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The Stata Journal

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Menu-driven X-12-ARIMA seasonal adjustment in Stata

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Abstract. The X-12-ARIMA software of the U.S. Census Bureau is one of the most popular methods for seasonal adjustment; the program `x12a.exe` is widely used around the world. Some software also provides X-12-ARIMA seasonal adjustments by using `x12a.exe` as a plug-in or externally. In this article, we illustrate a menu-driven X-12-ARIMA seasonal-adjustment method in Stata. Specifically, the main utilities include how to specify the input file and run the program, how to make a diagnostics table, how to import data, and how to make graphs.

Keywords: st0255, sax12, sax12diag, sax12im, sax12del, seasonal adjustment, X-12-ARIMA, menu-driven

1 Introduction

Seasonal data are widely used in time-series analysis, usually at a quarterly or monthly frequency. Some seasonal data have significant seasonal fluctuations, such as data on retail sales, travel, and electricity usage. Seasonality brings many difficulties to model specification, estimation, and inference. In most developed countries, researchers can directly use the seasonally adjusted data issued by the statistics bureau. Unfortunately, this statistical work is unavailable in most developing countries. Their departments of statistics do not provide the seasonal adjustment or are still in their early stages. In these cases, researchers must adjust the seasonal data themselves.

Several methods of seasonal adjustment are available, among which X-12-ARIMA of the U.S. Census Bureau and TRAMO-SEATS of the Bank of Spain are the most popular. The programs for both of them are free of charge. The statistics bureaus in many countries either use them directly or make some modifications based on them. The programs can also be run as a plug-in or externally with some statistical software, such as EViews, OxMetrics, and Rats. The U.S. Census Bureau also provides a Windows interface for X-12-ARIMA version 0.3, namely, Win X-12, which can be downloaded from http://www.census.gov/srd/www/winx12/winx12_down.html. In fact, we borrow many ideas from Win X-12 to design our dialog box in Stata.

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Stata is good at dealing with time series, file reading and writing, making graphs, and more, but it currently does not provide X-12-ARIMA seasonal adjustment. In this article, we describe a menu- and command-driven X-12-ARIMA seasonal adjustment with `sax12`, a Stata interface for the X-12-ARIMA software provided by the U.S. Census Bureau. We use the `shell` command to run the DOS program `x12a.exe`.[1] Our program is specifically designed for `x12a.exe` version 0.3 and may not work for previous or future versions.

In this article, we introduce several utilities, such as how to generate the specification file, how to import the adjusted series, and how to make graphs. We first outline the background of seasonal adjustment and then describe the design of the menus and dialog boxes. We illustrate the process using two examples. The first is a seasonal adjustment of a single series, and the second is a seasonal adjustment of multiple series simultaneously.

Several benefits are derived from the menu-driven commands. First, seasonal adjustment has so many options that consulting the reference manual is difficult, let alone trying to remember all the options. The dialog box makes the options easier to use. Second, some options are usually in conflict with others. The warning messages behind the dialog box save you much time by quickly identifying these conflicts. All the dialog boxes have the corresponding command line syntax. The full syntax with a description for each option can be obtained by typing `help sax12`, `help sax12im`, `help sax12diag`, and `help sax12del`.

2 Outline of the X-12-ARIMA seasonal adjustment

The X-12-ARIMA seasonal-adjustment program is an enhanced version of the X-11 Variant of the Census Method II (Shiskin, Young, and Musgrave 1967). We outline the framework of X-12-ARIMA in this section. Please refer to U.S. Census Bureau (2011) for more details. X-12-ARIMA includes two modules: regARIMA (linear regression model with ARIMA time-series errors) and X-11. Three stages are needed to complete the seasonal adjustment: model building, seasonal adjustment, and diagnostic checking.

2.1 Stage I: Regression with ARIMA errors (regARIMA)

In the first stage, regARIMA performs prior adjustment for various effects (such as trading-day effects, seasonal effects, moving holiday effects, and outliers) and forecasts or backcasts of the time series. The general regARIMA model can be written as

$$\phi(B)\Phi\left(B^s\right)(1-B)^d\left(1-B^s\right)^D\left(y_t-\sum\nolimits_{i=1}\beta_i x_{it}\right)=\theta(B)\Theta\left(B^s\right)u_t$$

where B is the backshift operator ($By_t = y_{t-1}$); s is the seasonal period; $\phi(B) = 1 - \phi_1 B - \cdots - \phi_p B^p$ is the regular autoregressive operator; $\Phi(B^s) = 1 - \Phi_1 B^s - \cdots - \Phi_P B^{Ps}$

1. The program is downloadable from http://www.census.gov/srd/www/x12a/x12downv03_pc.html and is free. Our program is limited to the Windows PC version of X-12-ARIMA and is not supported on Linux. Make sure `x12a.exe` is in your current working directory.

is the seasonal autoregressive operator; $\theta(B) = 1-\theta_1 B - \cdots - \theta_q B^q$ is the regular moving-average operator; $\Theta(B^s) = 1 - \Theta_1 B^s - \cdots - \Theta_Q B^{Qs}$ is the seasonal moving-average operator; the u_t are independent and identically distributed (i.i.d.) with mean 0 and variance σ^2; and d and D are the regular differencing order and seasonal differencing order, respectively.

y_t is the dependent variable to adjust. y_t is the original series or its prior-adjusted series, or some type of transformation, including log, square root, inverse, logistic, and Box–Cox power transformations. The transformations are listed in table 1, and the prior adjustments are listed in table 2.

Table 1. Transformations of the original series (*X-12-ARIMA Seasonal Adjustment* dialog box: **Prior** tab)

Type	Formula	Range for y_t	Option in `sax12`
log	$\log(y_t)$	$y_t > 0$	`transfunc(log)` or `transpower(0)`
square root	$1/4 + 2(\sqrt{y_t} - 1)$	$y_t \geq 0$	`transfunc(sqrt)` or `transpower(0.5)`
inverse	$2 - 1/y_t$	$y_t \neq 0$	`transfunc(inverse)` or `transpower(-1)`
logistic	$\log(y_t/(1 - y_t))$	$0 < y_t < 1$	`transfunc(logistic)`

Note: Part of the table is extracted from table 7.36 in U.S. Census Bureau (2011, 175).

A predefined prior adjustment includes length of month (or quarter) and leap year effect. Length of month (or quarter) adjustment means that each observation of a monthly series is divided by the corresponding length of month (or length of quarter for quarterly series) and then is rescaled by the average length of month (or quarter). You can define the modes of your own prior-adjustment variables. The mode specifies whether the factors are percentages or ratios, are to be divided out of the series, or are values to be subtracted from the original series. Ratios or percentage factors can only be used with log-transformed data, and subtracted factors can only be used with no transformation. You can also specify whether the prior-adjustment factors are permanent (removed from both the original series and the seasonally adjusted series) or temporary (removed from the original series but not from the seasonally adjusted series).

Table 2. Prior adjustment of the original series (*X-12-ARIMA Seasonal Adjustment* dialog box: **Prior** tab)

Predefined	Option in `sax12`	User defined	Option in `sax12`
length of month	`prioradj(lom)`	variables	`priorvar(`*varlist*`)`
length of quarter	`prioradj(loq)`	mode	`priormode(`*string*`)`
leap year	`prioradj(lpyear)`	type	`priortype(`*string*`)`

x_{it} are regression variables that include the predefined variables (such as trading-day effects), the automatically added variables (such as outliers), and the user-defined variables. So in the regARIMA model, the trading day, holiday, outlier, and other regression effects can be fit and used to adjust the original series prior to seasonal adjustment. The options for the regression variables in `sax12` are listed in table 3. The predefined variables are specified in the same way as those in table 4.1 of U.S. Census Bureau (2011). For example, the length of month and seasonal dummy variables can be specified as `regpre(lom seasonal)`. The user-defined variables are assumed to be of type `user` and already centered. Of course, you can change these options. For example, we add two holiday variables (`mb` and `ma`) in the regression model. We can specify these as `reguser(mb ma) regusertype(holiday holiday)`. The significance of different types of variables can be tested using the `regic(`*string*`)` option. For example, we specify `regic(td1nolpyear user)` to test the significance of the working-day effect and user-defined variables. The outliers in the model will be discussed shortly.

