

# PROGRAMS TRAMO AND SEATS

INSTRUCTIONS FOR THE USER  
(BETA VERSION: SEPTEMBER 1996)

Víctor Gómez and Agustín Maravall

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(\*) Time Series Regression with ARIMA Noise, Missing Observations, and Outliers.

(\*\*) Signal Extraction in ARIMA Time Series.

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# 1 Program TRAMO

## 1.1 Brief Description of the Program

TRAMO ("Time Series Regression with ARIMA Noise, Missing Observations, and Outliers") is a program written in Fortran for mainframes and PCs under MS-DOS. The program performs estimation, forecasting, and interpolation of regression models with missing observations and ARIMA errors, in the presence of possibly several types of outliers. The ARIMA model can be identified automatically. (No restriction is imposed on the location of the missing observations in the series.)

Given the vector of observations:

$$z = (z_{t_1}, \dots, z_{t_M}) \quad (1)$$

where  $0 < t_1 < \dots < t_M$ , the program fits the regression model

$$z_t = y_t' \beta + \nu_t, \quad (2)$$

where  $\beta = (\beta_1, \dots, \beta_n)'$  is a vector of regression coefficients,  $y_t' = (y_{1t}, \dots, y_{nt})$  denotes  $n$  regression variables, and  $\nu_t$  follows the general ARIMA process

$$\phi(B) \delta(B) \nu_t = \theta(B) a_t, \quad (3)$$

where  $B$  is the backshift operator;  $\phi(B)$ ,  $\delta(B)$ , and  $\theta(B)$  are finite polynomials in  $B$ , and  $a_t$  is assumed a n.i.i.d.  $(0, \sigma_a^2)$  white-noise innovation.

The polynomial  $\delta(B)$  contains the unit roots associated with differencing (regular and seasonal),  $\phi(B)$  is the polynomial with the stationary autoregressive roots (and the complex unit roots, if present), and  $\theta(B)$  denotes the (invertible) moving average polynomial. In TRAMO, they assume the following multiplicative form:

$$\begin{aligned} \delta(B) &= (1 - B)^d (1 - B^s)^D \\ \phi(B) &= (1 + \phi_1 B + \dots + \phi_p B^p) (1 + \Phi_1 B^s + \dots + \Phi_P B^{s+P}) \\ \theta(B) &= (1 + \theta_1 B + \dots + \theta_q B^q) (1 + \Theta_1 B^s + \dots + \Theta_Q B^{s+Q}), \end{aligned}$$

where  $s$  denotes the number of observations per year. The model may contain a constant  $\mu$ , equal to the mean of the differenced series  $\delta(B)z_t$ . In practice, this parameter is estimated as one of the regression parameters in (2).

As explained in Section 1.3, initial estimates of the parameters can be input by the user, set to the default values, or computed by the program.

The regression variables can be input by the user (such as economic variables thought to be related with  $z_t$ ), or generated by the program. The variables that can be generated are trading day, easter effect and intervention variables of the type:

- a) dummy variables (additive outliers);
- b) any possible sequence of ones and zeros;
- c)  $1/(1 - \delta B)$  of any sequence of ones and zeros, where  $0 < \delta \leq 1$ ;
- d)  $1/(1 - \delta_s B^s)$  of any sequence of ones and zeros, where  $0 < \delta_s \leq 1$ ;
- e)  $1/(1 - B)(1 - B^s)$  of any sequence of ones and zeros.

The program:

- 1) estimates by exact maximum likelihood (or unconditional/conditional least squares) the parameters in (2) and (3);
- 2) detects and corrects for several types of outliers;
- 3) computes optimal forecasts for the series, together with their MSE;
- 4) yields optimal interpolators of the missing observations and their associated MSE; and
- 5) contains an option for automatic model identification and automatic outlier treatment.

The basic methodology followed is described in Gómez and Maravall (1994). Additional documentation is contained in Gómez and Maravall (1992), Gómez (1994) and Gómez, Maravall and Peña (1996).

