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FORECASTING THE OUTPUT OF FINNISH FOREST INDUSTRIES USING BUSINESS SURVEY DATA

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ABSTRACT: In this paper forecasting the production volume of the Finnish forest industries one quarter ahead is discussed. We consider a practical way of making use of the predictive information in the aggregated answers of the quarterly business survey. It is based on the Kalman filter. However, a straightforward application of the idea is not possible, because the relations needed in the Kalman filter are unstable over time. Solutions to that problem are discussed. The results indicate that it is possible to increase the precision of one-quarter-ahead forecasts using business survey information compared to that of forecasts from autoprojective models. The improvement in prediction accuracy after taking account of relevant business survey information is significant.

KEY WORDS: Autoprojective model, autoregression, industrial production, Kalman filter, nonlinearity, smooth transition, structural change

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1. INTRODUCTION

A typical business survey questionnaire contains a host of questions on the recent economic performance of the firm. A few questions on its short-term plans/expectations are also included. The answers are most often trichotomous. The results are generally reported by tabulating the weighted relative shares of the alternative answers. More rarely, if ever, are quantitative forecasts for the next quarter's output, price level or employment enclosed in the report. A natural question therefore is whether the predictive information (answers to questions on plans or expectations of the firms) could be quantified in such a way that each time the results are published, an output forecast for a number of branches and the manufacturing in total based on them could be released as well. Theil (1952) already considered this possibility.

Theil (1952) proposed quantifying the relative shares directly. Another possibility would be to construct a model to link the relative shares to the output series and use that for forecasting. For instance, Teräsvirta (1985) chose this alternative and constructed simple regression models for predicting the output of the Finnish forest industries (SNI code 33 and 34). He reported improvements in prediction accuracy over autoprojective models, but the performance of the models based on very short time series has since been deteriorating over time. Öller (1990), using longer series, concluded that the plan/expectation information in the survey was useless in forecasting the output of Finnish forest industries one quarter ahead.

We shall return to this problem and do it by adopting a Kalman filter approach Rahiala and Teräsvirta (1991) recently introduced. Its basic outline is as follows. First construct an autoprojective model for the output changes and then introduce relevant information from the business survey as "new" information aimed at improving the autoprojective forecast. The Kalman filter with its prediction and updating steps provides a vehicle for incorporating the business survey information in the past information on the output series. The filter can be used to generate the desired output forecast for the next quarter each time a new business survey is conducted and information becomes available. A complication in the present application is that the linear relationships needed for the Kalman filter do not appear stable over time. The problem and solutions to it based on some recent work are discussed in the paper.

