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Recent Developments in Seasonal Adjustment Software at the Census Bureau

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Advances in Seasonal Adjustment Software at the U. S. Census Bureau

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1 Introduction

In 2006, the United States Census Bureau will release two seasonal adjustment programs: Version 0.3 of the X-12-ARIMA program, and a beta release of the X-13A-S (X-13-ARIMA-SEATS) program, a seasonal adjustment package that optionally produces either model based seasonal adjustments from SEATS or X-11 seasonal adjustments. This program, developed in collaboration with the current developers of SEATS, allows users to generate X-11 and SEATS seasonal adjustments using the same interface, and compare these seasonal adjustments using a common set of diagnostics. This paper will demonstrate new features of these programs, including providing accessible output, utilizing updated modeling techniques and diagnostics for model-based seasonal adjustments. Further directions for this work will also be discussed, including XML output.

2 Version 0.3

Version 0.3 of X-12-ARIMA has been under development for many years, and includes several new features, most notably a new automatic model identification procedure. Four of the most important new features of Version 0.3 are described below.

2.1 Automatic Model Identification Procedure

The automatic ARIMA model selection procedure implemented into Version 0.3 is based on the procedure in the TRAMO time series modeling program developed by Victor Gómez and Agustin Maravall (see Gómez and Maravall, 1997). It is very similar to TRAMO's procedure but contains modifications to make use of X-12-ARIMA's different model estimation procedure, regARIMA model options, transformation and outlier identification procedures and model diagnostics. Also some additional tests have been added. Consequently, the model selected can differ from the model TRAMO would select. Testing has shown that the models selected are usually at least as good as those selected by TRAMO (Hood, 2002a).

The TRAMO procedure is largely documented in Gómez and Maravall (2000), but the actual implementation of the procedure in the current TRAMO program differs somewhat from the description that appears in that paper.

The procedure can be summarized in five stages:

- **default model estimation:** a default model (almost always the airline model) is estimated, initial outlier identification and regressor tests are performed, and residual diagnostics are generated;
- **identification of differencing orders:** empirical unit root tests are performed to determine the orders of differencing needed for the model;
- **identification of ARMA model orders:** an iterative procedure is applied to determine the order of ARMA parameters using a revised version of the BIC model comparison criteria of Schwarz (1978);
- **comparison of identified model with default model:** the identified model is compared to the default model and possibly replaced;
- **final model checks:** where the final model is checked for adequacy.

The second stage is optional, as the user can specify the orders of regular and seasonal differencing using the **diff** argument.

An overview of the procedure is given in Monsell (2002) and Census (2006).

The procedure previously used in X-12-ARIMA can still be selected by the user with the `pickmdl` spec. A comparison documented in Dent, Hood, McDonald-Johnson, and Feldpausch (2005) showed little difference in the models selected by the two procedures, but expressed a preference for the new procedure due to the new method's flexibility in iterating over a number of possible seasonal and nonseasonal ARMA orders.

2.2 New Forcing Option

Many users wish to produce a seasonally adjusted series where the totals of each calendar (or fiscal) year match the totals of the original series. Earlier versions of X-12-ARIMA provided only the Denton proportional method (see Denton, 1971) as implemented in X-11-ARIMA (see Dagum, 1980) to force the totals of the seasonally adjusted series to match those of the original series. This method ensures that the differences between the annual totals is distributed over the seasonally adjusted values in a way that approximately preserves the month-to-month (or quarter-to-quarter) movements of the original series for an additive seasonal adjustment, and tries to keep the ratio of the forced and unforced values constant for multiplicative adjustments. For more details see Huot (1975), Cholette (1978) and Ladiray and Quenneville (2001).

However, this method can lead to problems with the changes between years of observation, and there can be large revisions at the ends as data is added to the series. In response to this, Statistics Canada developed several benchmarking methods for this and other problems. One of them is a regression-based method that uses two parameters: λ, which is used to determine the weight matrix for the regression equation, and ρ, the value of an AR(1) parameter. More details on this method are contained in Quenneville, Cholette, Huot, Chiu, and Fonzo (2004).