Estimation of the regression parameters (including intervention variables and outliers, and the missing observations among the initial values of the series), plus the ARIMÁ model parameters, can be made by concentrating the former out of the likelihood, or by joint estimation. Several algorithms are available for computing the likelihood or more precisely, the nonlinear sum of squares to be minimized. When the differenced series can be used, the algorithm of Morf, Sidhu and Kailath (1974), with a simplification similar to that of Mélard, (1984), is employed. This simplification extends to multiplicative seasonal moving average models, a case discussed, but not implemented, in Mélard.

For the nondifferenced series, it is possible to use the ordinary Kalman filter (default option), or its square root version (see Anderson and Moore, 1979). The latter is adequate when numerical difficulties arise; however it is markedly slower.

By default, the exact maximum likelihood method is employed, and the unconditional and conditional least squares methods are available as options. Nonlinear maximization of the likelihood function and computation of the parameter estimates standard errors is made using Marquardt's method and first numerical derivatives.

Estimation of regression parameters is made by using first the Cholesky decomposition of the inverse error covariance matrix to transform the regression equation (the Kalman filter provides an efficient algorithm to compute the variables in this transformed regression). Then, the resulting least squares problem is solved by applying the *QR* algorithm, where the Householder orthogonal transformation is used. This procedure yields an efficient and numerically stable method to compute GLS estimators of the regression parameters, which avoids matrix inversion.

For forecasting, the ordinary Kalman filter or the square root filter options are available. These algorithms are applied to the original series; see Gómez and Maravall (1993) for a more detailed discussion on how to build initial conditions on a nonstationary situation.

Missing observations can be handled in two equivalent ways. The first one is an extension to nonstationary models of the skipping approach of Jones (1980), and is described in Gómez and Maravall (1994). In this case, interpolation of missing values is made by a simplified Fixed Point Smoother, and yields identical results to Kohn and Ansley (1986). The second one consists of assigning a tentative value and specifying an additive outlier to each missing observation. If this option is used, the interpolator is the difference between the tentative value and the estimated regression parameter and, if the ARIMA parameters are the same, it coincides with the interpolator obtained with the skipping approach. Also, the likelihood can be corrected so that it coincides with that of the skipping approach. See Gómez, Maravall and Peña (1996) for more details.

When concentrating the regression parameters out of the likelihood, mean squared errors of the forecasts and interpolations are obtained following the approach of Kohn and Ansley (1985).

When some of the initial missing values are unestimable (free parameters), the program detects them, and flags the forecasts or interpolations that depend on these free parameters. The user can then assign arbitrary values (typically, very large or very small) to the free parameters and rerun the program. Proceeding in this way, all parameters of the ARIMA model can be estimated because the function to minimize does not depend on the free parameters. Moreover, it will be evident which forecasts and interpolations are affected by these arbitrary values because they will strongly deviate from the rest of the estimates. However, if all unknown parameters are jointly estimated, the program may not flag all free parameters. It may happen that there is convergence to a valid arbitrary set of solutions (i.e., that some linear combinations of the initial missing observations, including the free parameters, are estimable.)

The program has a facility for detecting outliers and for removing their effect; the outliers can be entered by the user or they can be automatically

detected by the program, using an original approach based on those of Tsay (1986) and Chen and Liu (1993). The outliers are detected one by one, as proposed by Tsay (1986), and multiple regressions are used, as in Chen and Liu (1993), to detect spurious outliers. The procedure used to incorporate or reject outliers is similar to the stepwise regression procedure for selecting the “best” regression equation. This results in a more robust procedure than that of Chen and Liu (1993), which uses “backward elimination” and may therefore detect too many outliers in the first step of the procedure.

In brief, regression parameters are initialized by OLS and the ARMA model parameters are first estimated with two regressions, as in Hannan and Rissanen (1982). Next, the Kalman filter and the QR algorithm provide new regression parameter estimates and regression residuals. For each observation,  $t$ -tests are computed for four types of outliers, as in Chen and Liu (1993). If there are outliers whose absolute  $t$ -values are greater than a pre-selected critical level  $C$ , the one with the greatest absolute  $t$ -value is selected. Otherwise, the series is free from outlier effects and the algorithm stops.

