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Keskusteluaiheita
Discussion papers

HOW TO USE PRELIMINARY VALUES IN FORECASTING THE MONTHLY INDEX OF INDUSTRIAL PRODUCTION?*

by

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ABSTRACT: The first preliminary values of the monthly index of Finnish industrial production undergo a major revision once a year. The problem discussed in this paper is how to take this into account when forecasting the index using a transfer function model based on quick indicators (Teräsvirta, 1984). The preliminary values may be interpreted as measurements with error and handled in the state space framework as proposed in the literature. However, if one forecasts beyond the period for which preliminary values are available this does not lead to any improvement in prediction accuracy compared to the case in which the preliminary values are treated as final values without any error. Reasons for this outcome are indicated.

KEYWORDS: ARIMA model, data revisions, Kalman filter, time series analysis, transfer function model

JEL Classification: 211, 221

1. INTRODUCTION

In model-based forecasting of economic time series, the most recent observations of the series are the most important ones in determining the forecast. A common problem is that these values may be preliminary and subject to revision. If this is the case, the errors in preliminary values may have an adverse effect on the forecast accuracy if they are treated in the same way as the final values of the series. To mitigate the problem, several researchers (Howrey, 1978, 1984; Conrad and Corrado, 1979; Harvey et al., 1983; Trivellato and Rettore, 1986; de Jong, 1987, among others) have suggested the use of the Kalman filter for handling the preliminary values in univariate economic forecasting. Their papers indicate that it is possible to improve the accuracy of the forecasts by taking the tentative nature of the preliminary values explicitly into account and treating them as observations with measurement error.

Teräsvirta (1984) constructed a short-term transfer function model to "predict" the most recent, still unpublished values of the monthly Finnish index of industrial production (IIP). The purpose of the model is to reduce the publication lag of the first estimate of the IIP. Therefore the input variables of the model are quick indicators based on time series published quicker than the industrial production index but related to it. In applying the model, no distinction has so far been made between the preliminary and final values of the industrial production series. This paper shows that this practice has not impaired prediction accuracy if one makes forecasts for periods for which preliminary values are not available and discusses reasons for this outcome.

2. THE DATA

The time series to be analyzed is the monthly Finnish IIP constructed by the Finnish Central Statistical Office (FCSO). We have used data from January 1974 to December 1985. The series has been published in terms of three base years, 1970, 1975 and 1980, but it has been chained to have a common base year, 1980. Note that when the base year changes, the way of constructing IIP may also be revised. Therefore it is important to have the preliminary and the final values to refer to the same vintage of the index if we want to model the relationship between the preliminary and the final data as accurately as possible. The first estimate of the monthly IIP is published about two months after the month has elapsed. A major revision of the preliminary values is carried out once year, in August. The revisions following it change the values of the series so little that the data from the large revision may safely be considered final for the purposes of this study.

3. LINKING PRELIMINARY AND FINAL VALUES

As mentioned above, we assume that the IIP is revised only once a year and that no further revisions are carried out. Let y_t^f and y_t^p be the final and preliminary values of the logarithm of the IIP, respectively. Our task is to obtain improved estimates for those final values for which only preliminary estimates exist. To this end we assume that the preliminary and final values are related by the following (updating) equation:

$$y_t^p = \mu + \beta_1 y_t^f + \beta(z) y_t^p + \gamma(z) y_t^f + \varepsilon_t, \quad \varepsilon_t \sim \text{nid}(0,\sigma^2) \qquad (3.1)$$

where $\beta(z) = \sum_{j=1}^{k} \beta_j z^j$, $\gamma(z) = \sum_{j=1}^{m} \gamma_j z^j$ and z is the lag operator. It is often assumed that y_t^f is generated by a univariate ARIMA(p,d,q) model; see for instance Harvey et al. (1983). However, following Teräsvirta (1984) we assume early information about y_t^f in the following form

$$\nabla_{12} y_t^f = \omega_1(z)p_{1t} + \omega_2(z)p_{2t} + \phi_t, \quad \phi_t \sim \text{nid}(0,\sigma_1^2) \qquad (3.2)$$

where $\nabla_{12} = 1 - z^{12}$, p_{1t} and p_{2t} are two linear combinations of quick indicators, and $\omega_i(z) = \sum_{j=1}^{h_i} \omega_{ij} z^j$, $i = 1,2$.