A special case of the regression method is when $\rho \rightarrow 1$; here one gets the same formulas as the Denton method. Choosing values of ρ close to one and $\lambda = 1$ allows the user to get values that are close to the Denton method, but with smaller revisions to the forced data in incomplete years as new observations come in. Hood (2005) presents comparison results for the regression method with various choices of λ and ρ and for other forcing methods.

To incorporate this functionality into Version 0.3 of X-12-ARIMA, a new spec was added - the `force` spec. This spec allows users to pick between the Denton and Statistics Canada regression method for forcing the totals of seasonally adjusted series. Users can also now choose the target series for this forcing operation: the yearly totals of the seasonally adjusted series can now be forced to match those of the calendar adjusted original series instead of the original series, for example. An example of an X-12-ARIMA spec file using the `force` spec is given in Table 1.

```
series{
  title= "Retail Shoe Store Sales"
# show how to specify force spec
  format="datevalue"
  file="shoers.dat"
  name="shoers" }
x11 { }
force { type = regression
  lambda = 1.0
  rho = 0.95
  save = saa
}
```

Table 1: X-12-ARIMA Version 0.3 input file demonstrating use of `force` spec

Forcing the agreement of annual totals is convenient for certain purposes, but it should be kept in mind that it can lower the quality of the seasonal adjustment when the seasonal effects are multiplicative or are not stable over time, ss the Details section for the `force` spec in the X-12-ARIMA Reference Manual (see Census, 2006).

2.3 Revised Composite Adjustment Procedures

X-12-ARIMA has facilities to enable users to compare composite seasonal adjustments of aggregate series that were originally developed for the X-11-ARIMA seasonal adjustment program (see Dagum, 1980). Analysts can examine the results of two types of adjustments - a **direct** adjustment that applies the seasonal adjustment method directly to the sum of the seasonally adjusted series, or an **indirect** adjustment that combines (usually summing) the component seasonal adjustments.

Along with the indirect seasonal adjustment, X-12-ARIMA develops indirect analogs for other seasonal adjustment components, such as an indirect seasonal factor and an indirect trend. These components are used to derive diagnostics for the indirect adjustment. However, the way some of these components were derived makes comparison to corresponding components for direct seasonal adjustment difficult.

For example, the indirect seasonal factor for multiplicative seasonal adjustments was computed as the aggregate of the original series divided by the aggregate of the seasonally adjusted series, i.e.,

$$SF_t^{ind} = \frac{\sum_{i=1,n} O_t^i}{\sum_{i=1,n} SA_t^i}, t = 1, \ldots, N \tag{1}$$

where O_t^i is component series i at time t, and SA_t^i is the seasonally adjusted series for component series i at time t, n is the number of components in the aggregate adjustment, and N is the length of the series.[1]

Computing the indirect seasonal factors in this way leaves some calendar effects and prior adjustments from the component series in the indirect seasonal factors. The indirect seasonal factors appear more like combined adjustment factors rather than seasonal factors; see Figure 1.

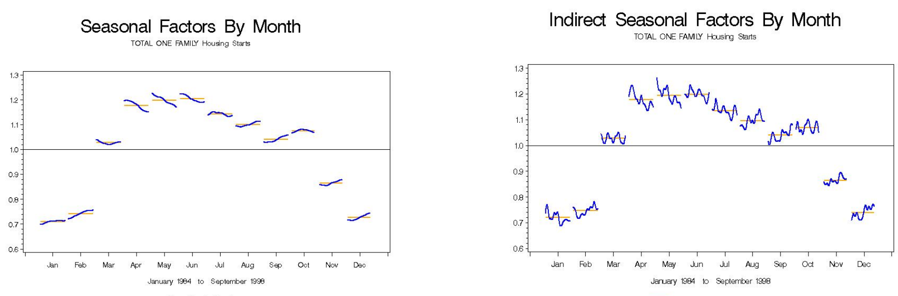

Figure 1: Direct and Indirect seasonal factors for Total One-Family Housing Starts [source: U. S. Census Bureau]

[1]Note that for series that are not seasonal, options in X-12-ARIMA can be set so that the seasonal adjustment for the original series is defined to be the original series, or the calendar adjusted original series. This means that in some cases, $SA_t^i = O_t^i$.