If some outlier has been detected, the series is corrected by its effect and the ARMA model parameters are first re-estimated. Then, a multiple regression is performed using the Kalman filter and the QR algorithm. If there are some outliers whose absolute  $t$ -values are below the critical level  $C$ , the one with the lowest absolute  $t$ -value is removed from the regression and the multiple regression is re-estimated. In the next step, using the regression residuals provided by the last multiple regression,  $t$ -tests are computed for the four types of outliers and for each observation. If there are outliers whose absolute  $t$ -values are greater than the critical level  $C$ , the one with the greatest absolute  $t$ -value is selected and the algorithm goes on to the estimation of the ARMA model parameters to iterate. Otherwise, the algorithm stops.

A notable feature of this algorithm is that all calculations are based on linear regression techniques, which reduces computational time. The four types of outliers considered are additive outlier, innovational outlier, level shift, and transitory change.

The program also contains a facility to pretest for the log-level specification (based on a trimmed range-mean regression, complemented with the BIC of the default model using both specifications) and, if appropriate, for the possible presence of Trading Day and Easter effects (the pretests are made with regressions using the default model for the noise and, if the model is subsequently changed, the test is redone); it further performs an automatic model identification of the ARIMA model. This is done in two steps. The first one yields the nonstationary polynomial  $\delta(B)$  of model (3). This is done by iterating on a sequence of AR and ARMA(1, 1) models (with mean), which have a multiplicative structure when the data is seasonal. The procedure is based on results of

Tiao and Tsay (1983, Theor. 3.2 and 4.1), and Tsay (1984, Corol. 2.1). Regular and seasonal differences are obtained, up to a maximum order of  $\nabla^2 \nabla_s$ . The program also checks for possible complex unit roots at nonzero and nonseasonal frequencies.

The second step identifies an ARMA model for the stationary series (corrected for outliers and regression-type effects) following the Hannan–Rissanen procedure, with an improvement which consists of using the Kalman filter instead of zeros to calculate the first residuals in the computation of the estimator of the variance of the innovations of model (3). For the general multiplicative model

$$\phi_p(B) \Phi_P(B^s) x_t = \theta_q(B) \Theta_Q(B^s) a_t,$$

the search is made over the range  $0 \leq (p, q) \leq 3$ ,  $0 \leq (P, Q) \leq 2$ . This is done sequentially (for fixed regular polynomials, the seasonal ones are obtained, and viceversa), and the final orders of the polynomials are chosen according to the BIC criterion, with some possible constraints aimed at increasing parsimony and favoring “balanced” models (similar AR and MA orders).

Finally, the program combines the facilities for automatic detection and correction of outliers and automatic ARIMA model identification just described in an efficient way, so that it has an option for automatic model identification of a nonstationary series in the presence of outliers.

Although TRAMO can obviously be used by itself, for example, as a forecasting program, it can also be seen as a program that polishes a contaminated “ARIMA series”. That is, for a given time series, it interpolates the missing observations, identifies outliers and removes their effect, estimates Trading Day and Easter Effect, etc., and eventually produces a linear purely stochastic process (i.e., the ARIMA model). Thus, TRAMO, can be used as a pre-adjustment process to SEATS (see below), which decomposes then the “linearized series” and its forecasts into its stochastic components.

Both programs can handle routine applications to a large number of series and provide a complete model-based solution to the problems of forecasting, interpolation and signal extraction for nonstationary time series.

## **1.2 Instructions for the User**

This Section is common to both programs, TRAMO and SEATS.

### **1.2.1 Hardware Requirements**

The present versions of SEATS and TRAMO are compiled with the Microway NDP Fortran486 - Ver. 4.2.5 and Microsoft Fortran77 Ver. 5.0, linked with the Microway 486 Linker Ver. 4.2.5 and Microsoft Fortran77 Linker Ver. 5.0.

The present releases break the 640K barrier by utilizing the full 32-bit addressing mode available on 80486 machines; they can run only on 80486-based computers (also PENTIUM) that have at least 4 MB of extended memory.

Executing SEATS and TRAMO requires the following hardware:

- an Intel 80486 or PENTIUM-based IBM-compatible PC;
- a 3.5" diskette drive;
- a hard disk with about 4 MB of free space;
- at least 4 MB of extended memory;
- MS-DOS V3.3 or greater;
- a video graphics adapter VGA, EGA, CGA (color video is recommended).

Note 1: When the execution of TRAMO or SEATS finds an NDP error, the file containing the error is stored in the file *report.bug*, and the program proceeds.