Table 3. Regression variables in regARIMA model (*X-12-ARIMA Seasonal Adjustment* dialog box: **Regression** tab)

Predefined	Option in `sax12`	User defined	Option in `sax12`
length of month, etc.	`regpre(`*string*`)`	variables	`reguser(`*varlist*`)`
		types	`regusertype(`*string*`)`
		center	`regusercent(`*string*`)`

X-12-ARIMA provides capabilities of identification, estimation, and diagnostic checking. Identification of the ARIMA model for the regression errors can be carried out based on sample autocorrelation and partial autocorrelation. You can specify the ARIMA model by hand or let the program automatically select the optimal model from among a set of models. X-12-ARIMA has an automatic model-selection procedure based largely on the automatic model selection of TRAMO (Gómez and Maravall 2001). X-12-ARIMA will select the optimal model given the maximum difference order and ARMA order or only given the maximum ARMA order at a fixed difference order. You can also let X-12-ARIMA automatically select the optimal ARIMA model from among a set of models stored in one file.

Once a regARIMA model has been specified, X-12-ARIMA estimates its parameters by maximum likelihood using an iterated generalized least-squares algorithm. Diagnostic checking involves examining the residuals from the fitted model for signs of model inadequacy, including outlier detection, normality test, and the Ljung–Box Q test. The options allowed in `sax12` of the ARIMA model are listed in table 4.

Table 4. ARIMA specifications in regARIMA model (*X-12-ARIMA Seasonal Adjustment* dialog box: **ARIMA** tab)

ARIMA model	Option in `sax12`	Example
user defined:		
	`ammodel(`*string*`)`	`ammodel((0,1,1)(0,1,1))`
automatic selection given maximum order:		
	`ammaxlag(`*numlist*`)`	`ammaxlag(2 2)`
	`ammaxdiff(`*numlist*`)`	`ammaxdiff(2 2)`
	`amfixdiff(`*numlist*`)`	`amfixdiff(2 1)`
automatic selection in models stored in file:		
	`amfile(`*filename*`)`	`amfile(d:/x12a/mymodel.mdl)`
common option:		
forecast	`ammaxlead(`*integer*`)`	`ammaxlead(12)`
backcast	`ammaxback(`*integer*`)`	`ammaxback(12)`
confidence level	`amlevel(`*real*`)`	`amlevel(95)`
sample	`amspan(`*string*`)`	`amspan(1996.1, 2003.3)`

An important aspect of the diagnostic checking of time-series models is outlier detection. X-12-ARIMA's approach to outlier detection is based on that of Chang and Tiao (1983) and Chang, Tiao, and Chen (1988), with extensions and modifications as discussed in Bell (1983) and Otto and Bell (1990). Three types of outliers are searched for: additive outliers (AO), temporary change outliers (TC), and level shifts (LS). In brief, this approach involves computing t statistics for the significance of each outlier type at each time point, searching through these t statistics for significant outlier(s), and adding the corresponding AO, LS, or TC regression variable(s) to the model.

X-12-ARIMA provides two variations on this general theme. The `addone` method provides full-model reestimation after each single outlier is added to the model, while the `addall` method refits the model only after a set of detected outliers is added to the model. During outlier detection, a robust estimate of the residual standard deviation—1.48 times the median absolute deviation of the residuals—is used. The default critical value is determined by the number of observations in the interval searched for outliers.

When a model contains two or more LSs, including those obtained from outlier detection as well as any specified in the regression specification, X-12-ARIMA will optionally produce t statistics for testing null hypotheses that each run of two, three, etc., successive LSs actually cancels to form a temporary LS. Two successive LSs cancel to form a temporary LS if the effect of one offsets the effect of the other, which implies that the sum of the two corresponding regression parameters is zero. Similarly, three successive LSs cancel to a temporary LS if the sum of their three regression parameters is zero, and so on. The options of outliers are listed in table 5.

Table 5. Outlier variables in regARIMA model (*X-12-ARIMA Seasonal Adjustment* dialog box: **Outlier** tab)

Automatically detected	Option in `sax12`	User defined	Option in `sax12`
type	`outauto(`*string*`)`	AO outliers	`outao(`*string*`)`
critical values	`outcrit(`*string*`)`	LS outliers	`outls(`*string*`)`
span	`outspan(`*string*`)`	TC outliers	`outtc(`*string*`)`
LS run	`outlsrun(`*integer*`)`		
method	`outmethod(`*string*`)`		

2.2 Stage II: Seasonal adjustment (X-11)

The original series is adjusted using the trading day, holiday, outlier, and other regression effects derived from the regression coefficients. Then the adjusted series (O) is decomposed into three basic components: trend cycle (C), seasonal (S), and irregular (I). X-12-ARIMA provides four different decomposition modes: multiplicative (the default), additive, pseudo-additive, and log-additive. The four modes are listed in table 6.

Table 6. Modes of seasonal adjustment and their models (*X-12-ARIMA Seasonal Adjustment* dialog box: **Adjustment** tab)

Mode	Model for O	Model for SA	Option in `sax12`
multiplicative	$O = C \times S \times I$	SA $= C \times I$	`x11mode(mult)`
additive	$O = C + S + I$	SA $= C + I$	`x11mode(add)`
pseudo-additive	$O = C \times (S + I - 1)$	SA $= C \times I$	`x11mode(pseudoadd)`
log-additive	$\log(O) = C + S + I$	SA $= \exp(C + I)$	`x11mode(logadd)`

Note: 1) The table is extracted from table 7.44 in U.S. Census Bureau (2011, 193). 2) SA denotes a seasonally adjusted series.

X-12-ARIMA uses a seasonal moving average (filter) to estimate the seasonal factor. An $n \times m$ moving average means that an n-term simple average is taken of a sequence of consecutive m-term simple averages. Table 7.43 of U.S. Census Bureau (2011) lists these options. If no selection is made, X-12-ARIMA will select a seasonal filter automatically. The Henderson moving average is used to estimate the final trend cycle. Any odd number greater than 1 and less than or equal to 101 can be specified. If no selection is made, the program will select a trend moving average based on statistical characteristics of the data. For monthly series, a 9-, 13-, or 23-term Henderson moving average will be selected. For quarterly series, the program will choose either a 5- or 7-term Henderson moving average.

The options allowed by `sax12` are listed in table 7. By default, a series is adjusted for both seasonal and holiday effects. The holiday-adjustment factors derived from the program can be kept in the final seasonally adjusted series by using the `x11hol` option. The final seasonally adjusted series will contain the effects of outliers and user-defined regressors. These effects can be removed using the `x11final()` option. The lower and upper sigma limits used to downweight extreme irregular values in the internal seasonal-adjustment iterations are specified using the `x11sig()` option.

Table 7. Options of seasonal adjustment (*X-12-ARIMA Seasonal Adjustment* dialog box: **Adjustment** tab)

Option	Option in `sax12`	Example
trend filter	`x11trend(`*string*`)`	`x11trend(23)`
seasonal filter	`x11seas(`*string*`)`	`x11seas(s3x5)`
factor removed	`x11final(`*string*`)`	`x11final(ao user)`
holiday kept	`x11hol`	
sigma limits	`x11sig(`*string*`)`	`x11sig(2,3)`

If an aggregate time series is a sum (or other composite) of component series that are seasonally adjusted, then the sum of the adjusted component series provides a seasonal adjustment of the aggregate series that is called the indirect adjustment. This adjustment is usually different from the direct adjustment that is obtained by applying the seasonal-adjustment program to the aggregate (or composite) series. The indirect adjustment is usually appropriate when the component series have very different seasonal patterns.