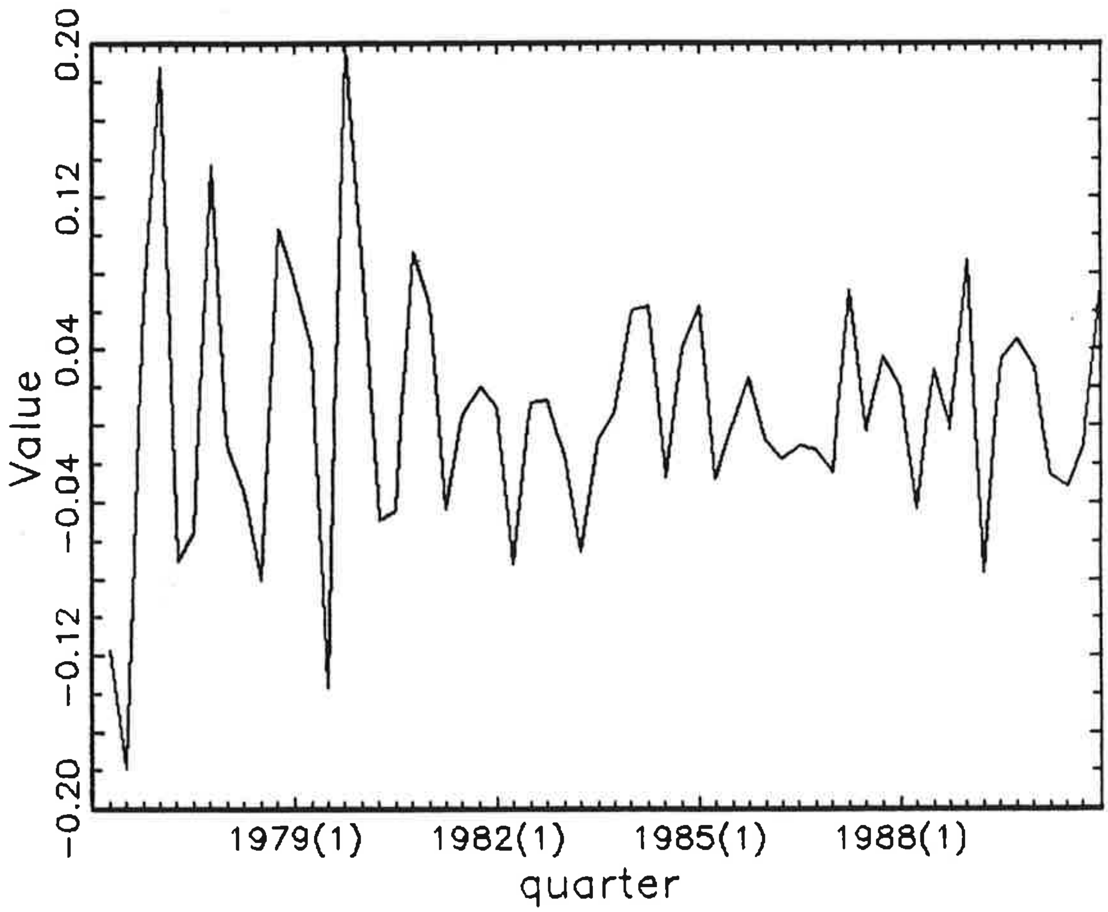
The performance of the Kalman filter obtained by model-building is checked by one-quarter-ahead post-sample forecasting using the period 1988(1) to 1990(4). The results indicate that information from the business survey does have a significant impact on the accuracy of one-quarter-ahead output forecasts. This is in accord with the results in Rahiala and

Teräsvirta (1991). The plan of the paper is as follows. In section 2 we shall discuss the data and in section 3 the Kalman filter. Sections 4 contains empirical results including those on parameter instability, and section 5 concludes.

2. THE DATA

The Finnish business survey is conducted quarterly at the end of March, June, September and December, respectively. The three alternative answers to a large majority of questions are "greater than", "no change" and "less than". Appendix 1 contains a list of questions considered in this paper. The answers of individual firms to each question are aggregated up to weighted relative shares. The annual turnover figures of the firms are used as weights. Untransformed time series of these shares are used as variables in our study.

Figure 1. First differences of the logarithm of the production volume index in the Finnish forest industries, 1976(2)-1990(4)



The number of firms participating in the survey is about 560. The largest firms participate every quarter, the rest are selected by stratified sampling. The forest industries, SNI code 33 and 34, account for about one quarter of the total value added in manufacturing. This makes it the second largest branch in Finnish manufacturing after the metal and engineering industries (SNI code 37 and 38). Its share of the exports is the largest, however, about 38 % of the total in manufacturing.

The variable to be predicted is the production volume index of the forest industries. Because our explicit aim is to forecast next quarter's figure, we use original, seasonally unadjusted series. The quarterly data at our disposal extend from 1976(1) to 1990(4). As the questions in the business survey concern realized or planned/expected changes during a quarter, it is appropriate to use first differences of the logarithmed industrial production indices as production volume data in the models. The time series of these differences is graphed in Figure 1. It is seen to contain considerable seasonal variation in the beginning, but that dies out or at least dampens down after 1981. It turns out to be difficult to describe that development adequately by a linear autoprojective model with constant parameters.

3. THE MODEL

The forecasting framework we shall apply in this paper is based on the idea of improving autoprojective predictions using information from the business survey. It is described in detail in Rahiala and Teräsvirta (1991). Another possibility would be to consider forecasting based solely on business survey data but that is not discussed here. At time t-1 we want to forecast y_t, the logarithmic difference of the volume of industrial production of a branch. Assume that we have information available about the output until t-1: the information set $\mathcal{F}_{t-1}=\{y_{t-1}, y_{t-2},..., y_0\}$. In addition we shall observe g_t, a vector which contains information from the business survey. This vector has as its elements relative shares of "greater than" and "less than" answers or functions of them. Our aim is to use the information in g_t to improve the forecast based solely on $\mathcal{F}_{t-1}$.