Note 2: At present, the two programs are compiled for a **maximum number of 600 observations** per series (this limit can be easily modified).

### **1.2.2 Expanded Memory Manager Vs. Microway Kernel**

SEATS and TRAMO are linked with the Microway Dos Extender Kernel (MK). It is an extended memory manager and makes the programs able to access the high memory addresses. The MK is compatible with expanded memory managers (EMM) like CEMM (Version 4.0 or better), EMM386 (Version 4.0 or better) or QEMM ( Version 4.1 or better). All these programs adhere to an interface standard called VCPI (Virtual Control Program Interface) to which MK also adheres. If you are running EMM, the primary control program (the EMM) provides the secondary control program (MK) with a set of services, and the two programs coexist sharing the machine's resources.

The MK is not compatible with the EMM only if you have in your CONFIG.SYS a line like this:

DEVICE = C : \DOS\EMM386.EXE NOEMS (4)

It means you are using an EMM only to address the upper memory area (where you are storing various Dos drivers) in order to increment the quantity of the total conventional memory available (usually the Dos MemMaker proposes this kind of configuration). In this case the EMM is not running in VCPI mode so the MK is not able to talk with it. If you are in this kind of situation, you can run SEATS and TRAMO only if you delete the option NOEMS in (4) (you pay for this with something like 64 Kb of conventional memory). Otherwise, you can create a double configuration config.sys: the first is your normal one and the other is a special one for SEATS and TRAMO. In order to do it, put in your config.sys:

```
[MENU]
MENUITEM=SEATS
MENUITEM=NORMAL
```

```
[SEATS]
your config.sys without the line where you define the EMM device
```

```
[NORMAL]
config.sys
```

#### **Example:**

##### **ORIGINAL CQCONFIG.SYS:**

```
DEVICE=C:\DOS\HIMEM.SYS
DEVICE=C:\DOS\EMM386.EXE NOEMS
FILES=35
DOS=HIGH
DEVICEHIGH=C:\DOS\SETVER.EXE
SHELL=C:\DOS\COMMAND.COM C:\DOS /P/E:2048
DEVICEHIGH=C:\DOS\ANSI.SYS
BREAK=ON
STACKS=9,512
```

##### **DUAL BOOT CONFIG.SYS:**

```
[MENU]
MENUITEM=SEATS
MENUITEM=NORMAL
[NORMAL]
DEVICE=C:\DOS\HIMEM.SYS
DEVICE=C:\DOS\EMM386.EXE NOEMS
```

```
FILES=35
DOS=HIGH
DEVICEHIGH=C:\DOS\SETVER.EXE
SHELL=C:\DOS\COMMAND.COM C:\DOS /P/E:2048
DEVICEHIGH=C:\DOS\ANSI.SYS
BREAK=ON
STACKS=9,512
[SEATS]
DEVICE=C:\DOS\HIMEM.SYS
FILES=35
DOS=HIGH
DEVICEHIGH=C:\DOS\SETVER.EXE
SHELL=C:\DOS\COMMAND.COM C:\DOS /P/E:2048
DEVICEHIGH=C:\DOS\ANSI.SYS
BREAK=ON
STACKS=9,512
```

With a config.sys like this, when you boot the machine you can select the NORMAL or the SEATS configuration.

### 1.2.3 Installation

Insert the diskette in drive A or B and change the default drive (type "A:" or "B:"); when the prompt appears, type **INSTALL**.

The installation procedure asks you for the name of directory in which TRAMO will be installed; by default the directory is TRAMO (in this case be sure it does not already exist).

Three subdirectories are created: SERIES, GRAPH and OUTPUT. The input files should be prepared in the SERIES subdirectory.

TRAMO uses two environment variables **SLIB** and **SERIES** to find the files needed to run. The variable SLIB is the path to look for the graphics library, the variable SERIES is the path to look for the series.

By default (if you install the program on C:\TRAMO) the values for these variables are SLIB = C:\TRAMO\LIB and SERIES = C:\TRAMO\SERIES, so no action is necessary.

If you specified a different directory for TRAMO, you must set them as needed; put in your AUTOEXEC.BAT the following two lines:

```
SET SLIB      =  path\LIB
SET SERIES   =  path\SERIES
```

where *path* is the full path name of the directory where the program is installed.