X-12-ARIMA makes three types of adjustment. Type I adjustment is for a single series based on a single specification file, which specifies the entire adjustment process and has the extension `.spc`. Type II adjustment is for multiseries using a data metafile with the extension `.dta`,[2] which is a list of data files to be run using the same `.spc` file. Type III adjustment is for multiseries using a metafile with the extension `.mta`, which is a list of specification files. Table 8 lists the options in `sax12` for each type of adjustment.

2. Though the data metafile has the same extension as the Stata data file, they have completely different formats.

Table 8. Direct and indirect seasonal adjustment (*X-12-ARIMA Seasonal Adjustment* dialog box: **Main** tab)

Types	Option in `sax12`	Specification file(s)	Prefix of output files
type I	`satype(single)`	`inpref(`*filename*`)` `comptype(`*string*`)`	`outpref(`*file prefix*`)`
type II	`satype(dta)`	`inpref(`*filename*`)` `dtafile(`*filename*`)`	`outpref(`*file prefix*`)`
type III	`satype(mta)`	`mtaspc(`*filenames*`)` `compsa` `compsadir`	`outpref(`*file prefix*`)`

2.3 Stage III: Diagnostics of seasonal adjustment

X-12-ARIMA contains several diagnostics for modeling, model selection, and adjustment stability. Spectral plots of the original series, the regARIMA residuals, the final seasonal adjustment, and the final irregular component help you check whether there still remains seasonal or trading-day variation. The sliding spans analysis and history revision analysis are two important stability diagnostics. The sliding spans diagnostics compare seasonal adjustments from overlapping spans of given series. The revision history diagnostics compare the concurrent and final adjustments. Table 9 lists the options of diagnostics in `sax12`.

Table 9. Diagnostics of seasonal adjustment (*X-12-ARIMA Seasonal Adjustment* dialog box: **Others** tab)

Option	Option in `sax12`
sliding span analysis	`sliding`
history revision analysis	`history`
check `.spc` file	`justspc`

The X-12-ARIMA software contains limits on the maximum length of series, maximum number of regression variables in a model, etc. For example, the maximum length of the series on an input series is 600, and the maximum number of regression variables in a model is 80. The limits in X-12-ARIMA are listed in table 2.2 of U.S. Census Bureau (2011). These limits are set at values believed to be sufficiently large for the great majority of applications, without being so large as to cause memory problems or to significantly lengthen program execution times. The `sax12` command will check these limits before executing `x12a.exe`.

3 Design of menus and dialog boxes for sax12

Menu-driven commands generate and execute the required files for `x12a.exe`. Some jargon used here, such as group box and check box, can be found in [P] **program**. For details about the X-12-ARIMA computations and terminology, please refer to U.S. Census Bureau (2011).

3.1 Main

The dialog box shown in figure 1 selects the adjustment type. Different types have different options.

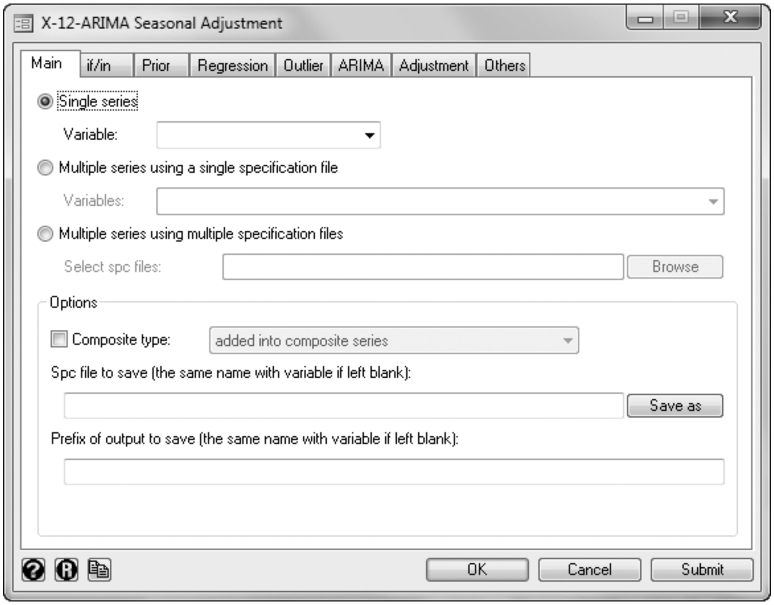

Figure 1. Screenshot of the **Main** tab (type I) in the *X-12-ARIMA Seasonal Adjustment* dialog box

The first bullet, labeled *Single series*, is selected to calculate a type I adjustment. If this is selected, you must also select the variable to adjust. If you want to perform composite adjustment, choose the *Composite type*. You can save the new input file in the field for *Spc file to save (the same name with variable if left blank)* by pressing the **Save as** button. You can also name the output file in the fields for *Prefix of output to save (the same name with variable if left blank)*. By default, both the input file and the output file are named after the variable.

The second bullet, labeled *Multiple series using a single specification file*, is selected to calculate a type II adjustment with the options shown in figure 2. If this is selected, you must also select the variables to adjust. By default, the program saves the new input file as `mvss.spc`—which means “multiple variables using single specification file”—saves the output files named after the variables, and saves the data metafile as `mvss.dta`. Of course, you can save these files by editing the fields *Spc file to save (mvss.spc if left blank)* and *Dta file to save (mvss.dta if left blank)* or by pressing the **Save as** button.

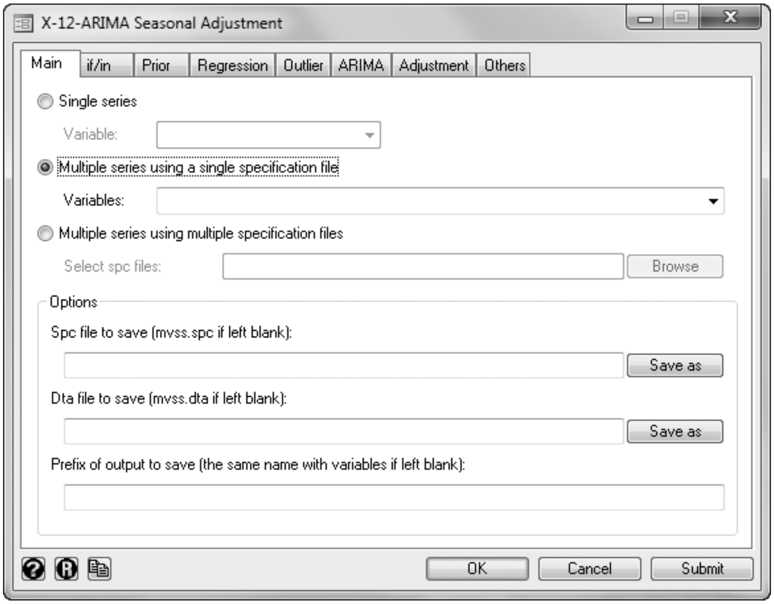

Figure 2. Screenshot of the **Main** tab (type II) in the *X-12-ARIMA Seasonal Adjustment* dialog box

The last bullet, labeled *Multiple series using multiple specification files*, is selected to calculate a type III adjustment with the options shown in figure 3. If this is selected, you must also select the input files by pressing the **Browse** button next to the *Select spc files* field. By default, the program saves the input metafile as `mvms.mta`, which stands for “multiple variables for multiple specification files”. If you want to perform the composite adjustment, click on the check box for *Composite adjustment*. If you also want to perform the direct adjustment for the aggregate series, click on *Direct seasonal adjustment for composite series* and input the name of the specification file in the *Spc file to save (mvms.spc if left blank)* field. The program saves the input file as `mvms.spc` by default. This produces an indirect seasonal adjustment of the composite series as well as a direct adjustment.