One technique removing these effects is to aggregate the original series adjusted for calendar and temporary prior effects; let us call this $OAdj_t^i$. Substituting this into Equation (1) gives us

$$SF_t^{ind} = \frac{\sum_{i=1,n} OAdj_t^i}{\sum_{i=1,n} SA_t^i}, t = 1, \ldots, N \tag{2}$$

In this way, we should be eliminating the effects of calendar adjustments and temporary prior adjustments. Figure 2 shows that using Equation (2) can lead to smoother indirect seasonal factors.

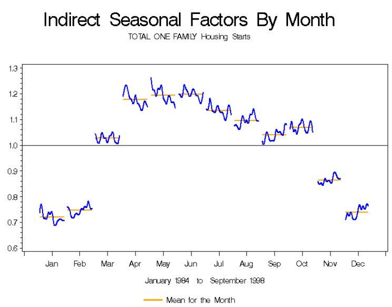

Figure 2: Indirect seasonal factors for Total One-Family Housing Starts produced by X-12-ARIMA Versions 0.2.10 (left) and 0.3 (right) [source: U. S. Census Bureau]

A new table of indirect combined adjustment factors provides users with indirect seasonal factors based on Equation (1).

2.4 Accessibility Concerns

Section 508 is an amendment to the U. S. government's Disabilities Act that requires Federal agencies to make their electronic and information technology accessible to people with disabilities and limiting conditions. As a start to making X-12-ARIMA compliant with this act, an effort is currently underway to (a) create a utility to convert the current X-12-ARIMA output to accessible HTML and (b) convert the X-12-ARIMA Reference Manual and Quick Reference to an accessible format.

We have addressed the first issue by developing a utility that converts the output of X-12-ARIMA Version 0.3 into a fully accessible HTML file. The standards and techniques used to achieve this are given in W3C (2000a) and W3C (2000b).

The user first must run Version 0.3 with a new runtime option for accessible output (the **-a** flag), which places codes into the X-12-ARIMA output that the utility reads and uses to convert specific output to HTML.

After the output file has been generated, a utility named `cnvOut2HTML` can then be used to read in the annotated X-12-ARIMA output file and generate an HTML version of the output that is fully accessible. In addition, links are included that allow the user to move easily from table to table in the output, allowing ease of navigation through the HTML file.

This software converts the log and error files generated by the X-12-ARIMA program as well, and can take as input X-12-ARIMA output, log, error, or metafiles. If the utility is reading in a metafile, it will attempt to convert all the output files referenced in the metafile as well as error files for the individual runs, and the log file generated by the metafile run.

The utility is written in the Icon programming language, see Griswold and Griswold (1997); source code is available upon request. It should be noted that the converted output files can become rather large.

This utility has been integrated into the Census Bureau's Windows interface for running X-12-ARIMA, called RunX12. This program was developed by Roxanne Feldpausch, and allows the user to automatically convert the output into HTML, and also has procedures to write X-12-ARIMA spec files with a menu driven interface. For more details, see Feldpausch (2003).

The original documentation for X-12-ARIMA was originally written in TeX; it has been converted into LaTeX in order to make it easier to convert to HTML. Our goal is to create HTML such that users with commercial screen reading software (such as Jaws®) will be able to navigate the document successfully, and use MathML to render the mathematical equations. Our current efforts are centered on an XML conversion system named Hermes (see Anghelache, 2006); other conversion utilities investigated could not support our needs for crossreferencing and indexing.

2.5 Unified Diagnostics File

X-12-ARIMA has long had a runtime option (the **-s** flag) to save seasonal adjustment and modelling diagnostics in a separate file from the main output. These diagnostics are stored in an ASCII database, in which each diagnostic has a unique key to access the value of the diagnostic. Prior to Version 0.3 of X-12-ARIMA, seasonal adjustment diagnostics were stored in a file with an **.xdg** file extension, and model diagnostics were stored in a file with an **.mdg** file extension. In Version 0.3 of X-12-ARIMA, these diagnostics are now stored in a unified diagnostics file, the **.udg** file.