For this purpose we consider the state space model Rahiala and Teräsvirta (1991) introduced. (For a good exposition of the Kalman filter see Harvey (1981)). Let $\alpha_t = (y_t, y_{t-1},...,y_{t-k+1}, 1, d_{1t}, d_{2t}, d_{3t}, d_{4t})'$ be the state vector where d_{jt}, j=1,...,4, are the four seasonal dummy variables. The state vector contains the unobservable (at time t-1) y_t we want to forecast as its first element. The movements of the α_t are governed by the transition equation

$$\alpha_t = T\alpha_{t-1} + Ru_t \tag{3.1}$$

where the transition matrix T is independent of t and has the form

$$T = \begin{bmatrix} \varphi_1 \ \varphi_2 \ \cdots \ \varphi_k & \mu & \delta_1 & \delta_2 & \delta_3 & 0 \\ I_{k-1} & 0 & & 0 & & \\ & 1 & 0 & 0 & 0 & 0 \\ & 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ & 0 & 0 & 1 & 0 & 0 \\ & 0 & 0 & 0 & 1 & 0 \end{bmatrix}.$$

Furthermore, R = (1,0,..,0)', because only y_t is not observed at t-1. The measurement equation is

$$x_t = Z\alpha_t + Sv_t \tag{3.2}$$

where

$$x_t = (y_{t-1}, g'_t)',$$

$$Z = \begin{bmatrix} z_1 \\ z_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 & \dots 0 & 0 \\ z_{21} & z_{22} & & \dots z_{2p} & 0 \end{bmatrix}$$

$$S = \begin{bmatrix} 0 \\ I_d \end{bmatrix}, \ d = \dim(z_2)$$

and

$$\begin{bmatrix} u_t \\ v_t \end{bmatrix} \sim \text{nid}(0, \text{diag}(\sigma^2, H)).$$

The measurement equation basically describes how the business survey answers depend on the observed production values.

The forecasting is carried out as follows. At time t-1 the relevant information in F_{t-1} appears in a_{t-1}, the estimate of α_{t-1}. In this case, α_{t-1} is observed directly, i.e., $\alpha_{t-1} \equiv a_{t-1}$. Thus $P_{t-1} = cov(a_{t-1}) = 0$. From the transition equation (3.1) we obtain the forecast $a_{t|t-1} = Ta_{t-1}$. The covariance matrix of the prediction error $e_t = a_{t|t-1} - \alpha_{t-1}$ is

$$cov(e_t) = P_{t|t-1} = \sigma^2 TP_{t-1}T' + \sigma^2 RR' = \sigma^2 RR'.$$

The autoprojective forecast $a_{t|t-1}$ is updated by incorporating the information in x_t. The updating equation for α_t is

$$a_t = a_{t|t-1} + P_{t|t-1}Z'F^-(x_t - Za_{t|t-1})$$

where

$$F = ZP_{t|t-1}Z' + SHS' = \sigma^2 ZRR'Z' + SHS' = diag\,(0,F_2)$$

and

$$F^- = diag\,(0,F_2^{-1}).$$

In practice, Z, σ^2, and H are replaced by their estimates. The correction to $a_{t|t-1}$ is a function of the prediction error made in forecasting x_t using the information in F_{t-1}. The first element of a_t is the forecast for y_t.

Above we have at least implicitly assumed that g_t is available and used in forecasting y_t. As noted above, the Finnish business survey is conducted just before the end of each quarter (t) and the results made public right after the quarter is over. The above framework is therefore suitable for obtaining the first estimate of y_t at the end of t. To apply it to forecasting y_t at the end of quarter t-1 we have to construct a separate prediction equation for forecasting g_t. This can be done by taking the answers to some of the plan/expectation questions in the business survey that become available at the end of quarter t-1. Their relative shares can be used to predict the relative shares of the answers to realization or judgmental questions appearing in x_t. These predictions are used in x_t in place of g_t when the autoprojective forecast is updated; see Rahiala and Teräsvirta (1991).