Equation (3.2) is our prediction equation and it is used to forecast y_t^f when related information in the form of quick indicators becomes available before the preliminary estimate y_t^p of y_t^f is released. Equation (3.1) is designed for updating this forecast after y_t^p has been published. This may be carried out in the Kalman filter framework as Howrey (1978) suggested; see the appendix for details. For information about the indicators, see Teräsvirta (1984).

4. APPLICATION

The observation period for the specification and estimation of (3.1) is 1975(i) to 1984(xii). The time series are seasonally unadjusted. After discarding the intercept whose coefficient estimate is not significant, the estimated model becomes

$$y_t^p = \underset{(0.082)}{0.84}y_t^f + \underset{(0.041)}{0.39}y_{t-12}^p - \underset{(0.087)}{0.23}y_{t-12}^f + e_t \qquad (4.1)$$

$R^2 = 0.99996$, $s = 0.0282$, $F_{ar}(12,93) = 1.54(0.12)$, $z_n(2) = 0.012(0.999)$, $F_{arch}(4,109) = 13.4(0.000)$, $F_{hs}(6,109) = 3.92(0.0014)$, $F_{reset}(2,115) = 0.31(0.73)$, $F_{chow}(12,117) = 0.12(0.999)$

where s is the standard deviation of the residuals, the figures in parentheses below the coefficient estimates are estimated standard deviations and those following the values of test statistics are p-values. Furthermore, $F_{ar}(n_1,n_2)$ is the Lagrange Multiplier test for testing the hypothesis of no autocorrelation against AR(12) or MA(12), $z_n(2)$ is the Bera-Jarque normality test of errors, $F_{arch}(n_1,n_2)$ is the test against conditional heteroskedasticity of errors, $F_{hs}(n_1,n_2)$ is the general (White) heteroskedasticity test, $F_{reset}(n_1,n_2)$ is the third order RESET test, and $F_{chow}(n_1,n_2)$ is the Chow structural stability test based on the twelve monthly values of 1985 outside the estimation period. All the results except for the normality test refer to the "F-form" of the tests; see e.g. Hendry (1989, chapter 3) or Spanos (1986, chapters 21 and 22) for definitions. The structure is stable, there is no error autocorrelation, and the only tests giving rise to concern are the two heteroskedasticity tests. However, a look at the data tells us that FCSO has gradually managed to improve the accuracy of the preliminary values of the IIP index. This means that the absolute values of the residuals also show a falling trend, which explains the outcome of the two tests. Because the parameter estimates are consistent in the presence of heteroskedasticity if the structure of the model is not otherwise mis-specified we thus continue to work with (4.1).

Note that $\hat{\beta}_1 + \hat{\beta}_2 + \hat{\beta}_3 = 1.00$ in (4.1) so that a reparameterization of that equation yields the following error-correction form; see, e.g. Davidson et al. (1978):

$$\nabla_{12} y_t^p = 0.84 \nabla_{12} y_t^f + 0.61 (y_{t-12}^f - y_{t-12}^p) + e_t \,. \qquad (4.2)$$

According to (4.2), a preliminary value smaller than the final one is taken into account in the form of an upward correction the same month next year. Yet, (4.1) is not intended as a model for the behaviour of FCSO, although interpreting (4.2) that way might be tempting. However, there has been a tendency for FCSO to underestimate the industrial output at the preliminary stage during periods of rapid growth. Equation (4.2) probably reflects that phenomenon to a certain degree.

