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SOFTWARE REVIEWS

STRUCTURAL TIME SERIES MODELLING WITH STAMP 6.02

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1. INTRODUCTION

The structural time series approach involves decomposing a series into components which have a direct interpretation. Usually, three components are considered: a trend, a seasonal component and an irregular component. However, other dynamic processes can also be included in this decomposition. The estimation of the components of this additive decomposition is called signal extraction. A structural time series model, henceforth STM, is a particular case of a regression model for which the explanatory variables are functions of time and the parameters are time-varying. Such a model is usually represented in the state space form, which models at a given time the various unobserved components. This state space form allows one to estimate the parameters of the model by using the principle of the Kalman filter; interested readers are referred to the book by Durbin and Koopman (2001).

Structural time series models are used in several fields: biology, engineering, environmetrics, social sciences, etc. In econometrics, structural time series models are commonly used by macroeconomists for trend extraction and forecasting and by official statisticians dealing with economic variables related to the business cycle and the evolution of GNP, etc. As it is likely that these practitioners do not wish to be involved in the sophisticated programming aspects of the estimation of a STM, a reliable software package is called for. I review here Version 6.02 of STAMP, which can be used to estimate such models.

STAMP 6.02 is published and distributed by Timberlake Consultants Limited and can be ordered from their web site: www.timberlake.co.uk. A single copy costs £500 (£250 for academics and £85 for students with proof of status). Multi-user and network licences are also available, and upgrades cost 60% of the new price. A single-user licence includes one set of books and one CD. A multi-user or network licence includes two sets of books and one CD per licence. STAMP is moderately expensive for the academic sector. Nonacademic prices are acceptable when compared with the prices of standard professional and industrial software packages.

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2. INSTALLATION

2.1. Required Configuration

STAMP 6.02 works under several Windows operating systems (95, 98, 2000, NT, XP) and uses the GiveWin 2.02 software as a front end. A Linux version is planned for the next release, which is a wise idea as Linux is becoming more widespread not only in the academic sector but also in the professional sector because of its reliability and low costs. I have been running STAMP on Pentium III and Pentium 4 computers, with several operating systems.

STAMP 6.02 is delivered on a CD-ROM and a companion installation diskette, along with two manuals. The CD-ROM also contains other software packages that use GiveWin as a front end, but access to them is controlled by a licence number. Updates and additional information on the current and future versions of this package can be obtained from the following web sites: www.STAMP-software.com and www.ssfpack.com.

2.2. Documentation

The documentation consists of two paperback manuals. The *first manual* is about the GiveWin software published and distributed by Timberlake Consultants Limited, since this interface program handles the input/output operations of STAMP, i.e., data input and graphics/text output. This manual contains several tutorials on data handling, graphics and the descriptive statistics computed by the interface program. There is also a chapter on the format of the data files handled by GiveWin.

The second manual, by Koopman *et al*. (1999), is about STAMP. It is divided into three parts. There are some minor redundancies, as writing a manual mixing the presentation of the statistical/econometric theory and its application to a particular package is a challenging task.

Part I contains a presentation of the main elements of the STAMP module and the data sets used for the subsequent econometric tutorial. Part II of the manual contains a 100-page tutorial on structural time series modelling. This tutorial starts with the basic structural model, henceforth BSM, the specification of which contains a stochastic level and slope for the trend component, a trigonometric seasonal component and an irregular component. The purpose of this chapter is to introduce the basic outputs of STAMP, i.e., the numerical and graphical results and tests, and to emphasize the importance of graphical outputs as they are the most easily interpretable. The next chapters focus on the main topics of structural modelling. A chapter presents the various components of the model: the level and slopes, which can be fixed or stochastic, the seasonal component, which can be trigonometric, fixed or dummy, the cycles (a trigonometric wave with fixed period) and the autoregressive components. A chapter is devoted to intervention analysis, i.e., the specific treatment for outliers and structural breaks with the use of the auxiliary residuals advocated by Harvey and Koopman (1992), and post-intervention diagnostics.