4. FORECASTING THE OUTPUT OF FINNISH FOREST INDUSTRIES

4.1. Constructing the model

To build a state-space type forecasting framework for the quarterly output of the Finnish forest industries the data is divided into two parts. The observations from 1970(1) until 1987(4) are used for estimating the parameters of our equations. The data from 1988(1) to 1990(4) are saved for post-sample forecasting. The steps in setting up the Kalman filter are as follows. First, construct an autoprojective model for y_t, i.e., define the state vector and the transition matrix. Second, choose the survey variables for the measurement equation and estimate the unknown parameters of that equation. Third, generate post-sample forecasts with the filter and discard those survey variables which do not seem to contribute to the precision of the forecast, i.e., reduce the dimension of the measurement equation.

We thus began by constructing an autoprojective model for y_t which appears as the first row of the transition equation (3.1). A model with the first and fourth lags of y_t, the intercept and the seasonal dummies seemed adequate. However, when we tested the constancy of parameters against parameterized structural change as Lin and Teräsvirta (1991) advocated, the stability was rejected by LM_1 and LM_2, see Table 1. When the nature of the change was

Table 1. The results of the parameter constancy tests of Lin and Teräsvirta (1991) on the autoprojective model estimated for the observations 1976(2)-1987(4)

Model	Test	Value	p-value
(4.1)	LM_1	$F(6,35) = 2.86$	0.022
	LM_2	$F(12,29) = 2.27$	0.035
	LM_3	$F(18,23) = 1,47$	0.19
	$LM_{2\|3}$	$F(6,23) = 0.42$	0.86
	$LM_{1\|2}$	$F(6,29) = 1.28$	0.30

tested using $LM_{1|2}$, the corresponding null hypothesis was not rejected. This suggested monotonic change in parameters; see Lin and Teräsvirta (1991). When this alternative was estimated, the parameter controlling the slope of the transition function became very large and the algorithm did not converge. Fixing the parameter at a large value and estimating the model conditionally on that value gave the following result:

$$y_t = \underset{(0.13)}{-0.32\, y_{t-1}} - \underset{(0.11)}{0.28\, y_{t-4}} + \underset{(0.023)}{0.14} - \underset{(0.034)}{0.022\, d_{1t}} - \underset{(0.035)}{0.16\, d_{2t}} - \underset{(0.034)}{0.26\, d_{3t}}$$

$$+ (\underset{(0.13)}{0.32\, y_{t-1}} + \underset{(0.11)}{0.28\, y_{t-4}} - \underset{(0.024)}{0.13} + \underset{(0.037)}{0.021\, d_{1t}}$$

$$+ \underset{(0.037)}{0.13\, d_{2t}} + \underset{(0.037)}{0.25\, d_{3t}}) F(t^*) + \hat{u}_t,\ t=1,...,n;\ t^* = 1/n, 2/n, ..., 1 \tag{4.1}$$

where

$$F(t^*) = (1+\exp\{-100 \underset{(0.016)}{s^*(t^* - 0.37)}\})^{-1} \tag{4.2}$$

and

$s = 0.0364$, $s^2/s_L 2 = 0.57$, where s_L is the residual standard deviation of the corresponding linear model, s^* is the inverse of the "sample standard deviation of t^*" used for standardizing the scale parameter, LB(4) = 4.3, ML(2) = 0.67 (0.72), sk = 0.79, ek = 0.35, JB = 5.2 (0.080). LB is the Ljung-Box test of no error autocorrelation, ML is the McLeod-Li test of no autoregressive conditional heteroskedasticity, sk is skewness, ek is excess kurtosis, and JB is the Jarque-Bera test of normality of errors. The figures in parentheses after the test statistics are p-values and those below the coefficient estimates are estimated standard deviations.

The residual variance of (4.1) is only 57 % of the residual variance of the corresponding linear model. The restrictions on the coefficients of y_{t-1} and y_{t-4} are supported by the data. It is seen that we could easily place similar restrictions on the coefficients of the intercepts and the dummy variables. The results suggest that in 1981, $\{y_t\}$ changes to being nearly white noise with zero mean. If this is compared to Figure 1 it is seen that the structural change occurs right after the large fluctuations in the graph of the series are over. The large (fixed) value of the slope parameter indicates that the change is abrupt.