The specification and estimation of (3.2), using observations 1975(vii) to 1984(xii) yields

$$\begin{aligned} \nabla_{12} y_t^f = {} & 0.030 + 0.079 p_{1t} + 0.029 p_{1,t-5} - 0.037 p_{1,t-6} + 0.091 p_{2t} \\ & (0.0048)(0.011) \quad (0.020) \quad (0.019) \quad (0.025) \\ & - 0.081 p_{2,t-5} + 0.097 p_{2,t-6} + e_t \qquad (4.3) \\ & (0.031) \quad (0.027) \end{aligned}$$

$R^2 = 0.570$, $s = 0.0413$, $F_{ar}(12,95) = 0.78(0.67)$, $Z_n(2) = 8.6(0.000)$, $F_{arch}(4,99) = 0.35(0.85)$, $F_{hs}(12,94) = 1.25(0.26)$, $F_{reset}(2,105) = 6.4(0.025)$, $F_{chow}(12,107) = 0.53(0.89)$

where p_{1t} and p_{2t} are the first two principal components of the 12-month differences of six quick indicators. The dynamic structure of (4.3) is somewhat different from that of its counterpart in Teräsvirta (1984). This is because the observation period has been shifted, the observations from the early 1970s are excluded and more recent data included, and the principal components have been rescaled. There is no indication of a structural break after the estimation period in 1985.

The rejection of normality of errors is due to large residuals in July 1979 and 1980; see Teräsvirta (1984) for reasons for them. The RESET test indicates that the structure of the relationship is not fully satisfactory (the two large July residuals do not seem to be the only reason for rejection), but with the given set of indicators we have not been able to improve it.

Consider now the following hypothetical situation. Assume that we at time T have final observations available up until T-M. Furthermore, there exist preliminary values up to T. Our task is to predict $y^f_{T+1},\ldots,y^f_{T+H}$. We consider three different techniques for generating the forecasts. The terminology is due to Harvey et al. (1983). First, we may estimate the prediction equation using the final observations up until T-M, ignore the preliminary values and predict y^f_t from T-M+1 to T+H. This is called pure forecasting. Second, it is possible to treat preliminary values as final ones. This is tantamount to estimating the prediction equation using all the information up to T and forecasting $y^f_{T+1},\ldots,y^f_{T+H}$; we call this naive forecasting. Finally, we may first make efficient use of the preliminary observations, $y^p_{T-M+1},\ldots,y^p_T$, in the Kalman filter framework and continue by forecasting $y^f_{T+1},\ldots,y^f_{T+H}$.

We have reconstructed the above situation six times starting at T = 1982(vi) and continuing until T = 1984(xii), using the logarithmic IIP and the corresponding preliminary values with M=H=6. As the prediction equation, we have used both a transfer function model of type (3.2) and an ARI(2,0) $x(0,1)_{12}$ model.

The results appear in Tables 1 and 2. They show the root mean square errors of prediction (RMSEP) computed from forecasts for $y^f_{T+1},\ldots,y^f_{T+6}$ for the

five six-month periods and the total RMSEP. They also contain the RMSEP for $y^f_{T-5},\ldots,y^f_T$ for optimal predictions using preliminary values and the RMSEP of the preliminary values themselves. It is seen that using preliminary values in predicting $y^f_{T-5},\ldots,y^f_T$ increases prediction accuracy by about one percentage point compared to pure forecasting if we use the prediction equation with quick indicators. If the prediction equation is the ARI model, the improvement is larger still. But then, the preliminary values as such are almost as accurate forecasts of y_t as the optimal predictions. This has to do with the improvement in the accuracy of the preliminary values. For the period 1983(i)-1985(xii), the RMSEP of the preliminary values equals 0.0176 which is clearly below the standard deviation of the residuals in (4.1). Finally note that the prediction equation is not of major importance when the Kalman filter is applied. The improvement in the accuracy of the updated final values is rather small on the average when we come back from Table 2 to Table 1.

Next consider forecasting outside the sample period. (We assume, however, that the twelve monthly values of the quick indicators are always available outside the sample). From Table 1 it is seen that the RMSEP of the optimal and pure forecasts are identical. This is exactly what happens if we predict outside the period for which we have preliminary values. The updating equation (3.1) can then no longer be used as no preliminary values are available. The optimal method only makes use of (3.2) exactly as in pure forecasting. Because (3.2) does not contain lags of y_t, the pure and optimal methods yield exactly the same predictions. On the other hand, the only difference between the naive and the pure method is that the former uses all the preliminary values in estimating the parameters of (3.2) whereas the latter does not. If (3.2) is as stable a relation as in this application and the preliminary values are not grossly inaccurate,

this difference does not have practical significance. Table 1 illustrates the situation: the RMSEP for the naive technique are mainly very close to those for the pure one.