Support programs developed by the Time Series Methods Staff of the U. S. Census Bureau, such as the X-12-Graph SAS® program used to develop the graphs for this paper (see Hood, 2002b) and the X-12-Rvw-Excel software which generates customized diagnostic summaries and stores them in Excel® worksheets (see McDonald-Johnson, 2003), use the information stored in the **.udg** file to assist in generating their output. There are new versions of these programs available that utilize the unified diagnostics file.

3 X-13A-S

Monsell, Aston, and Koopman (2003) detailed two alternatives to X-12-ARIMA for dealing with model-based approaches to seasonal adjustment. One was an experimental version of X-12-ARIMA that produced model-based seasonal adjustments from the SEATS seasonal adjustment procedure of Gómez and Maravall (1997) and is a collaboration between the U. S. Census Bureau and the current developers of SEATS, Agustín

Maravall and Gianluca Caporello.

With this prototype, analysts have access to SEATS seasonal adjustments using the familiar X-12-ARIMA input syntax, and can compare SEATS and X-12-ARIMA seasonal adjustments using the seasonal adjustment diagnostics produced by the X-12-ARIMA seasonal adjustment program, most notably the spectrum, sliding spans and history diagnostics (see Findley et al., 1998), as well as the diagnostic graphs of X-12-Graph (see Hood, 2002b).

This program includes all the signal extraction routines from the SEATS seasonal adjustment program, with some revisions to allow for the generation of finite filter seasonal adjustment diagnostics. To minimize revisions to the base SEATS code, an interface routine available within the standard SEATS source code is used as an interface between the signal extraction code and source code used to generate seasonal adjustment diagnostics and other special output. Additional routines allow for the transfer of regARIMA model information from the data structures used in X-12-ARIMA's model estimation procedures to the format required for use with SEATS.

Next we discuss some of the advanced capabilities of this software beyond the inclusion of SEATS, including new modeling options which simulate classical intervention effects and improvements in seasonal adjustment diagnostics and seasonal adjustment.

3.1 Seasonal Outliers

One of the effects included in X-13A-S is a seasonal outlier effect similar to the Seasonal Level Shift outlier from Bell (1983) that is discussed in Kaiser and Maravall (2002). The new seasonal outlier effect can be used with other predefined regression variables specified in regARIMA models. The automatic outlier identification procedure has also been modified to include identification of these seasonal outliers effects (although not by default).

A seasonal outlier effect beginning at time t_0 is defined as

$$SO_t^{(t_0)} = \begin{cases} 0 & \text{for } t \geq t_0 \\ 1 & \text{for } t < t_0, t \text{ same month as } t_0 \\ -1/(s-1) & \text{otherwise} \end{cases}, \tag{3}$$

where s is the period of the time series being modelled (12 for monthly series, 4 for quarterly series).

This regressor captures an abrupt change in the seasonal pattern, and maintains the level of the series with a contrasting change spread over the remaining months or quarters.

It is equivalent the seasonal level shift found in Kaiser and Maravall (2002), given below:

$$SLS_t^{(t_0)} = \begin{cases} 0 & \text{for } t < t_0 \\ 1 & \text{for } t \geq t_0, t \text{ same month as } t_0 \\ -1/(s-1) & \text{otherwise} \end{cases}, \tag{4}$$

In X-13A-S the regressor is constructed so that the seasonal pattern of the data before the date of the seasonal outlier is changed to conform with the seasonal pattern of the present, rather than altering the seasonal pattern of the present to conform with that of the past. An example of seasonal outlier factors is given in Figure 3.