Several data sets are provided. These data sets are well known, as they have been used as examples in reference research papers and standard textbooks in statistics and econometrics, e.g., the so-called airline, Nile river, spirits and seat-belt data sets. Thus, it is very likely that the user would be familiar with the issues at hand: seasonality, trend and changes in regimes (intervention analysis). The integrated help system with hypertext links displays the main topics of the manual.

The multivariate models considered by STAMP are seemingly unrelated time series equations, multivariate models with cycles and VAR models with common factors and cointegration. Explanatory variables and interventions can be included in the multivariate framework. There is a specific chapter on applications in macroeconomics and finance, which introduces the method of seasonal adjustment and detrending with the standard Hodrick–Prescott filter. Some topics, such as the inclusion of seasonal components in the error correction model framework, or the estimation of univariate and multivariate stochastic volatility models, are also briefly presented. A chapter on model building presents the main options of the menus for model building and testing, and provides a description of the menu controlling the optimization process: starting values, restrictions on the parameters, convergence settings, etc.

STAMP performs unconstrained optimization by using the BFGS algorithm, with forward numerical derivatives, the constraints on the model parameters being imposed by a set of transformations described in the manual. I have been unable to get more detailed information on the optimization procedure, such as the local search procedure chosen and the step length of the numerical derivatives. The examples supporting these chapters are easy to follow, and a few exercises are included at the end of the chapters of the tutorial. The exposition of the various topics is rather uneven. For example, the chapter on applications in macroeconomics and finance is rather peripheral, and the approach considered here is strongly inspired by the works of *Harvey, Koopman and Shephard*, mentioned in the bibliography of the stamp manual; see also Durbin and Koopman (2001). However, teachers can use this manual as a companion textbook for a course on structural time series modelling.

Part III of the manual formally describes the main technical details of the package: the formulas for the various descriptive statistics computed, the structural modelling of time series, the state space form, a survey of the diffuse Kalman filter algorithm by de Jong (1991) used by this software, the estimation procedure and a few technical issues related to the optimization procedure. An exhaustive treatment of the Kalman filter, the diffuse Kalman filter and the estimation procedure is given in the third chapter of Harvey (1989), which could be read independently from the remainder of that book. The estimation method used by STAMP handles the start-up problem differently than the method proposed by Burman (1980), which is the approach chosen by Maravall's program TRAMO-SEATS. The choice between these two approaches is still a matter of debate. Note that STAMP and TRAMO-SEATS do not target the same market. STAMP is a commercial program which provides a self-contained econometric environment that includes many statistical modules from descriptive statistics to model estimation and forecasting. In contrast, the current version of TRAMO-SEATS, which is available for free, is much more limited in what it attempts to do; see Pollock (2002).

3. RUNNING STAMP

Running STAMP opens two windows, one for GiveWin and one for STAMP. Thus, after running a few procedures, your screen might become very busy with various graphs and other figures, and you may well feel that a multi-screen system, like the virtual screens of X Windows under Linux, would have made your work easier.

STAMP is a menu-driven program, which can be run without any knowledge of programming. It is possible to save the various operations performed with the menus in a proprietary batch language and to run again the same tasks without going through the menus. This batch language is briefly presented in an appendix to the manual. Users familiar with programming languages will have to save the code of their working sessions in order to learn more about this one.

3.1. The GiveWin Interface

As mentioned above, the GiveWin software manages the input/output of STAMP. The STAMP logo is included in the GiveWin bar menu, for direct access to the various modelling steps of STAMP. GiveWin, and then STAMP, can read data from spreadsheets using the Excel (.xls) and Lotus (.wks/wks1) formats, from Gauss data files (.dht/.dat), from Stata data files (.dta) and, obviously, from ASCII files.

GiveWin has its own format for storing data: the data files are stored in a binary file, with the suffix .bn7, while their companion information file (.in7) is stored in ASCII format. The information file includes the data file name, definition of variables, the name of the variables, the sample period, the frequency, etc. It is strongly recommended to use this proprietary format, because working with an ASCII file implies entering this information with the menus, which can be tedious. It would have been more convenient to allow ASCII data files with a few header lines containing all this information as an alternative to using the menus.