In univariate forecasting the optimal and pure methods yield different predictions, because they use different starting-values for forecasting from y_T onwards. The naive method has another set of starting-values, and the preliminary values are used in estimating the parameters of the prediction equation. If the specified univariate relation (here an ARI(2,0)x $(0,1)_{12}$ model) is stable, no great differences in forecasts between the methods may be expected. This is the case here, as Table 2 confirms. The superiority of the optimal technique over the pure one is restricted to the period for which preliminary values already exist. This advantage is largely academic, because few practitioners choose to ignore preliminary values completely if they have access to them. However, the real boost to genuine forecasting accuracy in this application comes from making use of the information contained in quick indicators. This strengthens the earlier conclusion in Teräsvirta (1984).

5. CONCLUSIONS

In this paper we consider three different prediction techniques for short-term forecasting the monthly Finnish industrial production. A comparison between them leads to the following conclusions:

1. Consider forecasting outside the period for which preliminary values exist. If the prediction equation contains lags of the predictand, the difference between optimal and pure forecasting techniques (Harvey, et

al., 1983) lies in different starting-values. This difference disappears if the prediction equation does not contain lags of the predictand. The naive technique in which the preliminary values are treated as final is hardly inferior to the other two if the prediction equation is stable and well-specified.

2. Trivially, the optimal technique is useful compared to the pure method in predicting final values for which preliminary values exist. More interestingly, however, the Kalman filter technique does not offer a significant improvement over the preliminary values themselves in predicting the corresponding final values. Generally, this is possible if the quality of the preliminary values improves during the period under consideration as in the present application.

3. The main factor in increasing the prediction accuracy in forecasting beyond the preliminary values of the IIP is the information in the quick indicators. Thus in this application the choice between the three prediction techniques is of minor or no importance. The answer to the question posed in the title of the paper clearly is that treating the preliminary values as final is not harmful, i.e., the naive forecasting technique is fully applicable.

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Table 1. The root mean squared errors of prediction in forecasting the Finnish index of industrial production six (or twelve) months ahead using the "optimal", "pure", and "naive" techniques, respectively, as well as the preliminary values of the index and a transfer function model with quick indicators as the prediction equation, 1983(i)-1985(xii)

	Forecasting period	Technique		Preliminary values
		Optimal	Pure	
Preliminary values exist	1983(i) - 1983(vi)	0.0246	0.0299	0.0321
	1983(vii) - 1983(xii)	0.0158	0.0202	0.0035
	1984(i) - 1984(vi)	0.0092	0.0200	0.0150
	1984(vii) - 1984(xii)	0.0081	0.0297	0.0093
	1985(i) - 1985(vi)	0.0084	0.0191	0.0185
	1985(vii) - 1985(xii)	0.0169	0.0386	0.0135
	Total (36 observations)	0.0151	0.0272	0.0176

	Forecasting period	Technique		
		Optimal	Pure	Naive
Predicting beyond preliminary values	1983(i) - 1983(vi)	0.0338	0.0338	0.0287
	1983(vii) - 1983(xii)	0.0216	0.0216	0.0190
	1984(i) - 1984(vi)	0.0199	0.0199	0.0200
	1984(vii) - 1984(xii)	0.0302	0.0302	0.0301
	1985(i) - 1985(vi)	0.0193	0.0193	0.0191
	1985(vii) - 1985(xii)	0.0385	0.0385	0.0385
	Total (36 observations)	0.0282	0.0282	0.0269

Table 2. The root mean squared errors of prediction in forecasting the Finnish index of industrial production six (or twelve) months ahead using the "optimal", "pure", and "naive" techniques, respectively, as well as the preliminary values of the index and an $ARI(2,0)x(0,1)_{12}$ model as the prediction equation, 1983(i)-1985(xii)

