(t) = (\tau/\mu)f_0 - (\tau/\phi)Ew(t) - \tau RcEw(t+1) + (\tau c/\phi)n(t-1)$, where $\tau = 1/((f_1+c)^2+f_1Rc)$. Under policy A the chosen labor input is $n_A(t) = (\tau/\mu)f_0 - (\tau/\phi)w^*(t) + (\tau c/\phi)n(t-1) - \tau Rcw^*(t+1)$ and under policy B, $n_B(t) = (\tau/\mu)f_0 - (\tau/\phi)w^*(t) + (\tau c/\phi)n(t-1)$. For period t+1, the expected labor inputs are $En_A(t+1) = \phi f_0 + \phi cn_A(t) - \phi w^*(t+1)$ and $En_B(t+1) = \phi f_0 + \phi cn_B(t)$. The choices are again related through $n_A(t) = n_B(t) - \tau Rcw^*(t+1)$ and $En_A(t+1) = En_B(t+1) + \phi c[n_A(t)-n_B(t)] - \phi w^*(t+1) = En_B(t+1) - (\tau/\mu)w^*(t+1)$.

The expected period t profits under policy A are

$$\begin{aligned}E\pi_A(t) &= -\tfrac{1}{2}f_1E[n_B(t)-\tau Rcw^*(t+1)]^2 + f_0E[n_B(t)-\tau Rcw^*(t+1)]\\ &\quad - Ew(t)[n_B(t)-\tau Rcw^*(t+1)] - \tfrac{1}{2}cE[n_B(t)-n(t-1)-\tau Rcw^*(t+1)]^2 - p\\ &= E\pi_B(t) - \tfrac{1}{2}(\tau^2R^2c^2/\phi)Ew^*(t+1)^2\\ &\quad + \tau RcEw(t)w^*(t+1) - (\tau^2Rc/\phi\mu)Ew^*(t)w^*(t+1)\\ &\quad + R^2\tau^2c^3[f_0-f_1n(t-1)]Ew^*(t+1) - p. \qquad (3)\end{aligned}$$

The expected period t+1 profits under A are

$$\begin{aligned}E\pi_A(t+1) &= -\tfrac{1}{2}f_1E[n_B(t+1)-(\tau/\mu)w^*(t+1)]^2\\ &\quad + f_0E[n_B(t+1)-(\tau/\mu)w^*(t+1)] - Ew(t+1)[n_B(t+1)-(\tau/\mu)w^*(t+1)]\end{aligned}$$

$$
\begin{aligned}
&- \tfrac{1}{2}cE[n_B(t+1)-n_B(t)-(\tau/\mu)w^*(t+1)]^2 \\
&= E\pi_B(t+1) - \tfrac{1}{2}\tau^2[(c/\phi^2)+(f_1/\mu^2)]Ew^*(t+1)^2 \\
&\quad + (\tau/\mu)Ew(t+1)w^*(t+1) - (Rc^2\phi\tau^2 f_1/\mu)Ew^*(t)w^*(t+1) \\
&\quad - R\tau^2c^3[f_0-f_1 n(t-1)]Ew^*(t+1). \qquad (4)
\end{aligned}
$$

The combined profits are $\pi_A = E\pi_A(t) + RE\pi_A(t+1)$ and $\pi_B = E\pi_B(t) + RE\pi_B(t+1)$. From (3) and (4) the profits are obtained as

$$
\begin{aligned}
\pi_A &= \pi_B + (R\tau/\mu)[Ew(t+1)w^*(t+1)-\tfrac{1}{2}Ew^*(t+1)^2] \\
&\quad + \tau RcEw(t)w^*(t+1) - (\tau\phi Rc/\mu)Ew^*(t)w^*(t+1) - p \\
&= \pi_B + (R\tau/\mu)(b'-\tfrac{1}{2})\sigma'^{*2} - p \\
&\quad + \tau Rc[Ew(t)w^*(t+1)-(\phi/\mu)Ew^*(t)w^*(t+1)] \qquad (5)
\end{aligned}
$$

where $b' = Ew(t+1)w^*(t+1)/Ew^*(t+1)^2$ is the slope from a regression of real wage on the two periods ahead forecast and σ'^{*2} is the variance of the two periods ahead forecast.