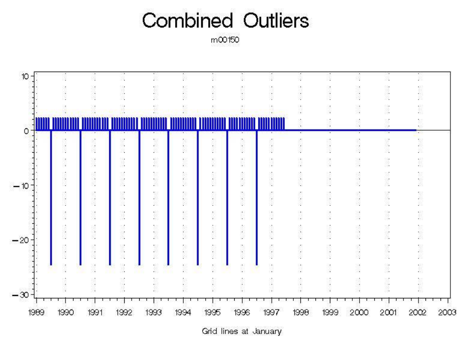

Figure 3: Seasonal Outlier Factor for M00150 (source: U. S. Census Bureau).

Sometimes, having two of these outliers in tandem can create a seasonal outlier effect similar to one proposed by Peter Burman and used in Buszuwski and Scott (1993). This type of outlier effect captures an abrupt change in the seasonal pattern which is then compensated by an equal change in the opposite direction in the next month or quarter. Sometimes the combination of two seasonal outlier regressors as defined in Equation (3) can create an effect similar to this, where the two effects essentially cancel each other out except for two adjoining months. An example of this is given in Figure 4.

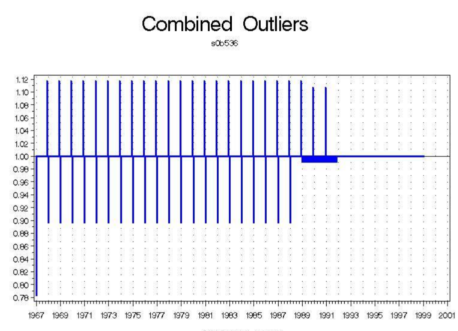

Figure 4: Combined Seasonal Outlier Factor for Imports of Automobiles, New and Used (source: U. S. Census Bureau).

Users should be careful when specifying this effect with other preexisting outliers, as seasonal differencing can cause a seasonal outlier regressor to be very similar to level change outlier regressors for the same date, which can cause difficulties with model estimation due to the singularity or near singularity of the regression matrix.

Currently, the program will not attempt to identify seasonal change outliers along with level change outliers for the final year of data when the model contains a regular and seasonal difference, as in this case the differenced seasonal and level change outliers are practically identical.

Empirical analysis will be done to examine how best to identify seasonal outliers in practice, and whether other types of outliers, like the seasonal outlier effect in Buszuwski and Scott (1993), should be considered.

3.2 Diagnostics

The most recent change in the X-13A-S diagnostics is the inclusion of finite filter versions of seasonal adjustment and trend diagnostics that were originally computed using the infinite length Wiener-Kolmogorov filter statistics, which assumed an infinite span of data. The new diagnostics are computed using matrix formulas first shown in Bell and Hillmer (1988) and developed more fully in McElroy (2005) which produce finite-sample ARIMA model-based signal extraction filters along with the error covariances of their estimates.

Early versions of these finite-sample diagnostics have been examined previously in Findley, McElroy, and Wills (2005). A large scale study using U. S. Census Bureau series to determine the effectiveness of these diagnostics is currently underway (see Findley, Gagnon, and McElroy, 2006).

Sliding spans diagnostics compare seasonal adjustments from overlapping spans of a given time series. Up to four spans of data are chosen, with the final span ending in the last year of the series, and the preceding spans formed by dropping a year of data from the end of the span and adding a year of data to the beginning of the span. Data points common to more than one span are examined to see if their adjustments are stable – observations whose adjustments are too variable from span to span cannot be considered reliable. For more details on sliding spans analysis, see Findley, Monsell, Shulman, and Pugh (1990) and Findley, Monsell, Bell, Otto, and Chen (1998).

One important choice that needs to be made in a sliding spans analysis is the length of the overlapping spans. When used with the `x11` spec of X-12-ARIMA, where seasonal adjustment is performed with fixed length seasonal filters, the length of the span is based on the length of the seasonal filter. The ARIMA model-based seasonal adjustment filters of SEATS are always as long as the data span being adjusted (when the ARIMA model specified has a moving average component), so a different approach is needed.