To proceed, an obvious possibility is to take the regime corresponding to F =1, the value of the transition function at the end of the sample, and use that for forecasting. The regime is

$$y_t = -\,0.01 + 0.0001\, d_{1t} + 0.03\, d_{2t} + 0.01\, d_{3t} + \hat{u}_t \tag{4.3}$$

Another possibility is to discard the early part of the sample and begin by estimating an autoprojective model for y_t from the data 1981(1) to 1987(4). The estimated model is

$$y_t = \underset{(0.22)}{-0.019\, y_{t-1}} \; \underset{(0.21)}{-\,0.11\, y_{t-4}} \; \underset{(0.015)}{+\,0.017} \; \underset{(0.020)}{+\,0.0001\, d_{1t}}$$

$$\underset{(0.022)}{-0.032\, d_{2t}} \; \underset{(0.021)}{-\,0.019\, d_{3t}} + \hat{u}_t \qquad (4.4)$$

s = 0.0375, LB(6-4) = 3.6 (0.17), ML(2) = 1.7 (0.42)

sk = 0.54, ek = 0.37, JB =1.5 (0.46).

As may be expected, (4.3) and (4.4) are rather similar.

Next we select the realization variables for the measurement equation and then estimate the parameters of (3.2). The variables were chosen as in Rahiala and Teräsvirta (1991) by adding a set of realization variables to the autoprojective equation (4.1) and retaining the ones that seemed to have explanatory power. Two variables appeared to meet this criterion, pr^+_t, the share of firms reporting increased output (question 1a), and no^-_t, the proportion of firms observing a decrease in new orders (question 4a). However, the contribution of the latter variable to the precision of forecasts in 1988-1990 turned out to be rather small. We can thus simplify the exposition by concentrating the interest on the measurement equation in which pr^+_t is the only business survey variable. When the model for pr^+_t implied by the transition equation (3.2) was estimated and the constancy of its parameter tested, the constancy hypothesis was rejected (LM_1 = 3.6 (0.0047)). We therefore shortened the estimation period to 1981(1)-1987(4) and re-estimated the model. The result is

$$pr^+_t = \underset{(51)}{307\, y_t} \underset{(51)}{+\,109\, y_{t-1}} \underset{(51)}{+\,125\, y_{t-2}} \underset{(52)}{+\,44\, y_{t-3}}$$

$$\underset{(3.6)}{+\,27} \; \underset{(5.1)}{-\,1.9\, d_{1t}} \underset{(5.3)}{+\,7.2\, d_{2t}} \underset{(5.1)}{+\,12\, d_{3t}} + \hat{v}_t \qquad (4.5)$$

s = 8.92, LB(4) = 5.0 (0.29), ML(2) = 0.58 (0.75), sk = 0.17,

ek = -1.22, JB = 1.9 (0.39).

As discussed above, to generate a genuine one-quarter-ahead forecast for y_t we also need a model to obtain a forecast for g_t. Our specification search showed that two plan/expectation variables appeared to contribute to the explanation of pr^+_t. They were $pre^+_{t|t-1}$, the share of firms planning an increase in output (question 2a), as might have been expected, and $be^-_{t|t-1}$, the proportion of firms expecting deteriorating business prospects in the future (question 15).