Consider first the case where forecast for period t+1 is not correlated with real wage or forecast for period t, so that the last term in (5) is zero. Use of the two periods ahead forecast is profitable if $b' > \frac{1}{2} + (\mu p/R\tau\sigma'^{*2})$. The conclusions of forecast accuracy are similar to those in the one period model. The forecast has to be more accurate than with costless information.

Assume that p is a function of r', the correlation coefficient of the two periods ahead forecast and the corresponding real wage. The optimal forecast accuracy is determined by the condition $R\tau\sigma\sigma'^*/\mu - p'(r') = 0$. It is easily shown that r' varies inversely with c, f_1 and upward shifts in $p'(r')$. However, now r' varies also directly with R, i.e. inversely with the discount rate. If future profits are heavily discounted, it is not profitable to pay much to obtain a forecast.

Finally, consider the possibility of correlation between the two periods ahead forecast and the previous period's forecast and realization. The last term in (5) appears because at period t the choice of $n_A(t)$ depends on the forecast $w^*(t+1)$ and at period t+1, $n_A(t+1)$ nepends on $n_A(t)$, and therefore on $w^*(t)$. If there are no adjustment costs, i.e. $c=0$, neither effect appears. It is likely that the correlations are positive and $Ew^*(t)w^*(t+1) > Ew(t)w^*(t+1) > 0$. $w(t)$ is not known when the forecasts are made, but $w^*(t)$ and $w^*(t+1)$ are based on the same information available at t-1 and are therefore likely to be highly correlated. In addition, $\o/\mu = 1+Rc\o > 1$, so that the negative effect in the last term of (5) is likely to outweigh the positive one. This increases the required accuracy of the forecast $w^*(t+1)$. An interesting case to consider is when the forecast is autocorrelated so that $w^*(t+1) = dw^*(t) + e(t+1)$. In this case $Ew(t)w^*(t+1) = dEw(t)w^*(t) + Ew(t)e(t+1)$ and $Ew^*(t)w^*(t+1) = Ew^*(t)^2 + Ew^*(t)e(t+1)$. The last terms of these expressions can be assumed to be zeros. (5) can be rewritten as

$$\pi_A = \pi_B + (R\tau/\mu)[(b'-\tfrac{1}{2})\sigma'^{*2} + \mu cd(b-(\o/\mu))\sigma^{*2}] \qquad (6)$$

Now the profitability of using the two periods ahead forecast depends not only on its own accuracy but also on the accuracy of the one period ahead forecast. Even if $w^*(t)$ were a perfect forecast, i.e. $b=1$, $b-\o/\mu=-Rc\o<0$ so that b' had to be greater than $\frac{1}{2}$ for the use of $w^*(t+1)$ to be profitable. On the other hand, if $w^*(t)$ underestimates $w(t)$, i.e. $b>1$, more overestimation is allowed for $w^*(t+1)$, i.e. b' can be smaller than $\frac{1}{2}$.

References

Ashley, R., 1983, On the usefulness of macroeconomic forecasts as inputs to forecasting models, Journal of Forecasting 2, 211-223

Darby, M.R., 1976, Rational expectations under conditions of costly information, Journal of Finance 31, 889-895

Feige, E.L. and Pearce, D.K., 1976, Economically rational expectations: Are innovations in the rate of inflation independent of innovations in measures of monetary and fiscal policy, Journal of Political Economy 84, 499-522

Granger, C.W.J., 1973, On the properties of forecasts used in optimal economic policy decisions, Journal of Public Economics 2, 347-356

Holden K. and Peel, D.A., 1983, Forecasts and expectations: some evidence for the UK, Journal of Forecasting 2, 51-58

Ilmakunnas, P., 1987, Further results on the usefulness of macro forecasts as inputs to forecasting models, mimeo

Johansen, L., 1972, On the optimal use of forecasts in economic policy decisions, Journal of Public Economics 1, 1-24

Johansen, L., 1978, Lectures on Macroeconomic Planning, Part 2, (Amsterdam: North-Holland)

Kihlstrom, R.E., 1976, Firm demand for information about price and technology, Journal of Political Economy 84, 1335-1341

Paroush, J., 1981, Market research as self protection of a competitive firm under price uncertainty, International Economic Review 22, 365-375

Sargent, T., 1979, Macroeconomic Theory, (New York: Academic Press)

Theil, H., 1971, Applied Economic Forecasting, (Amsterdam: North-Holland)

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