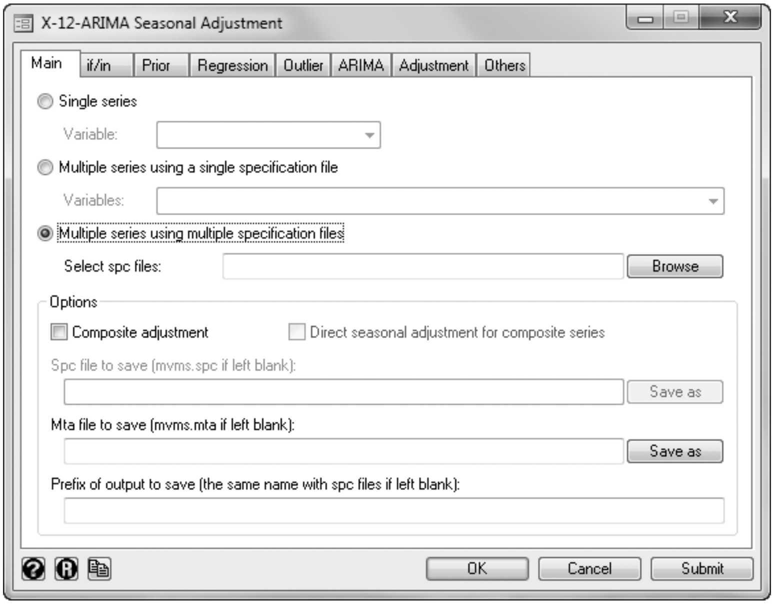

Figure 3. Screenshot of the **Main** tab (type III) in the *X-12-ARIMA Seasonal Adjustment* dialog box

3.2 Prior

The dialog box shown in figure 4 specifies the data properties, the transformation method, and the prior adjustment. Data properties include *Flow or stock* and *Frequency* (`monthly` or `quarterly`). The dialog box will determine the frequency automatically if there are data in the memory. Trading days and Easter have different regression variables for flow series than for stock series. The predefined variables on this dialog box and the **Regression** tab of the *X-12-ARIMA Seasonal Adjustment* dialog box will change according to these choices.

Data transformation includes *Auto (log or none)*, *Log*, *Square Root*, *Inverse*, *Logistic*, and *Box-Cox Power*. The *Auto (log or none)* option lets X-12-ARIMA automatically decide whether the data should be log-transformed using Akaike's information criterion (AIC) test. If you choose *Box-Cox Power*, then include the transformation parameter in the edit field.

In the *Prior Adjustment* group box, you can select the predefined variables in the *Predefined Variable* combo box or choose the user-defined variables in the *User-defined variables* group box. For the user-defined variables, you can also select your modes and types. *Mode* specifies the way in which the user-defined prior-adjustment factors will be applied to the time series. For example, `mode=diff` means that the prior adjustments are to be subtracted from the original series. *Type* specifies whether the prior-adjustment factors are permanent or temporary.

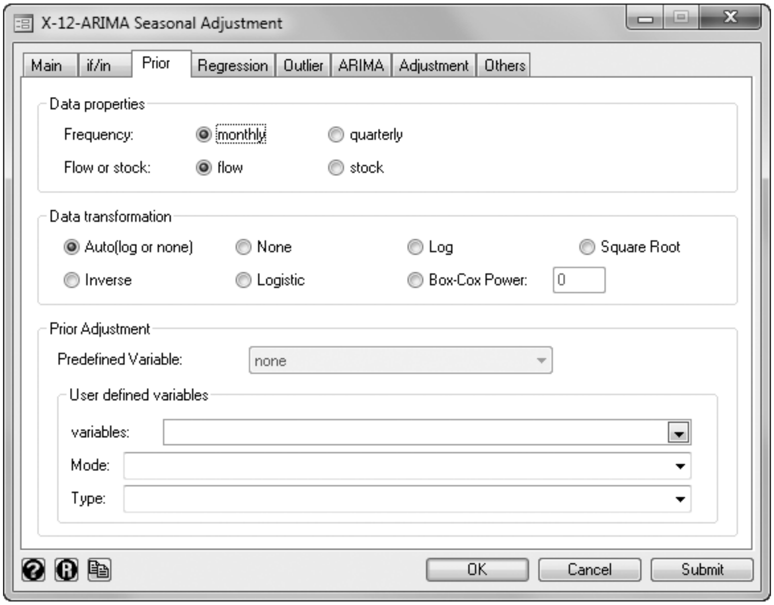

Figure 4. Screenshot of the **Prior** tab in the *X-12-ARIMA Seasonal Adjustment* dialog box

3.3 Regression

In the **Regression** tab of the *X-12-ARIMA Seasonal Adjustment* dialog box, shown in figure 5, you can choose the predefined variables and user-defined variables. The available predefined variables are determined by the data properties and transformation. For the user-defined variables, you can also choose their types and centering method. If *Types* is left blank, all variables are assumed to be of the type `user`. *Center type* includes *already centered*, *subtract overall mean*, and *subtract mean by season*. By default, the program assumes the variables have already been centered. In the *AIC test* group box, you can choose the types of variables to test based on AIC, and the insignificant variables will be dropped automatically from the regression.

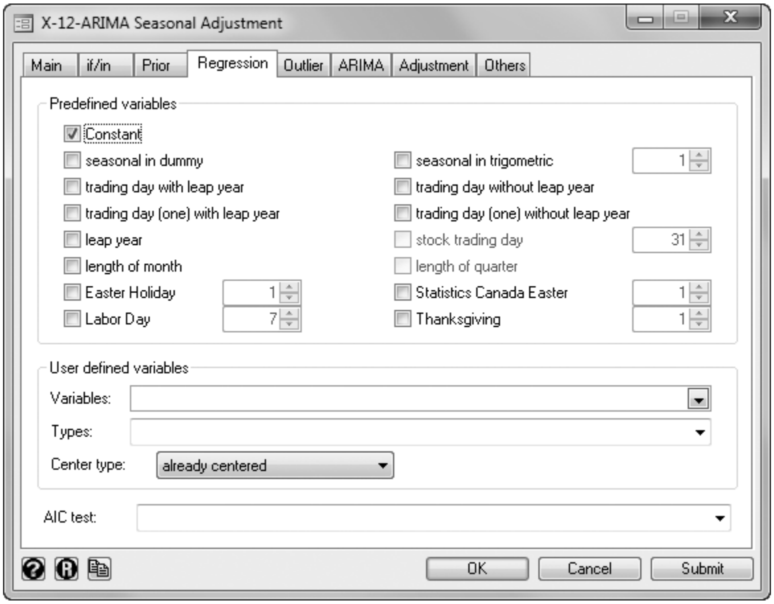

Figure 5. Screenshot of the **Regression** tab in the *X-12-ARIMA Seasonal Adjustment* dialog box

3.4 Outlier

In the **Outlier** tab of the *X-12-ARIMA Seasonal Adjustment* dialog box, shown in figure 6, you can let the program automatically identify the outliers in the *Automatically identified outliers* group box. By default, the program searches AO and LS outliers.

You can adjust the criteria in the *Options* group box. *Critical values* sets the value to which the absolute values of the outlier t statistics should be computed to detect outliers. The default critical value is determined by the number of observations in the interval searched for outliers. You can also specify the critical values manually by selecting *user defined*. The values are set for AO, LS, and TC sequentially and separated by commas, as in `3.5, 4.0, 4.0` or `3.5, , 4.0`. Blank means the default value. If only one value is specified, it applies to all types of outliers. *Outlier span* specifies the start and end dates of a span that should be searched for outliers, as in `1995.1, 2008.12` or `1995.1, `. Blank means the default date. *LS run* specifies the maximum length of a period to form a temporary LS. The value must lie between 0 and 5. The default value is 0, which means no temporary LS t statistics are computed. *Identify method* includes two methods to successively add detected outliers to the model: *addone* (the default) and *addall*.

You can also input the outliers by hand in the *User-defined outliers* group box in the respective field for each outlier type. A tool tip will pop up when you mouse over a field, and it will give an example to fill in.