By following the same procedure, the program SEATS would be installed (by default) in C:\SEATS.

#### 1.2.4 Execution of the Program

Once in TRAMO type: **INPUT**

This is a very simple usable program to prepare the input file for the main program TRAMO. It shows a list of the available series (in the directory specified by variable SERIES) and, after you have selected one of them, it permits to set the values of the program parameters showing a list of all default values.

The program allows some simple facilities:

- “q” to exit;
- “h” to see default parameter values;
- “l” to list already set parameters.

Set the parameters typing them one by one according to the following syntax:

*parameter-name = parameter-value*

Once all (non-default) parameter values have been set, in the next line type “end”. This creates the file SERIE, containing the data and parameter values for the main program. Of course the file SERIE can be edited directly; this will typically be more convenient when minor changes are desired on an already existing SERIE file.

Having, thus, the SERIE file ready, to run the program type **TRAMO**. Alternatively, TRAMO can be run on a bat file by simply typing Tramo *filename*.

#### 1.2.5 Command-Line Options

For the two programs, some options can be directly entered in the command-line. These options are the following:

- s** (Silent-mode) no output is seen in the screen during execution.
- o *outpath*** Specifies the directory where the output file should be stored (when not used, the output file goes to the directory OUTPUT; see Section 2.4 of User Instructions).
- i *filename*** Specifies the name of the input file (when not used, the input file is always ‘series’; see Section 2.3).

- g graphpath** Specifies the directory where the files for the graphics should be stored. (In Dos this option should not be used because the graphics programs only look in the directory GRAPH.) In the case of SEATS, care should be taken that the subdirectories SERIES, ACF, SPECTRA, FILTERS, and FORECAST are present in the specified path.
- OF filename** Specifies the name of the output file. This file contains all the program output. Thus, even when ITER  $\neq 0$ , the two programs contain a single output file each, with all the results for the processed series. The name of this file is '*filename.out*'.

With this option, the files with extension .tre, .sa, .cyc in SEATS, or .ser, .lin in TRAMO, disappear and instead a single file, '*filename.cmp*' is created. Its structure will be

```

    :      :      :
seriename
TREND   SA SERIES CYCLE
xxxx    xxxx    xxx
---     ---     ---
xxxx    xxxx    xxx
seriename
TREND   SA SERIES CYCLE
xxxx    xxxx    xxx
---     ---     ---
xxxx    xxxx    xxx
    :      :      :

```

and similarly for TRAMO.

For TRAMO, the following command permits the rename of the file *seats.itr* (see Section 1.6).

- k filename** Specifies the name assigned to the file *seats.itr*. (In the examples below it is passed to SEATS as *serie*).

Examples: C:\> SEATS -s -i alp -o C:\temp -OF alpout  
C:\> TRAMO -k C:\SEATS\serie

Warning: Options are case sensitive!

### 1.2.6 Output File

You can see the result of the program by editing or printing the file *seriesname.OUT* in the subdirectory OUTPUT.

As mentioned earlier, several arrays are stored in the subdirectory GRAPH, from which they can be easily retrieved. A table describing the meaning of each array is contained in Subsection 1.6.

### 1.2.7 Graphics

Typing **GRAPH** you can see some graphics on the screen. The program selects the better graphics resolution for you (if you have any graphics adapter). Running the program, files are created in the subdirectory GRAPH, containing all relevant output arrays (used by the GRAPH program), from which they can be retrieved for further use in packages such as SAS, MATLAB and GAUSS or for further numerical analysis. This version also supports direct laser-jet prints of the graphics produced. Typing the command "egalaser" from the prompt (before calling GRAPH), and calling GRAPH with the option "-P", the file GRAPH.LHJ is created which can then be printed.

Different graphs (such as the original, outlier corrected, and linearized series, for example) can be compared through an OVERLAY facility. Further, graphs from different runs of TRAMO can be simultaneously plotted. When exiting GRAPH (after its execution), you will be asked if you wish a backup copy of the graphics. By typing Y, the graphs are copied in the directory GRAPH, in the files *seriesname.bk1*, and *seriesname.n1*. (If a backup was previously made, then the files become *.bk2* and *.n2*.) In the next execution of GRAPH, you will have the option of comparing the new and old graphics (by typing 77). The maximum number of models that can be compared is 3.