Findley, Wills, Aston, Feldpausch, and Hood (2003) develops an approach for determining span lengths that is based on an analysis of SEATS model-based adjustment filters associated with the airline model, the model chosen for about half the series adjusted by SEATS, see Gómez and Maravall (1997). Since values of θ and Θ are known for which the SEATS seasonal adjustment filters have gain and phase-shift properties very close to those of the X-11 filters, as shown in Planas and Depoutot (2002) and Findley and Martin (2003), the sliding span lengths used for SEATS adjustments within X-13A-S are calibrated to coincide with the span lengths used for the X-11 filters when the two types of filters are close. In this way, the span length specifications used for SEATS adjustments are anchored to those of the X-11 filters.

The table below gives the span length used by the program for a given value of Θ. Research of the type described in Feldpausch, Hood, and Wills (2004) showed that for simulated series with known components, using the sliding spans lengths based on the seasonal moving average parameter seemed to provide a more reliable indication of inaccuracy in the seasonal adjustment than other diagnostics commonly used with SEATS seasonal adjustments.

Seasonal MA	Length of Span (in years)
0.160	5
0.325	6
0.490	7
0.535	8
0.620	9
0.640	10
0.695	11
0.710	12
0.750	13
0.760	14
0.795	15
0.805	16
0.840	17
0.850	18
0.910	19

Table 2: Seasonal MA parameter greater than 0 at which the span length increases to the value indicated.

For users interested in the properties of the SEATS signal extraction filters, X-13A-S produces spectral diagnostics for the finite concurrent signal extraction filter, as well as the filter weights for the finite concurrent adjustment filter. These are the filters that are used to adjust the most recent observations, and can be compared to concurrent filters from X-11 based adjustments (see Bell and Monsell, 1992), rather than the infinite central filters.

Comparison of SEATS and X-11-ARIMA adjustment filters can be found in Findley and Martin (2003). Squared gain and time-shift diagnostics are also implemented in X-13A-S. There are discussed extensively with applications in Findley and Martin (2003)

4 Future Plans for X-13A-S

Currently, the format of the SEATS output of the program is identical to that produced by the DOS version of SEATS, which is different than the X-12-ARIMA output format of the rest of the program. The tabular output of the program will be standardized, with labels assigned to each of the tables. The user will be given more control over which output tables can be stored or saved than SEATS currently offers, and some of the output will be revised. There will also be an effort render the program output accessible (see section 2.4).

SEATS produces a wide variety of growth rate estimates for the seasonally adjusted series, trend cycle, and other series. Current research at the Census Bureau examines these growth rates and attempts to develop finite sample formulas for their standard errors, see McElroy (2006). This facility will be expanded to provide growth rates for X-11 seasonal adjustments and trends.

There will also be efforts to improve the automatic model identification procedure and the modeling procedure in general. One such effort is to fully implement pulse regressors into the software.

4.1 Pulse and Intervention Regressors

Another type of regressor that has been implemented in prototypes of X-13A-S are pulse regressors. These are taken from the same type of regressor in TRAMO. A new **`pulse`** spec will be used to generate a linear regressor of zeroes and ones by specifying starting dates for a series of pulses and the duration of the effect starting at the pulse.

For example, specifying a `pulse` spec with

```
pulse {   begin = 1990.jan    duration = 5   }
```

will generate a regressor with a series of ones starting in January of 1990 that lasts for five observations. The regressor will be zero otherwise.

Seasonal (δ_s) and nonseasonal (δ) parameters can be specified within the `pulse` spec that allow for filtering of these pulse regressors.

$$X'_t = \frac{1}{(1-\delta B)} X_t$$

$$X'_t = \frac{1}{(1-\delta_s B^s)} X_t$$

These parameters, to be specified in the X-13A-S input as `deltas` and `delta`, allows for the estimation of very flexible intervention effects of the type outlined in Box and Tiao (1975).