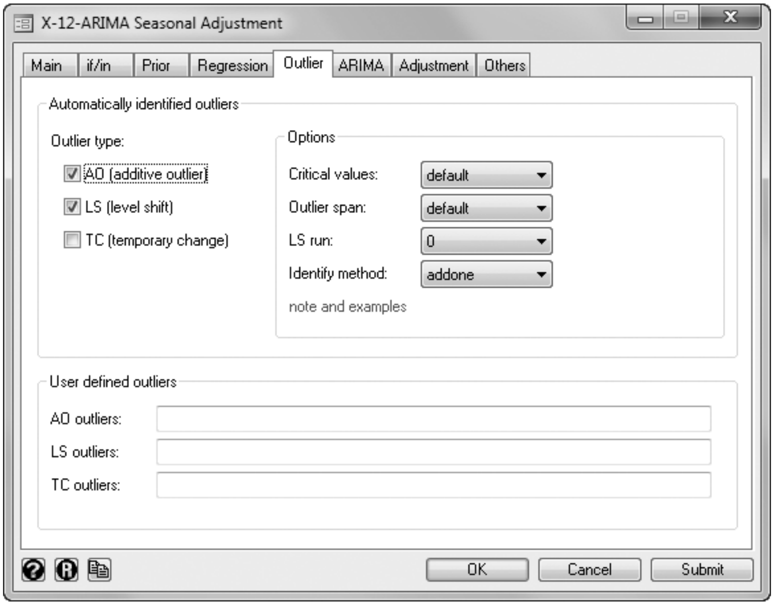

Figure 6. Screenshot of the **Outlier** tab in the *X-12-ARIMA Seasonal Adjustment* dialog box

3.5 ARIMA

The **ARIMA** tab of the *X-12-ARIMA Seasonal Adjustment* dialog box, shown in figure 7, specifies the ARIMA model. You can specify the ARIMA model directly by clicking on *Specify by hand (non-seasonal, seasonal)*. The model should be specified with the format $(p,d,q)(P,D,Q)$, such as `(0,1,1)(1,1,0)`. The former part is the regular ARIMA model, and the latter part is the seasonal ARIMA model. You can also let the program automatically select the optimal model through two ways. The first is through *Automatic selection given maximum lag and difference*. You should choose the *Max lag of ARMA part* for both the regular and the seasonal ARMA model. The difference order can be specified to the maximum order by clicking on *Max difference*, or it can be fixed at a specified order by clicking on *Fixed difference*. The second is through clicking on *Automatic selection in models stored in file* and then clicking on the **Browse** button to choose the optimal model from among several models listed in the stored file. The default file extension is `.mdl`.

You can restrict the estimation sample in the field following the *Sample* option or can change the default forecast options in the *Forecast options* group box.

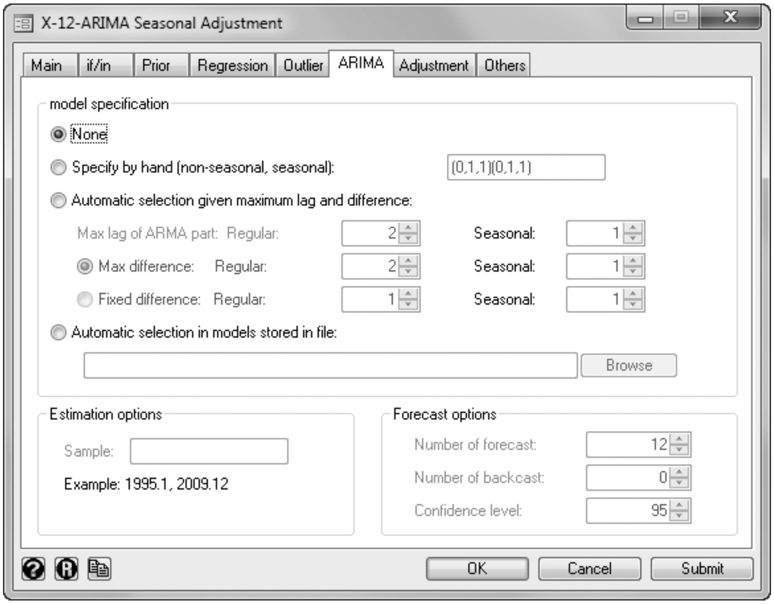

Figure 7. Screenshot of the **ARIMA** tab in the *X-12-ARIMA Seasonal Adjustment* dialog box

3.6 Adjustment

In the **Adjustment** tab of the *X-12-ARIMA Seasonal Adjustment* dialog box, shown in figure 8, you can specify the X-11 seasonal adjustment. The *X11 mode* specifies the seasonal-adjustment mode. The default mode (*multiplicative*) is disabled because the default transformation is set to *Auto (log or none)* on the **Prior** tab of the *X-12-ARIMA Seasonal Adjustment* dialog box.

Extreme limits specifies the lower and upper limits used to downweight extreme irregular values in the internal seasonal-adjustment iterations. The default values are set to 1.5 for the lower limit and 2.5 for the upper limit. If you specify the values manually, then you should select *user defined* and input the values in the appropriate fields. Valid list values are any real numbers greater than zero with the lower-limit value less than the upper-limit value and the two values separated by a comma. Blank denotes the default value. Valid specifications include `1.8,2.8` and `1.8,` . More examples can be viewed by clicking on *note and examples*.

Trend filter specifies that the Henderson moving average should be used to estimate the final trend cycle. Any odd number greater than 1 and less than or equal to 101 can be specified. By default, the program will select a trend moving average based on statistical characteristics of the data. For monthly series, a 9-, 13-, or 23-term Henderson moving average will be selected. For quarterly series, the program will choose either a 5- or 7-term Henderson moving average. *Seasonal filter* specifies that a seasonal moving average will be used to estimate the seasonal factors. By default, X-12-ARIMA will choose the final seasonal filter automatically.

If some outliers are excluded from the adjusted series, choose the types in the field for *Exclude the outliers out of the seasonally adjusted series*. If you want to include the holiday effect in the adjusted series, click on *Keep holiday effect in the seasonally adjusted series*.

If you do not want to perform seasonal adjustment, just click on *No adjustment*. In this case, the program will just fit the regARIMA model.

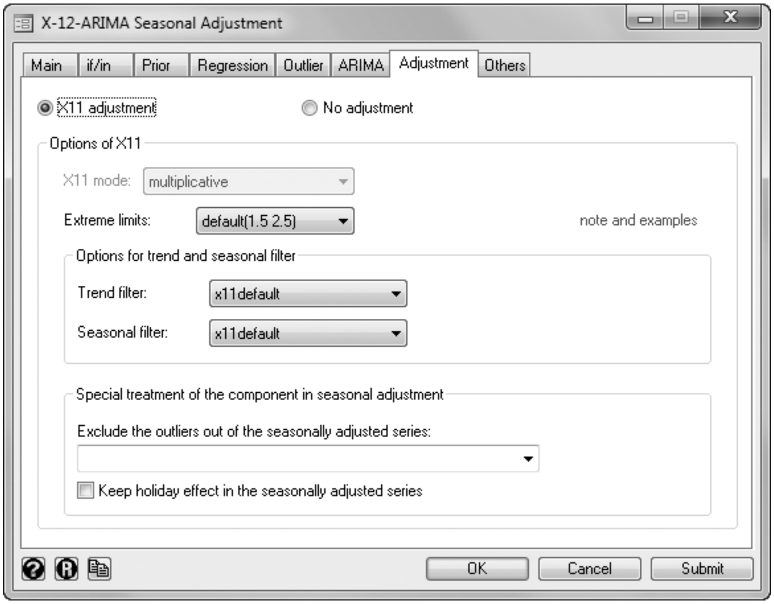

Figure 8. Screenshot of the **Adjustment** tab in the *X-12-ARIMA Seasonal Adjustment* dialog box

3.7 Stability and other options

The **Others** tab of the *X-12-ARIMA Seasonal Adjustment* dialog box, shown in figure 9, includes two kinds of stability analysis: *Sliding span analysis* and *Revision history analysis*. If you just want to view the input file before adjustment, click on *Just generate spc file and check it but not perform seasonal adjustment*.