GiveWin possesses a basic batch language, with all the standard mathematical and statistical functions, including some useful functions for simulations, e.g., random number generators (RNGs) for uniform, Gaussian, Chi-square and t deviates, some probabilistic functions like cumulative distribution and survival functions, and quantiles for the Gaussian, F, Chi-square and t distribution functions. The Chi-square distribution allows non-integer degrees of freedom. Kernel and spline smoothers are also available. However, only the standard bandwidth for kernel smoothing, which assumes that the data are normally distributed, is used; see Silverman (1986). If further programming is necessary, users can resort to TSP or Ox (Doornik, 1998) since GiveWin can also run programs written in these programming languages. Thus, one can easily make all the usual data transformations before moving to the modelling phase.

GiveWin output files have the suffixes .out for output in ASCII format and .gwg for GiveWin graphics. They also have the standard suffixes for PostScript files (.eps/.ps) and for Enhanced and Windows metafiles (.emf/.wmf).

Graphical output can be modified and edited by the options menu. Legends and scales of graphs can be changed, and graphs are available in both two and three dimensions. Mathematical symbols can be used through an extended $\LaTeX$ language. The graphical interface is of professional quality, although the process of editing numerous graphs with a menu-driven program might become tedious.

3.2. Numerical Accuracy

The issue of reliability of econometric software is rarely taken into account when presenting estimation results. McCullough and Vinod (1999), and McCullough (1999a,b) reviewed the accuracy of several packages. While statistical software appears to be reliable, the conclusions for econometric software are less appealing. Some of them fail even to compute descriptive statistics with an acceptable level of accuracy, which casts doubt on many reported empirical results. The issue of accuracy is addressed in only a few econometric textbooks; see, for example, Davidson and MacKinnon (1993). McCullough (1998) proposed a general methodology for assessing the reliability of statistical software.

I tested the numerical accuracy of the statistical functions used by STAMP, which is of interest for the user, as the STAMP batch language relies on these functions. However, because I do not have reference results against which to test them, I have been unable to check the numerical accuracy of the estimation procedures for STM models.

I tested numerical accuracy by using three standard benchmarks and programs. The NIST StRD database (www.itl.nist.gov/div898/strd) contains several data sets and the certified values for the main statistics that can be computed from this database. I used the test with the highest level of difficulty, which uses the data set NumAcc4. STAMP does not compute the sample variance, but the population variance, as for the StRD certified values. I tested the randomness of the pseudo-random number generator using Marsaglia's (1996) program, Diehard (stat.fsu.edu/pub/diehard). The accuracy of statistical distributions was assessed using Knüsel's ELV software (www.stat.uni-muenchen.de/~knuesel/elv/elv.html), which has a better level of accuracy than the one reported in the tables of, e.g., Abramowitz and Stegun (1965). STAMP passes the StRD test, but it fails one of the Diehard tests. Failure means a *P*-value equal to either 1.0 or 0.0 up to six places. The failed test is the count-the-ones test, which is based on the number of 1's in each byte. If a RNG fails this test, it cannot be recommended as a satisfactory source of random bytes, and thus should not be used for Monte Carlo simulations. This RNG is not very recent, but it has been kept for backward compatibility with previous versions of GiveWin.

I tested the distribution functions by using the examples provided by McCullough (1999a). For each statistic, I computed the relative error defined by $|x - c|/c$, where c denotes the exact value computed by ELV and x the statistic computed by the software. I focus on the extreme tail of the distribution. For numerical reasons, the probabilities should be computed from the upper tail. For extreme values in the lower tail, the package incorrectly gave probabilities equal to zero. For most applications, this is not a problem. In other respects, GiveWin appears to be reliable, and a user having both STAMP and Excel on his computer is strongly advised to use STAMP for computing descriptive statistics; see McCullough and Wilson (2002). Due to space constraints, the results of the accuracy tests are not presented here. They are available from the JAE Data Archive.

3.3. Estimating Structural Time Series Models

Estimating this type of model is easy, as one merely needs to follow the examples in the STAMP manual. The first step consists in loading with the GiveWin interface the data set of interest. Transformations of the data can be performed in the STAMP module, e.g., absolute value, logarithmic transformation, Box–Cox, differentiation, seasonal difference, detrending with the Hodrick–Prescott filter, etc. Next, one moves to the model step, where the dependent and, if necessary, explanatory variables, as well as the various type components, e.g., level, slopes, seasonal, and the parameters of the cycle are selected.

