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Structural Time Series Modeling with SAS Proc UCM and STAMP

By Robert Yaffee

Structural time series analysis involves the decomposition of the series into unobserved components. In this kind of analysis, analysts identify the presence or absence of the level, trend, seasonality, cyclicity, autoregressiveness, or irregularity inherent in a particular series. When identifying these components, they designate those contained in the model as nonexistent, stochastic or deterministic. The developed models help analysts identify interventions and structural breaks in the underlying data generating process. They can build and trim their models with maximum-likelihood estimated parameters for these components and try to optimize model fit by adding or trimming interventions, level shifts, autoregressive components, or exogenous series to explain the univariate or multivariate processes.

Unlike the older ARIMA models, these new models use filtering and disturbance smoothing to handle missing data and to accomplish their other objectives. With Kalman filter updating, analysts can perform within-sample or ex-post forecasting of the estimated model components. The new models permit extraction of these components and the combination of them constitute the full model.

These models can now be estimated with two different software packages:

1. SAS (Statistical Analysis System) Proc UCM. SAS version 9.0 includes an experimental version of Proc UCM, developed by Dr. Rajesh Selukar. In earlier versions, SAS users had to depend on Proc Statepace for this kind of analysis.

2. STAMP (Structural Time Series Analysis, Modeler, and Predictor) with SsfPack (State space formulation Package). Written by Drs. S. J. Koopman, N. Shepard, and J. A. Doornik, STAMP is a module of the Oxmetrics package. A growing number of users are discovering the real advantages of the STAMP program with SsfPack, a package of C programs that can be downloaded and used for free by interested parties. SsfPack is also available for S-Plus users.

According to Selukar, Proc Statespace was written for the analysis of multivariate time series data using the method proposed by H. Akaike (1976) and M. Aoki (1987). Their analysis was mostly geared towards Gaussian processes that are "stationary," or can be made stationary by differencing. The underlying state space model for such analyses is "time-invariant", i.e., the system matrices in the model do not depend on time (Selukar, 2003).

In more recent years, new algorithms contributed by C. F. Ansley and R. Kohn (1985, 1986), A. C. Harvey (1981,

1992), and J. Durbin and S. J. Koopman (2001), among others, have made analysis of non-stationary and time-varying state-space models more feasible and easier to implement. With the new models, we no longer have to adjust for trend and seasonality by differencing; we can simultaneously analyze the non-stationary and stationary aspects of a time series using a single model.

Structural time series analysis in state space form (SsfPack) can parameterize ARIMA, exponential smoothing, RegARIMA models, regressions with ARMA errors, ARFIMA long memory models, nonparametric cubic-spline models, moment-smoothing, and simulation models.

With Proc UCM, SAS has internally implemented these new state space algorithms (along lines similar to SsfPack). Proc UCM currently handles univariate unobserved component models, and will be developed to handle multivariate models in the future. The syntax of Proc UCM is different from that of Proc Statespace, and UCM has new graphical and HTML output capabilities as well.

Some of the principal differences between STAMP and SAS Proc UCM within the univariate context are that Proc UCM can handle higher-order autoregressive lags with the DEPLAG option. Both STAMP and Proc UCM can model multiple cycles at the same time. Proc UCM can handle up to five seasonal components of different lengths. Unlike the current Proc UCM, the version of STAMP included in the Oxmetrics Givewin interface will now handle multivariate models.

Both SAS and UCM are powerful and easy to use. STAMP handles a wide variety of models, including basic GARCH and stochastic volatility models, has excellent graphics, and can display forecasts with error fans. STAMP algorithms are fast, and STAMP SsfPack contains a host of useful utilities for performing analysis with state space models.

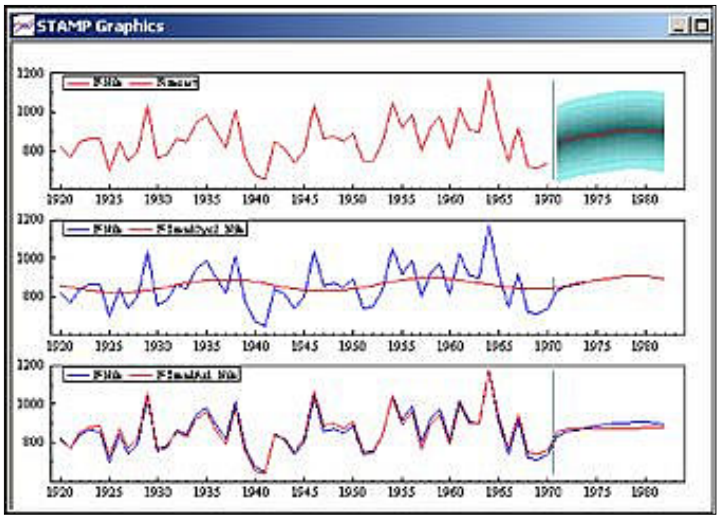

Figure #1 - STAMP graphical forecasts of the series, trend-cycle, and trend-autoregressive components.

In the near future, NYU Information Technology Services will be obtaining both SAS 9.1 (containing Proc UCM) and STAMP (with SsfPack) for users who wish to do advanced time series analysis. For information about using either of these software packages, interested persons can contact Robert Yaffee (1-212-998-3402) of the ITS Social Science, Statistics, and Mapping Group.

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References

Aoki, M. (1987). *State Space Modeling of Time Series*. New York: Springer.

Akaike, H. (1976). "Canonical Correlations of Time Series and the Use of an Information Criterion," in Mehra, R. and Lainiotis, D.G. (eds.) *Advances and Case Studies in System Identification*. New York: Academic Press, Inc.

Ansley, C.F. and Kohn, R. (1985). "Estimation and Smoothing in State Space Models with Incompletely Specified Initial Conditions". *Annals of Statistics*, 13, pp. 1286-1316.

Ansley, C.F. and Kohn, R. (1986). "Estimation, Prediction, and Interpolation for ARIMA Models with Missing Data". *Journal of the American Statistical Society*, 81, pp. 751-762.

Durbin, J. and Koopman, S.J. (2001). *Time Series Analysis by State Space Methods*. New York: Oxford University Press, pp. 51-56.

Harvey, A. C. (1981). *Time Series Models*. Oxford: Phillip Allan Publishers, Ltd., pp.82-105.

Harvey, A.C. (1992). *Forecasting, Structural Time Series, and the Kalman Filter*. New York: Cambridge University Press, pp. 22-26.

Selukar, R. *Personal Communication*, January 9, 2003.

Selukar, R. *PROC UCM: Cary, NC: SAS Institute, Inc.*, a draft, pp. 1497-1563.

Author Biography

Dr. Robert A. Yaffee is a research/statistical consultant with the Statistics, Social Science, and Mapping Group of ITS Academic Computing Services. He can be reached at robert.yaffee@nyu.edu.