If the input files have already been generated, you can perform seasonal adjustment directly by clicking on *Directly perform seasonal adjustment based on already defined spc (dta, mta) file(s)* and select the corresponding files in the *Options* group box. Note that if you choose this option, all other specifications will be omitted.

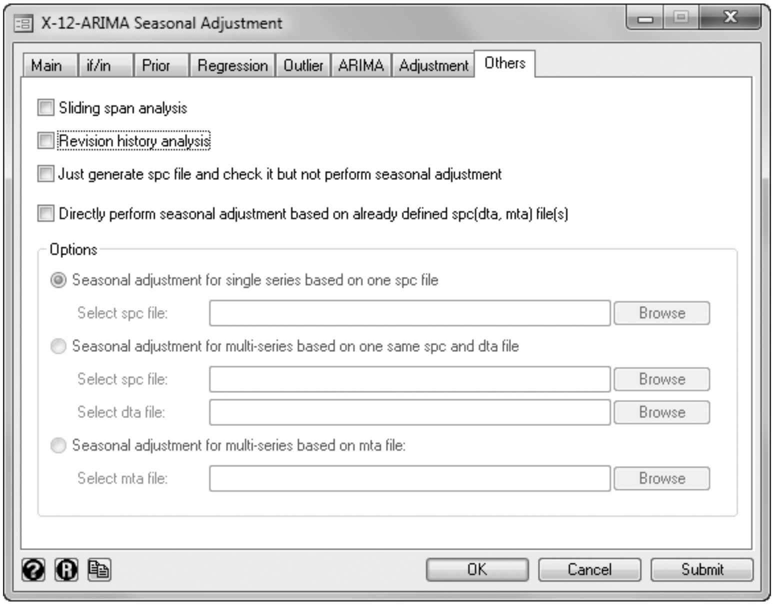

Figure 9. Screenshot of the **Others** tab in the *X-12-ARIMA Seasonal Adjustment* dialog box

4 Design of menus and dialog boxes for sax12im

When X-12-ARIMA is run, a number of output files can be created. These generally have the same name (or base name) as the specification file or metafile, unless an alternate output name is specified, but have extensions based on the file type. The main output is written to the file *filename*`.out`. Run-time errors are stored in file *filename*`.err`, and a log file *filename*`.log` is also generated.

`sax12im` is used to import the series generated by `sax12`, or more precisely, by X-12-ARIMA. Input the following command to open the dialog box as shown in figure 10.

```
. db sax12im
```

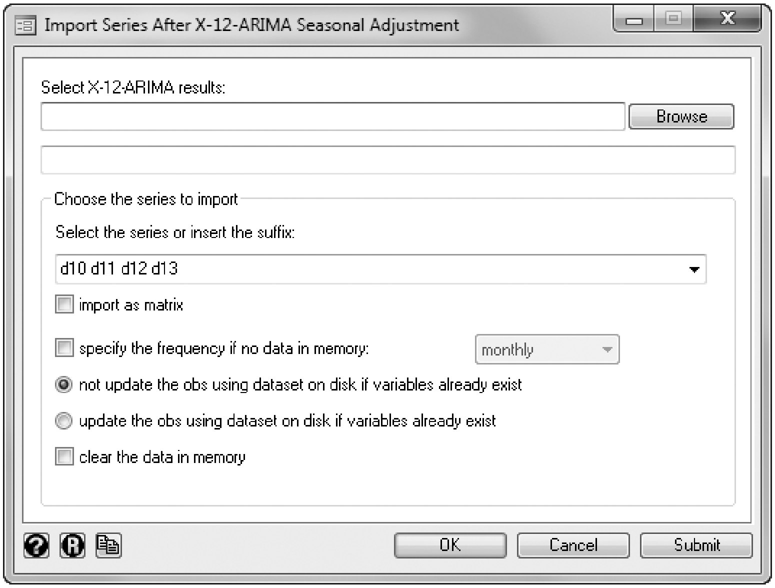

Figure 10. Screenshot of the dialog box to import data

First, select the results in the field for *Select X-12-ARIMA results*. After pressing the **Browse** button, all the results with extension `.out` are listed. You can select multiple results. Results in the same directory or different directories are both allowed. This will be convenient if the results of different specifications are stored in different directories. In the field for *Select the series or insert the suffix*, you can select the series to import. We list the most often used series. With the specific variable selected, the corresponding suffix will appear in the edit fields. By default, the imported series are as follows: seasonal factor (`d10`), seasonally adjusted series (`d11`), trend-cycle component (`d12`), and irregular component (`d13`). If you want to import more series, you can insert the suffix directly.

By default, the program imports the series as variables, and this is the usual case. For some other cases, it is appropriate to import the data as matrices, such as the spectral density and the autocorrelation function. The option *import as matrix* provides this utility.

If there are no data in memory, you should select the frequency (monthly or quarterly) by clicking on *specify the frequency if no data in memory*. The new date variable will be named after `sdate` automatically. If you want to replace the data in memory, select the *clear the data in memory* option. Note that if you select this option, you must also choose the frequency because there are no data after the memory is cleared. The program will not import those variables already existing in memory. In this case, you can update the observations by clicking *update the obs using dataset on disk if variables already exist*. For example, let's pretend you have a variable (such as `gdp`) using a subsample from January 1992 to December 2008, and you have imported the variables `gdp.d10` and `gdp.d11`. Then you make a new adjustment using the sample from January 1992 to December 2009. Unless you specify the `update` option, `sax12im` will not import the newly generated series `gdp.d10` and `gdp.d11` because they already exist. The names of all the variables needed to import are stored in `r(varlist)`. The names of the newly generated variables are stored in `r(varnew)`, and the names of the already existing variables are stored in `r(varexist)`.

5 Design of menus and dialog boxes for sax12diag

X-12-ARIMA automatically stores the most important diagnostics in a file, which will have the same path and filename as the main output but with the extension `.udg`. The diagnostics summary file is an ASCII database file. Within the diagnostic file, each diagnostic has a unique key to access its value. We extract the most important information into a table. The diagnostics table consists of five parts: general information, X-11, regARIMA, outliers, and stability analysis. Input the following command to open the dialog box as shown in figure 11.

```
. db sax12diag
```

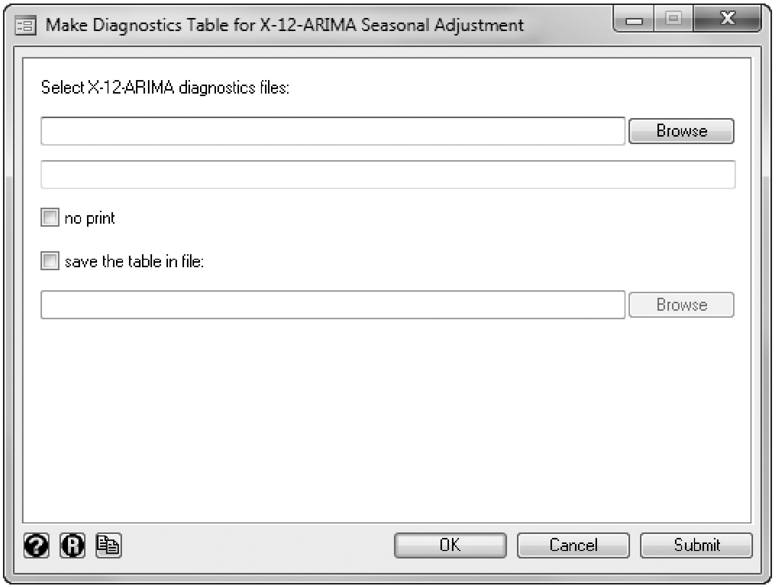

Figure 11. Screenshot of the dialog box to make diagnostics tables

First, select the diagnostics files in the *Select X-12-ARIMA diagnostics files* field. After pressing the **Browse** button, all the files with extension `.udg` are listed. You can select multiple files. Use the check box for *no print* if you want to suppress the output on the screen. You can save the diagnostics table in another file by clicking on *save the table in file* and using the **Browse** button to select your file.