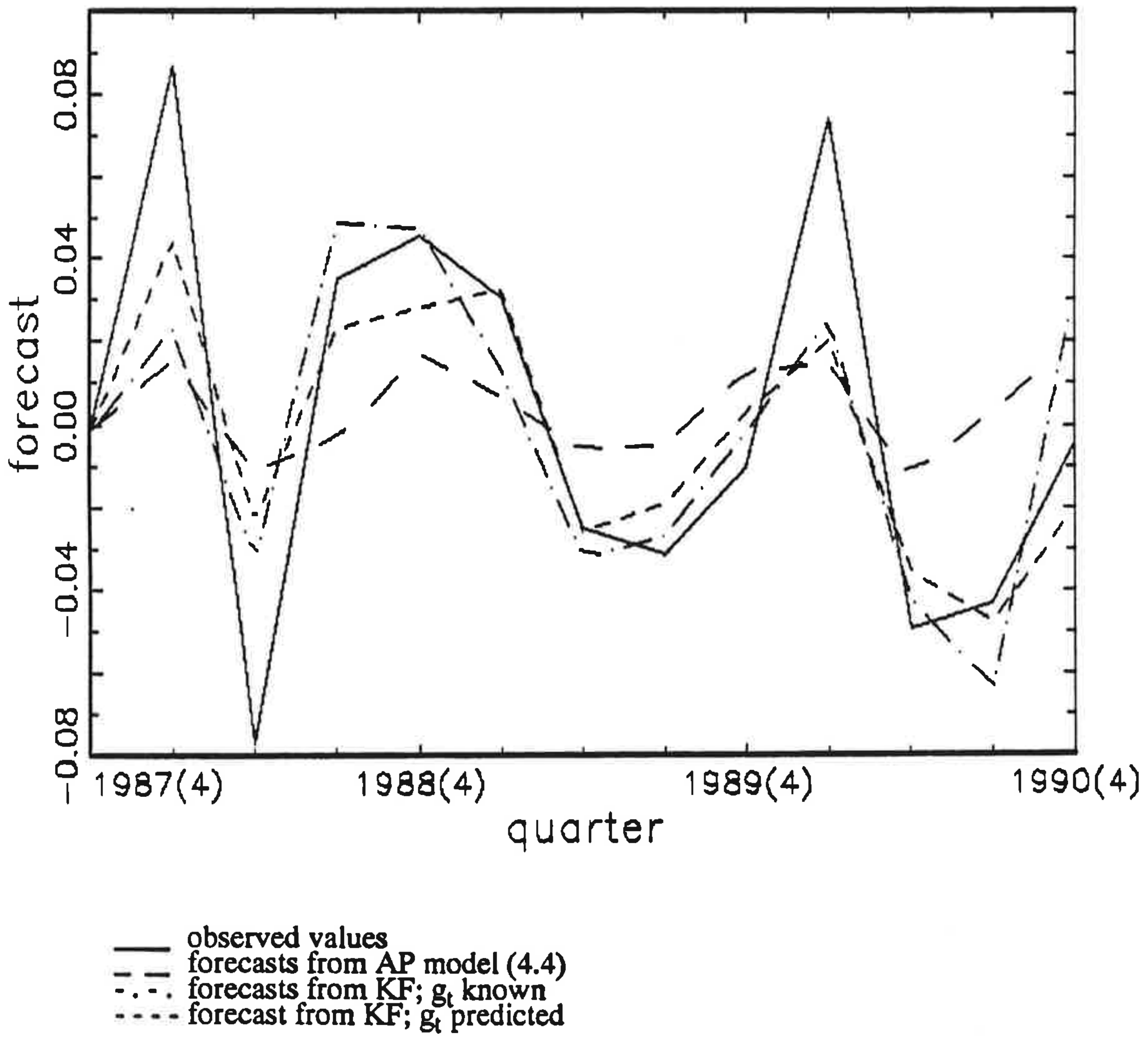
The latter variable seems to be a very useful one in forecasting industrial output in Finland; see Rahiala and Teräsvirta (1991) for results in metal and engineering industries. The estimated model for pr^{+}_{t} is

$$pr^{+}_{t} = \underset{(10)}{24} + \underset{(0.27)}{0.56}\, pre^{+}_{t|t-1} - \underset{(0.092)}{0.30}\, be^{-}_{t|t-1} + \underset{(5.0)}{8.8}\, d_{1t} + \underset{(4.7)}{3.7}\, d_{2t} + \underset{(4.7)}{6.4}\, d_{3t} + \hat{w}_t \qquad (4.6)$$

s = 8.70, LB(4) = 6.6 (0.16), ML(2) = 1.4 (0.50), sk = 0.84,

ek = 0.24, JB = 3.4 (0.18).

Figure 2. The one-quarter-ahead forecasts for the first differences of the logarithm of the production volume in the Finnish forest industries in 1988(1)-1990(4) from the autoprojective model and the Kalman filter for g_t known and g_t predicted, respectively, and the corresponding observed values



There is some evidence for seasonality in plans/expectations but it is not strong. The positive skewness is largely due to two outliers in 1982(3) and 1986(2) when the firms planned a lower production volume than that they finally achieved.

4.2. Forecasting with the model

The equations we just described are used for post-sample forecasting within the Kalman filter framework. The forecasts are one-quarter-ahead forecasts that have been computed without re-estimating the model and the prediction period is 1988(1) to 1990(4). The annual growth rates of the period are positive at first but turn negative in 1989. The period may be easy to forecast with autoprojective models because apart from this single drop in the growth rate the output volume has not fluctuated very much.