Warning: The files *seriesname.bk1* and *seriesname.n1* are not automatically erased at the next execution of TRAMO. By typing (from \TRAMO)

CLEAN,

all previous backups will be erased from the directory GRAPH.

### 1.2.8 Printing TRAMO User's Manual

In the directory MANUAL you can find the file EXTMAN.EXE, a self-extracting compressed file. It contains a POSTSCRIPT copy of the TRAMO and SEATS user manual.

In order to print it, type EXTMAN from the DOS prompt; this command produces a file MANUAL.PS, and then you can print it in your POSTSCRIPT printer.

### **1.2.9 Downloading TRAMO Using FTP Anonymous**

The PC MS-DOS programs SEATS and TRAMO are now available to anyone, on the INTERNET, without requiring a login and password. The following is one way to download the programs from Datacomm.iue.it:

Step 1: FTP 149.139.6.101 using login name as ‘anonymous’, password as your E-mail address. Go to the directory ‘seats-tramo’. This directory contains three files:

- extseats.exe (SEATS self-extracting compressed program)
- exttramo.exe (TRAMO self-extracting compressed program)
- readme (these instructions).

Step 2: Change the transfer type to binary in order to upload binary compressed files and retrieve the three files.

Step 3: Transfer the files on your PC.

Step 4: When on your PC, in order to install the programs, type (from Dos prompt): “EXTSEATS -d” and “EXTTRAMO -d”; the two programs will be installed in the directory SEATS and TRAMO, respectively.

## 1.3 Description of the Input Parameters

### 1.3.1 Control of the Output File

In TRAMO and SEATS, the output file is controlled with the following parameter:

<u>Parameter</u>	<u>Meaning</u>	<u>Default</u>
<i>OUT</i>	= 0 Detailed output file for each series = 1 Reduced output file for each series = 2 Very brief summary for all series in one file (TRAMO); in one file per series (SEATS) = 3 No output file = -1 As <i>OUT</i> = 0, but also the details for the automatic model identification are given in each file (only TRAMO) = -2 As <i>OUT</i> = 0, but also a very brief summary for all series is given in a separate file (only TRAMO)	0

In the case of  $OUT = \pm 2$ , the very brief summary from TRAMO can be seen in the file *table.out*, in the OUTPUT directory.

When the two programs are used together, *OUT* is entered in TRAMO, and passed on to SEATS through the file *seats.itr*.

### 1.3.2 ARIMA Model

<i>MQ</i>	= Number of observations per year (12 for monthly, 6 for bimonthly, 4 for quarterly, 1 for annual, and so on).	12
<i>LAM</i>	= 1 No transformation of data = 0 Take logs of data	0
<i>IMEAN</i>	= 0 No mean correction = 1 Mean correction	1
<i>D</i>	= # of non-seasonal differences	1
<i>BD</i>	= # of seasonal differences	1
<i>P</i>	= # of non-seasonal autoregressive terms	0
<i>BP</i>	= # of seasonal autoregressive terms	0
<i>Q</i>	= # of non-seasonal moving average terms	1

<u>Parameter</u>	<u>Meaning</u>	<u>Default</u>
$BQ$	= # of seasonal moving average terms	1
$TH$	= $Q$ initial estimates of the regular moving average parameters (not input if $INIT=0$ and $JQR(I)=0$ for all $I$ ).	All -.1
$BTH$	= $BQ$ initial estimates of the seasonal moving average parameters (not input if $INIT=0$ and $JQS(I)=0$ for all $I$ ).	All -.1
$PHI$	= $P$ initial estimates of the regular autoregressive parameters (not input if $INIT=0$ and $JPR(I)=0$ for all $I$ ).	All -.1
$BPHI$	= $BP$ initial estimates of the seasonal autoregressive parameters (not input if $INIT=0$ and $JPS(I)=0$ for all $I$ ).	All -.1
$JPR(I)$	= 1 Parameter number I in the regular autoregressive polynomial fixed to the value set in $PHI(I)$ (it is not estimated). = 0 Parameter not fixed.	0
$JPS(I)$	= 1 Parameter number I in the seasonal autoregressive polynomial fixed to the value set in $BPHI(I)$ (it is not estimated). = 0 Parameter not fixed.	0
$JQR(I)$	= 1 Parameter number I in the regular moving average polynomial fixed to the value set in $TH(I)$ (it is not estimated). = 0 Parameter not fixed.	0
$JQS(I)$	= 1 Parameter number I in the seasonal moving average polynomial fixed to the value set in $BTH(I)$ (it is not estimated). = 0 Parameter not fixed.	0

