by the auxiliary variables described above and the dominant structure is Intervention Variables (described in 2). Approach 3 pursues model construction by identifying the Intervention Variables first and then augmenting the model with identified ARIMA structure.

The Forecast Pro methodology

Robert L. Goodrich*

Business Forecast Systems, Inc., Belmont, MA, USA

Forecast Pro is an off-the-shelf product of Business Forecast Systems (BFS), one of the five commercial entrants in the M3 competition. This article provides details about the product as it was configured for the competition.

BFS generated the M3 forecasts in April 1997, employing a Beta-test version of its desktop product Forecast Pro Version 3, Extended Edition. This product has since been revised and is now commercially available as Forecast Pro Version 4. All of the BFS products are based upon the dynamic link library FpwLib.Dll, an Application Program Interface (API) to the BFS forecasting engine. This program, which has no interface, can be accessed from within the code of a client program. Thus Forecast Pro Unlimited, which can handle as many as one million items at a time, creates essentially the same forecasts. Many details of the forecasting process are under direct control of the user.

In this case all forecasts were prepared entirely automatically under the *Expert Selection* option of the product. Because the M3 data set was too large for the product we used, the file was broken down and forecasted in several executions. The total time used was about 15 min on a Dell Pentium Pro 200 MHz computer, by today's standards a slow computer.

The basic premise of the Forecast Pro methodology is simple – fit the appropriate forecasting model to the data at hand. To accomplish this, Forecast Pro has three logical layers.

1. The top layer consists of a master control program to select the family of models to be selected, e.g. exponential smoothing or Box–Jenkins[1]. This protocol is executed when *Expert selection* is chosen from the menu.
2. The second layer identifies a particular model from the family, e.g. ARIMA(1,1,0) or multiplicative Winters. The identification protocol is, of course, specialized to the particular method.
3. The third layer optimizes the parameters via

*68 Leonard St., Belmont, MA 02478, USA. Tel.: +1-617-484-5050.

E-mail address: Info@ForecastPro.com (R.L. Goodrich); web site: www.forecastpro.com

[1]We use the term Box–Jenkins even though it is technically incorrect. Forecast Pro identifies ARIMA models via a procedure altogether different from that espoused by Box and Jenkins (1976).

unconditional least squares and prepares the actual point forecasts, forecast interval and safety stock requirements.

The methodologies considered by the master control program (expert selection) are as follows:

1. Exponential smoothing
2. Box–Jenkins
3. Croston intermittent data model
4. Simple moving average
5. Discrete data models (Poisson and negative binomial distributions).

The format of the competition did not allow consideration of other methodologies available in Forecast Pro, such as dynamic regression, multiple level forecasting, event (interaction) models and Census X11. Thus only a fraction of Forecast Pro methodology was actually tested in the competition.

For the most part, the five tested methodologies are well defined in the literature, but the software designer must still make numerous decisions concerning the details of the algorithms – How is exponential smoothing to be initialized? Should seasonal multipliers be renormalized? How should the Poisson parameter be estimated? Most of these details make little difference to forecast accuracy, but there are some significant exceptions, which will be cited below.

Expert selection. The master control protocol has evolved from FOREX, a Prolog expert system written by R.L. Goodrich (1984, 1986) more than ten years ago in an attempt to develop a method selection strategy based upon the properties of the data. The protocol first polls several functions that answer questions like ''Do the data appear to be from a Poisson process? A Croston process? . . . '' These functions rely on simple properties of the data that can be estimated very quickly, so this stage is very fast, and may resolve the issue without further investigation. More frequently, however, logical rules result in an ambiguous result – it's either Box–Jenkins or exponential smoothing. In that case, an out-of-sample testing procedure is used to select a model family. When the data are very short or appear to be highly irregular, the safety net of simple methods – Poisson, negative binomial or simple moving average – is called into play.

An important principle of the algorithm is our belief that, while exponential smoothing tends to outperform ARIMA for most business data, there are many specific instances where ARIMA is superior to exponential smoothing, usually because the ARIMA seasonal model describes the data structure better than the index-based Winters model.

Exponential smoothing. The BFS implementation of exponential smoothing uses the simplex algorithm (not to be confused with the linear programming procedure) to minimize the sum of squared errors over the historic data. This procedure, selected because of its stability, is followed by a Newton step to obtain parameter estimation variances. The model is identified via the BIC, supplemented by some additional logical rules. We believe that this method is superior to the out-of-sample identification method used in certain other commercial packages and the results of the competition seem to support this contention. Perhaps more significantly, Forecast Pro monitors the multiplicative seasonal model carefully for signs of instability in this highly nonlinear model. We find that, on the average, the multiplicative model fits business data better than the additive, but does so with the danger of instability and egregiously bad forecasts. The BFS procedure effectively screens against this possibility, at the cost of extra computer time for the number crunching involved.

Box–Jenkins. Details of the BFS model identification protocols must remain proprietary secrets, but we will reveal our general approach to ARIMA model identification. Forecast Pro begins by overfitting a *state space* model that is then used to obtain approximate parameter estimates for a large number of alternative ARIMA models. The Bayesian Information Criterion (BIC) is used, along with several other rules, to identify the specific ARIMA model. Its parameters are then refined via unconditional least squares as described by Box and Jenkins (1976). The principal advantage of this procedure is its extreme speed – it can generate alternative ARIMA models very quickly.

It is unnecessary to elaborate on identification and estimation of the other methods because of their extreme simplicity.

The Forecast Pro methodology incorporates many specialized handling algorithms for treatment of special data problems that have been detected over several years. Thus the overall algorithm consists both of straightforward statistics and special handling for such peculiarities in the data.

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John Galt's ForecastX Engine

Anne Omrod*

John Galt Solutions Inc., 39 South LaSalle St., Suite 815, Chicago, IL 60603, USA

ForecastX™ has an open architecture and programmable modules that offers professional statisticians and academicians considerable power and capability. ForecastX™ provides stability and consistency under a wide variety of forecasting conditions.

ForecastX™ has a multi-factored approach to selecting the best model and method for generating the forecast. In creating results, John Galt uses a fully automated process that does not require human intervention or overrides. The automated selection process uses a combination of SSE, BIC and rolling evaluation to select the best forecasting model. This combined approach allows ForecastX™ to change its optimization process based on the number of observations and seasonal patterns within the data.

*Tel.: + 1-312-701-9026; fax: + 1-312-701-9033.

E-mail address: omrod@johngalt.com (A. Omrod); web site: www.forecastx.com