The forecasts are graphed in Figure 2. A general impression is that the business survey information has increased the precision of the forecasts compared to the autoprojective ones from (4.4). The RMSEs of the forecasts are in Table 2. The RMSE of the autoprojective model (4.4) is about 4.2 % which may be compared to the residual standard error of (4.4), about 3.8 %. The period 1988-1990 has thus been a rather "normal" one and therefore the use of business survey information may not improve things much. It is seen that if we know pr^{+}_{t} at the time of forecasting, the RMSE decreases to 3.0 %. Having to predict it using equation (4.6) leads to a further decrease to 2.7 %. This is unexpected and reflects the

Table 2. Root mean square errors (RMSE) and medians of absolute errors (MAE) for the forecasts of the output of Finnish forest industries in 1988(1)-1990(4) from the autoprjojective model (4.4) and the Kalman filter

Autoprojective model	Prediction method		
	AP	KF: g_t known	g_t predicted
	RMSE:		
(4.4)	0.0423	0.0300	0.0272
	MAE:		
	0.0326	0.0156	0.0137

difficulties in describing the process generating pr^+_t by y_t and its lags. If structural change in the autoprojective model is ignored despite the test results and the parameters of the models estimated from the observations 1976(2)-1987(4), the RMSE of the autoprojective forecasts is somewhat smaller than previously whereas the other two RMSEs are higher. These results are not reported here. If we use the median absolute error as our measure of precision the differences between (4.4) and the Kalman Filter appear larger than if we consider RMSE. This reflects the fact (see also Figure 2) that while there are occasional large prediction errors also when the Kalman filter is used, the business survey information is generally useful in forecasting the production volume of the Finnish forest industries.

The interesting question is whether the observed differences in prediction performance between the models are significant or not. We investigated that by testing the hypothesis that the MSEs of the forecasts with and without business survey information are equal. The alternative was that the forecasts obtained using business survey information have the lower MSE of the two; for the test see Granger and Newbold (1986, pp. 278-279). The p-values of the test statistic appear in Table 3. The business survey information does seem to increase the accuracy of the forecasts. The evidence is more compelling when pr^+_t is predicted than when it is known, which is surprising but obviously a consequence of (4.6) not being a very accurate description of pr^+_t.

Table 3. The p-values of the Granger and Newbold test for testing that the mean square error (MSE) of forecasts from two models are equal against the alternative that MSE from the Kalman filter is smaller of the two

Autoprojective (AP) model	Testing AP against KF:	
	g_t known	g_t predicted
(4.4)	0.079	0.015

5. CONCLUSIONS

The above results show that the information contained in the business survey is useful in predicting the next quarter's output in Finnish forest industries. In this respect they contradict the conclusions in Öller (1990) but conform to the results in Rahiala and Teräsvirta (1991).

These authors found that the present Kalman filter approach improved the precision in forecasting the output of Swedish and Finnish metal and engineering industries compared to that of autoprojective models. Both that study and the present one have made use of untransformed relative shares of alternative answers. An interesting question not discussed so far is whether the precision of the forecasts could be further increased by an appropriate transformation of these relative shares or not. We shall return to this issue in the near future.

In this paper we have assumed that the output figure for t-1 is available at the end of that quarter and used in forecasting the production volume at time t. In practice, that is not the case. A forecast for the output at t-1 can be obtained, however, by the Kalman filter using the judgmental business survey information for quarter t-1 as discussed in the paper. That forecast may then be used for obtaining a prediction for the output at quarter t. The autoprojective counterpart of this forecast is a prediction two quarters ahead.

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Appendix 1. The questions of the Finnish business survey used in this paper

Note: The alternative answers are generally "greater than", "no change" and "less than". In question 3b they are "yes" and "no", in question 5 "large", "normal" and "small" and in question 15 "better", "the same" and "worse", respectively. The limits of the "no change" category are ± 2 %. The respondents are asked to give "seasonally adjusted" answers.

Question:

1a	Production volume this quarter compared to previous quarter
1b	Production volume this quarter compared to the same quarter last year
2a	Production volume next quarter compared to this quarter
3b	Idle production capacity six months from now
4a	Amount of new orders this quarter compared to previous quarter
4b	Amount of new orders next quarter compared to this quarter
5	Present order stock
7a	Number of employees now compared to three months ago
7c	Number of employees after next three months compared to now
8a	Exports volume this quarter compared to previous quarter
8c	Exports volume next quarter compared to this quarter
15	Business prospects in the near future

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