6 Design of menus and dialog boxes for sax12del

Many files are generated in the X-12-ARIMA seasonal adjustment. You may wish to delete these files when you obtain satisfactory results. We designed a dialog box as shown in figure 12 to fulfill this task. The `sax12del` command automatically identifies and deletes all the files of the seasonal adjustment.

```
. db sax12del
```

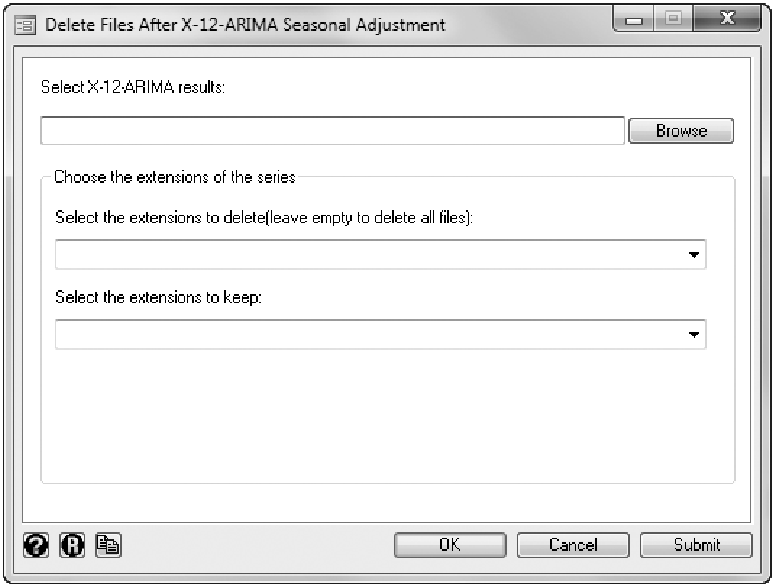

Figure 12. Screenshot of the dialog box to delete files

First, select the diagnostics files in the *Select X-12-ARIMA results* field. After pressing the **Browse** button, all the files with extension `.out` are listed. Only one file can be selected at a time. You can choose which files are to be deleted via *Select the extensions to delete (leave empty to delete all files)*; likewise, you can choose which files are to be kept via *Select the extensions to keep*. The default is to delete all files.

7 Example

Next we use two examples to illustrate how to make a seasonal adjustment using our programs. The first example contains monthly data for one series, and the second example contains quarterly data for nine series.

7.1 Example: Adjustment for a single series

The `retail.dta` file contains the monthly data of the total retail sales of consumer goods in China (`retail`) from January 1990 (`1990m1`) to December 2009 (`2009m12`).

regARIMA model specification

We import the data into memory and make a trend plot. In this example, we assume the data are stored in the directory `d:\sam`.

```
. cd d:\sam
d:\sam

. use retail, clear

. tsset
        time variable:  mdate, 1990m1 to 2011m12
                delta:  1 month

. des

Contains data from retail.dta
  obs:           264
 vars:             5                          11 Jan 2011 14:39
 size:         5,808
-------------------------------------------------------------------------------
              storage  display     value
variable name   type   format      label      variable label
-------------------------------------------------------------------------------
mdate           int    %tm
retail          double %10.0g                 total retail sales of consumer
                                                goods in China
sprb            float  %9.0g                  1st variable of Spring Festival
sprm            float  %9.0g                  2nd variable of Spring Festival
spra            float  %9.0g                  3rd variable of Spring Festival
-------------------------------------------------------------------------------
Sorted by:  mdate

. tsline retail
```

Note that the available data for the three variables `sprb`, `sprm`, and `spra` span from January 1990 (`1990m1`) to December 2011 (`2011m12`). This overage is necessary to forecast in the ARIMA model. The default number of forecasts is 12; the allowed maximum number of forecasts is 24 for our data unless we extend the observations of `sprb`, `sprm`, and `spra`. It is evident that the magnitude of the seasonal fluctuations is proportional to the level. So we prefer to log-transform and use multiplicative-adjustment mode.

We include the trading day, leap year, and one AO outlier at May 2003 because of SARS in the regression. We let the program automatically detect all other outliers of type AO, LS, and TC; automatically select the optimal ARIMA model given maximum difference order of `(2 1)` and maximum ARMA lag of `(3 1)`; and automatically determine whether to transform the variable though we prefer the log-transformation. Also included are three variables denoting the Spring Festival moving holiday, `sprb`, `sprm`, and `spra`. The Spring Festival is the biggest holiday in China. We use the three-stage method to generate the three variables.[3]

3. The `genhol.exe` program of the U.S. Census Bureau is a special tool to generate the variables for a moving holiday. This program is freely available from http://www.census.gov/srd/www/genhol/.

Specification through the dialog box

In the **Main** tab of the *X-12-ARIMA Seasonal Adjustment* dialog box, select the variable `retail` for the type I seasonal adjustment.

In the **Regression** tab, select *trading day with leap year* in the *Predefined variables* group box. Choose `sprb`, `sprm`, and `spra` in the *User-defined variables* group box. Choose the *Types* with `holiday` because the three variables belong to the same type.

In the **Outlier** tab, click on *TC (temporary change)* so that all three types of outliers are automatically detected. In the *User-defined outliers* group box, input `ao2003.5` or `ao2003.may` in the field for *AO outliers*.

In the **ARIMA** tab, select *Automatic selection given maximum lag and difference*, and change the *Max lag of ARMA part* from `(2 1)` (the default case) to `(3 1)`.

In the **Others** tab, click on *Sliding span analysis* and *Revision history analysis*.

All other options remain unchanged. Press **OK** to execute the command. The command is as follows:

```
. sax12 retail, satype(single) transfunc(auto) regpre(const td)
> reguser(sprb sprm spra) regusertype(holiday) outao(ao2003.5)
> outauto(ao ls tc) outlsrun(0) ammaxlag(3 1) ammaxdiff(2 1) ammaxlead(12)
> x11seas(x11default) sliding history
```

The adjustment results are stored in the `retail.*` files with different extensions. The main output file, `retail.out`, will pop up in the Viewer window. We can check the adequacy and stability of the adjustment through the diagnostics table that will be illustrated in the second example.

Import the adjusted series and make graphs

Next we illustrate how to import data and make graphs through two examples: making a seasonal plot of the seasonal factor and making a spectrum plot of the irregular component. First, open the dialog box. Then select the X-12-ARIMA result `retail.out`, and replace the default suffix (`d10 d11 d12 d13`) with `d10`. Press **Submit** to import the seasonal factor as a new variable. The command is

```
. sax12im retail.out, ext(d10)
Variable(s) (retail_d10) imported
```

Then we clear the suffix and select *spectrum of irregular component (sp2)*. Next click on *import as matrix*. Press **OK** to import the data as a matrix with the name `retail_sp2`. The command is

```
. sax12im retail.out, ext(sp2) noftvar
```

You can view the matrix by typing the command `matlist retail_sp2`.