	Period	Technique		Preliminary values
		Optimal	Pure	
Preliminary values exist	1983(i) - 1983(vi)	0.0258	0.0349	0.0321
	1983(vii) - 1983(xii)	0.0162	0.0512	0.0035
	1984(i) - 1984(vi)	0.0143	0.0375	0.0150
	1984(vii) - 1984(xii)	0.0100	0.0590	0.0093
	1985(i) - 1985(vi)	0.0118	0.0297	0.0185
	1985(vii) - 1985(xii)	0.0123	0.0369	0.0135
	Total (36 observations)	0.0160	0.0428	0.0176

	Period	Technique		
		Optimal	Pure	Naive
Predicting beyond preliminary values	1983(i) - 1983(vi)	0.0575	0.0432	0.0639
	1983(vii) - 1983(xii)	0.0201	0.0221	0.0231
	1984(i) - 1984(vi)	0.0355	0.0383	0.0378
	1984(vii) - 1984(xii)	0.0557	0.0607	0.0676
	1985(i) - 1985(vi)	0.0268	0.0288	0.0276
	1985(vii) - 1985(xii)	0.0354	0.0391	0.0325
	Total (36 observations)	0.0401	0.0405	0.0455

Appendix: Setting up the Kalman filter for prediction and updating

The principle is the same as in Howrey (1978) and Harvey et al. (1983). Let

$$y_t^0 = y_t^p - b_1 y_t^f.$$

Then

$$y_t^p = b_1 y_t^f + b_2 y_{t-12}^p + b_3 y_{t-12}^f + \varepsilon_t$$

see (4.1), can be written as

$$y_t^0 = b_2 y_{t-12}^0 + b_4 y_{t-12}^f + \varepsilon_t$$

where $b_4 = b_3 + b_1 b_2$. Let the state vector

$$\alpha_t = (y_t^f, y_{t-1}^f, \ldots, y_{t-11}^f, y_t^0, \ldots, y_{t-11}^0)'.$$

The measurement equation is $y_t^p = z'\alpha_t$ where $z = (b_1, 0, \ldots, 0, 1, 0, \ldots, 0)'$.

Define the transition equation as

$$\alpha_t = T\alpha_{t-1} + \mu_t + R\upsilon_t \qquad \text{(A.1)}$$

see Harvey (1981, p. 107). With the transfer function prediction equation of type (4.3) we have in (A.1)

$$T = \left[\begin{array}{ccc|ccc} 0 & \ldots & 0\ 0 & & & \\ \multicolumn{3}{c|}{I_{11}} & \multicolumn{3}{c}{0} \\ & & 0 & & & \\ \hline 0 & \ldots & 0\ b_4 & 0 & \ldots & 0\ b_2 \\ \multicolumn{3}{c|}{0} & \multicolumn{3}{c}{I_{11}\quad 0} \end{array}\right]$$

and $\mu_t = (\mu_{t1},0,..,0)'$ where

$$\mu_{t1} = c_0 + c_1 p_t^1 + c_2 p_{t-5}^1 + c_3 p_{t-6}^1 + c_4 p_t^2 + c_5 p_{t-5}^2 + c_6 p_{t-6}^2 .$$

Furthermore,

$$R' = \begin{bmatrix} 1 & 0 & \dots & 0 & 0 & 0 & \dots & 0 \\ 0 & 0 & \dots & 0 & 1 & 0 & \dots & 0 \end{bmatrix}$$

and $\nu_t = \text{diag}(\varepsilon_t,\phi_t)$, $\text{cov}(\nu_t) = \sigma_\varepsilon^2 \text{diag}(1,\sigma_\star^2)$ where $\sigma_\star^2 = \sigma_\phi^2/\sigma_\varepsilon^2$.

At time T-M, the start of the filter, the covariance matrix of the estimated α_{T-M}, $P_{T-M} = 0$, because every component of α_{T-M} is observed. For actual prediction and updating steps, see e.g. Harvey (1981, pp. 107-110). For the ARI(2,0)x(0,1)$_{12}$ prediction equation $\mu_t \equiv 0$, and the dimension of α_t and the whole matrix T have to be modified accordingly.

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