In the next step, the user can control the optimization process by editing the starting values, the step length, the method used for computing the gradient, and so on. The estimation results, as well as standard specification tests such as heteroskedasticity tests and the Durbin–Watson and Ljung–Box statistics, are displayed in the results window. Since the output of a working session can be rather long, text search functions are available for finding the set of results of interest.

Since the STAMP developers have rightly emphasized the importance of graphical representation and interpretation of the results, numerous graphs are available. These graphs display the estimated components, the residuals and the post-sample forecasts. However, all these graphs are inserted in the same window, which makes them difficult to interpret when the number of graphs is greater than 6. To my great amazement, I have found research papers using GiveWin output, with pages

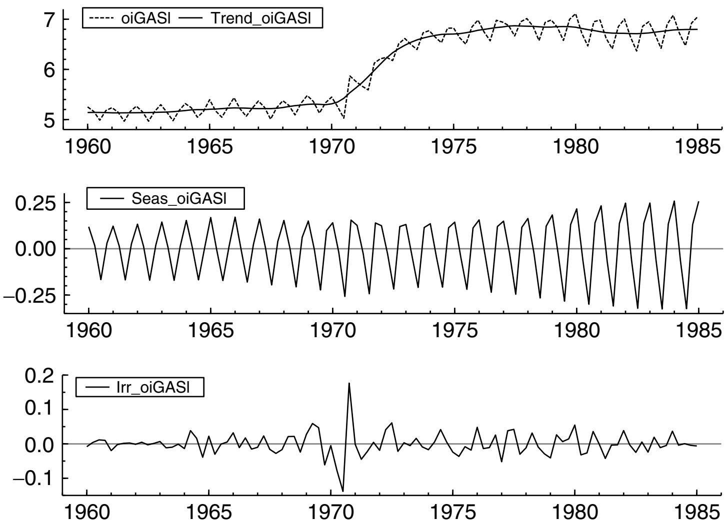

Figure 1. An example of the STAMP graphical display

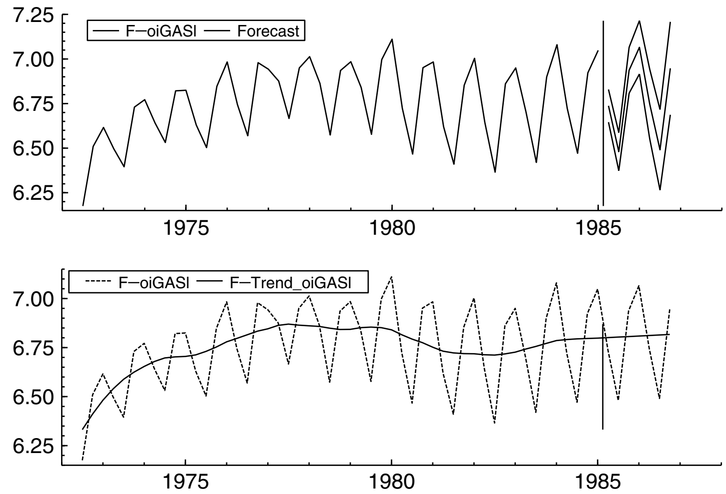

Figure 2. Forecast plots

filled by tiny (2 cm × 1 cm) plots, which are hardly readable. An example of the STAMP output is given in Figure 1.

The test menu allows the user to plot the model forecasts, the horizon of which is selected by the user, so as to check the adequacy of the estimated model; see Figure 2.

Some convenient functions, e.g., summary statistics, have been included in the further output item so as to complete a research report without moving again to the GiveWin interface.

4. CONCLUSION

STAMP is of interest to researchers and practitioners interested in the use of structural time series methods. The package sticks to the STM approach of the STAMP authors. As there are no missing important features, STAMP can also support a graduate course in structural time series methods. However, some econometricians and statisticians with the necessary skills might still prefer to develop their own programs, as STAMP users have limited control over the internal operations of the package.

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