We use the cycleplot[4] command of Cox (2006) to make the seasonal plot of the seasonal factor, as shown in figure 13.

```
. gen year = year(dofm(mdate))
. gen month = month(dofm(mdate))
. cycleplot retail_d10 month year, summary(mean) lpattern(dash) xtitle("")
```

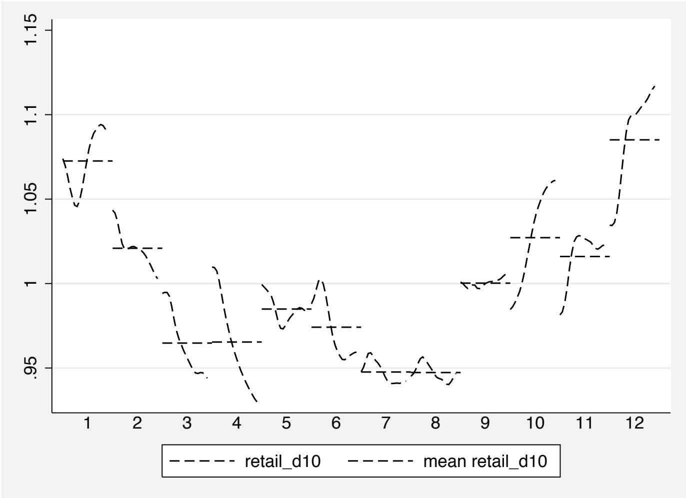

Figure 13. Seasonal factor plot by season

We use _matplot to make the spectrum plot of the irregular component. We add the vertical lines of two trading day peaks at (0.348, 0.432), and we add six seasonal peaks at $(1/12, 2/12, \ldots, 6/12)$. The command is as follows:

```
. _matplot retail_sp2, columns(3,2)
> xline(0.348 0.432, lpattern(dash) lcolor(brown) lwidth(thick))
> xline(0.08333 0.16667 0.25 0.33333 0.41667 0.5, lpattern (dash) lcolor(red)
> lwidth(medium)) connect(direct) msize(small) mlabp(0) mlabs(zero) ysize(3)
> xsize(5) ytitle("Density") xtitle("Frequency")
```

(output omitted)

7.2 Example: Adjustment for multiseries based on multispecification

We use the aggregate quarterly gross domestic product of China from the first quarter of 1992 (1992q1) to the fourth quarter of 2009 (2009q4) as an example to illustrate the multiseries adjustment.

4. You can download and install the package by typing the command ssc install cycleplot.

Generate a separate spc file for each series

There are nine component series, and for convenience, we create the input files for the nine components by using the same specifications. Assume the data are stored in the directory `d:\saq`.

```
. cd d:\saq
d:\saq
. use gdpcn, clear
(constant price based on 2005; unit: hundred million yuan)
. tsset
        time variable:  qdate, 1992q1 to 2009q4
                delta:  1 quarter
. foreach v of varlist agri - other {
  2.        sax12 `v´, satype(single) comptype(add) transfunc(auto)
> regpre(const) outauto(ao ls) outlsrun(2) ammaxlag(2 1) ammaxdiff(1 1)
> ammaxlead(12) x11seas(x11default) sliding history justspc noview
  3. }
```

Nine input files will be created: `agri.spc`, `const.spc`, `indus.spc`, `trans.spc`, `retail.spc`, `service.spc`, `finance.spc`, `house.spc`, and `other.spc`. Note that if you create the files through the *X-12-ARIMA Seasonal Adjustment* dialog box, do not forget to choose the *Composite type* on the **Main** tab.

Specification through the dialog box

Now we adjust the series based on the nine input files and we make composite adjustments. On the **Main** tab of the *X-12-ARIMA Seasonal Adjustment* dialog box, select *Multiple series using multiple specification files* and then select the nine input files in your directory. Click on *Composite adjustment* and *Direct seasonal adjustment for composite series* to make both direct and indirect adjustments for the aggregate series. Save the input file as `gdp.spc` by typing that into the field for *Spc file to save (mvms.spc if left blank)*, and save the metafile as `gdp.mta` by typing that into the field for *Mta file to save (mvms.mta if left blank)*.

Next we make specifications for direct adjustment of the composite series. In the **Prior** tab, select *quarterly* for the data frequency and select the *Log* transformation. In the **Regression** tab, select *leap year* in the *Predefined variables* group box. In the **Others** tab, click on *Sliding span analysis* and *Revision history analysis*.

All other options remain unchanged. Press **OK** to get the results. The command is as follows:

```
. sax12, satype(mta)
> mtaspc("agri const finance house indus other retail service trans")
> mtafile(gdp.mta) compsa inpref(gdp.spc) compsadir transfunc(log)
> regpre(const lpyear) outauto(ao ls) outlsrun(0) x11mode(mult)
> x11seas(x11default) sliding history
```

View the diagnostics table of multiple adjustments

We view the diagnostics table to check the adequacy of the model and the sufficiency of the adjustment or to compare the different adjustments. We illustrate the usage of the diagnostics table just through the composite series. Select the diagnostics files `gdp.udg`, and save the diagnostics table in the file `mydiag.txt`. The command and output are as follows:

```
. sax12diag gdp.udg using mydiag.txt
```

	gdp.udg	gdp.udg(ind)
General information:		
Series name	gdp	gdp
Frequency	4	4
Sample	1992.1-2009.4	1992.1-2009.4
Transformation	Log(y)	
Adjustment mode	multiplicative	indirect
Seasonal peak	rsd	indirr
Trading day peak	none	none
Peak of TD in adj	no	
Peak of Seas. in adj	no	
Peak of TD in res	t1	no
Peak of Seas. in res	s1	s1
Peak of TD in irr	no	no
Peak of Seas. in irr	no	s1
Peak of TD in ori	no	
Peak of Seas. in ori	s1	
X11:		
M1	0.046	0.006
M2	0.070	0.000
M3	0.000	0.000
M4	0.696	0.476
M5	0.512	0.200
M6	0.044	1.302
M7	0.155	0.085
M8	0.248	0.226
M9	0.203	0.180
M10	0.207	0.211
M11	0.207	0.211
Q	0.20	0.25
Q without M2	0.22	0.28
Seasonality F test(%)	193.587 0.00	1366.726 0.00
Seasonality KW test(%)	61.386 0.00	63.945 0.00
Moving seas. test(%)	0.773 71.38	4.228 0.00
regARIMA model:		
Model span	1992.1-2009.4	
Model	(0 0 0)	
Num. of regressors	5	
Num. of sig. AC	2	
Num. of sig. PAC	2	
Normal	0.8140	
Skewness	0.1494	
Kurtosis	2.4021	
AICC	1461.3847	

```
Outliers:                    |
  Outlier span               | 1992.1-2009.4
  Total outliers             | 3
  Auto detected outliers     | 3
  AO critical                | 3.732 *
  LS critical                | 3.732 *
  TC critical                |
  Outliers:                  | LS1995.4(7.73)
                             | LS2001.4(7.16)
                             | LS2005.4(7.17)
-----------------------------+------------------------
Stability analysis:          |
  Revision span              | 2007.1-2009.3
  Span num., length, start   | 4 32 1 1999
  unstable SF                | 8 36 22.222
  unstable MM change in SA   | 13 35 37.143
  unstable YY change in SA   | 2 32 6.250
  Ave. abs. perc. rev.       | 4.255275
-----------------------------+------------------------
 Description of the diagnostics
```

The tables contain the diagnostics information of the composite series for both the direct and the indirect adjustments.

We import the adjusted series by using `sax12im` command described above. For example, the following command imports the seasonal factor, the seasonally adjusted series, the irregular series, and the trend cycle series of both the direct and the indirect seasonal adjustment.

```
. sax12im gdp.out, ext(d10 d11 d12 d13 isf isa itn iir)
Variable(s) (gdp_d10 gdp_d11 gdp_d12 gdp_d13 gdp_isf gdp_isa gdp_itn gdp_iir)
> imported
```

More than 200 files are generated in this example. The following command deletes all the files except those with extensions `d10`, `d11`, `d12`, `d13`, and `spc`.

```
. foreach s in "agri const finance house indus other retail service trans gdp" {
  2.          sax12del `s´, keep(d10 d11 d12 d13 spc)
  3. }
. dir gdp.*
   2.2k   1/06/12  0:38  gdp.d10
   2.2k   1/06/12  0:38  gdp.d11
   2.2k   1/06/12  0:38  gdp.d12
   2.2k   1/06/12  0:38  gdp.d13
   0.7k   1/06/12  0:38  gdp.spc
```

8 Conclusion

The X-12-ARIMA software of the U.S. Census Bureau is one of the most popular methods for seasonal adjustment, and the program `x12a.exe` is widely used around the world. In this article, we illustrated the menu-driven X-12-ARIMA seasonal-adjustment method in Stata. Specifically, the main utilities include how to specify the input file and run the program and how to import the adjusted results into Stata as variables or matrices. Because of the strong graphics utilities in Stata, the special tools for producing graphs, like Win X-12, are not provided in our article. This may be an extension in the future based on our work.

9 Acknowledgments

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