A spec file that reproduces the model from one of the examples from this paper is given in Table 3, which also appears as an example in Gómez and Maravall (1997). The model fit for this example is

$$\begin{aligned} (1-B^{12})(1-\phi B)y_t = \\ \frac{\omega_1}{1-B}\xi_{1,t} + \frac{\omega_2}{1-B^{12}}\xi_{2,t} + \frac{\omega_3}{1-B^{12}}\xi_{3,t} + \\ (1-\Theta_{12}B^{12})a_t \end{aligned}$$

where

$$\xi_{1,t} = \begin{cases} 1 & \text{for } t = \text{January 1960} \\ 0 & \text{otherwise} \end{cases},$$

$$\xi_{2,t} = \begin{cases} 1 & \text{for June through October, starting in 1966} \\ 0 & \text{otherwise} \end{cases},$$

$$\xi_{3,t} = \begin{cases} 1 & \text{for November through May, starting in 1966} \\ 0 & \text{otherwise} \end{cases}.$$

Note that each pulse regressor is specified within its own `pulse` spec. If only one value is specifed for the duration of the pulse effect, then this is assumed to be the duration for all the starting dates specified in the `begin` argument.

```
series{
  title= "Oxident recordings, LA"
# show how to specify pulse spec
  format="datevalue"
  span=(1955.1,1972.12)
  file="boxtiao.dat"
  name="O3LA" }
arima { model = (1 0 0)(0 1 1) }
pulse {
  begin = 1960.jan
  duration = 1
  delta = 1 }
pulse {
  begin = ( 1966.jun 1967.jun
  1968.jun 1969.jun 1970.jun
  1971.jun 1972.jun 1973.jun
  1974.jun )
  duration = 5
  deltas = 1.0 }
pulse {
  begin = ( 1966.nov 1967.nov
  1968.nov 1969.nov 1970.nov
  1971.nov 1972.nov 1973.nov
  1974.nov )
  duration = (7 7 7 7 7 7 7 7 2)
  deltas = 1.0 }
check { }
forecast { maxlead = 24 }
```

Table 3: X-13A-S input file for Oxident O_3 level recordings in downtown Los Angeles (Jan 1955-Feb 1972, source: JASA)

These intervention effects were incorporated into the model to examine the impact of air pollution control laws; for more information on the analysis, see Box and Tiao (1975).

5 Longer Range Plans

In this section, I discuss some possible enhancements that, while important, may not be implemented for the beta release of X-13A-S.

5.1 XML output

Lefrançois and Mamay (2004) recommended that developers of software such as X-13A-S consider using XML as a way of better documenting input and specifications used between the different software and improve the integration of stand alone seasonal adjustment packages with other software systems.

Work will begin soon on examining how best to implement XML for the saved output of X-13A-S, both for the resulting series and components generated by the seasonal adjustment and the modeling diagnostics that are produced. There will need to be agreement among different partners and software developers for this conversion; we hope to use the U. S. Census Bureau's experience in developing web based systems such as Ferret as well as other agencies' experiences to inform this effort.

5.2 regCMPNT Modeling Capabilities

The `regCMPNT` modeling package will be made available for distribution soon, with revised documentation and new features. This software allows the fitting of regression models with error terms that are distributed as ARIMA component models. These models are referred to as REGCMPNT models in Bell (2004), and have proven useful in a number of contexts, including utilizing sampling error information to improve seasonal adjustments for series with high sampling error variances (see Bell and Nguyen, 2002), and modeling moving trading day effects in economic time series (see Bell and Martin, 2005).

There were once plans of incorporating the modeling capabilities of `regCMPNT` directly into X-13A-S in order to derive the standard errors for the SEATS components using state space algorithms, rather than using the infinite Wiener-Kolmogoroff filter. However, the results of McElroy (2005) allow us to do this entirely within a matrix framework, as the implementation described in McElroy and Gagnon (2006) shows. This made the incorporation of the regCMPNT code unnecessary.

Current plans are to incorporate signal extraction routines within the `regCMPNT` program, so that seasonal adjustments can be obtained from this software. This will make it possible to provide a means of estimating generalized airline models of the type developed in Findley, Martin, and Wills (2002) and Aston, Findley, Wills, and Martin (2003). These models expand the available models that can be used for model-based seasonal adjustment beyond simple ARIMA models and allow for more flexible specification of trend and seasonal effects.

The decision to postpone incorporating `regCMPNT` modeling capabilities into X-13A-S may be revisited if research on this and other applications of `regCMPNT` modeling proves promising.

6 Acknowledgements

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