### 1.3.3 Minimum Number of Observations

The minimum number of observations depends on  $MQ$ , on the particular model, and on the options requested. By default, if  $m$  denotes the minimum number of observations,

- for  $MQ \geq 12$ ,  $m = 36$
- for  $MQ < 12$ ,  $m = \max(12, 4 \times MQ)$ .

If the number of observations satisfies these minima, but is not enough for some additional option requested, the option is removed and its default value reset.

### 1.3.4 Pretest for the log vs. level specification

The program can pretest for the level-versus-log specification. This is controlled as follows:

<u>Parameter</u>	<u>Meaning</u>	<u>Default</u>
<i>LAM</i>	= 0 As before (logs).	0
	= 1 As before (levels).	
	= -1 The program tests for the log-level specification.	

The test is based, first, on the slope ( $b$ ) of a range-mean regression, “trimmed” to avoid outlier distortion. This slope  $b$  is compared to a constant ( $\beta$ ), close to zero, that depends on the number of observations and on the value of  $RSA$ . When the results of the regression are unclear, the value of  $LAM$  is chosen according to the  $BIC$  of the default model, using both specifications.

Note 1: The value  $LAM = -1$  is recommended for automatic modelling of many series.

Note 2: The value  $\beta$  increases when  $RSA > 0$ , so as to favor the choice of the log transformation when a large number of series are routinely adjusted.

### 1.3.5 Automatic Model Identification

<i>INIC</i>	= 0	No automatic model identification is performed	0
	= 2	The program searches for regular polynomials up to order 2, and for seasonal polynomials up to order 1.	
	= 3	The program searches for regular polynomials up to order 3, and for seasonal polynomials up to order 1.	
	= 4	The program searches for regular polynomials up to order 3 and for seasonal polynomials up to order 2 (not input if $IDIF=0$ ).	
<i>IDIF</i>	= 0	No automatic model identification.	0
	= 1	Used for automatic model identification. The program searches for regular differences up to order 2 and for seasonal differences up to order 1 and then it stops. Used with $INIC>1$ .	
	= 2	Used for automatic model identification. The program accepts the regular ( $D$ ) and seasonal ( $BD$ ) differences entered by the user. Used with $INIC>1$ .	

<u>Parameter</u>	<u>Meaning</u>	<u>Default</u>
= 3	Same as with $IDIF=1$ , but the program does not stop. It continues with the identification of an ARMA model for the differenced series. Used with $INIC>1$ .	
= 4	Same as $IDIF=1$ , but the program also searches for unit complex roots	
= 5	Same as $IDIF=3$ , but the program also searches for unit complex roots.	

When TRAMO is run with  $SEATS \neq 0$ , if  $INIC = 4$ , it is automatically changed to  $INIC = 3$ .

$UB1$	= If one of the roots in the “ $AR(2) \times AR_s(1)$ plus mean” estimation in the first step of the automatic identification of the differencing polynomial is larger than $UB1$ , in modulus, it is set equal to unity.	.96
$UB2$	= If one of the roots in the “ $ARMA(1,1) \times ARMA_s(1,1)$ plus mean” estimation in the second step of the automatic model identification is larger than $UB2$ , in modulus, it is set equal to unity.	.88
$CANCEL$	= If the difference in moduli of an AR and an MA root (when estimating $ARMA(1,1) \times ARMA_s(1,1)$ models in the second step of the automatic identification of the differencing polynomial) is smaller than $CANCEL$ , the two roots cancel out.	.10
$IMVX$	= See Section 1.3.9 (“Outliers”).	
$PCR$	= $\alpha$ Level of significance for the Ljung-Box Q-test used in automatic model identification.	.95
$IFAL$	= 0 Normal Procedure = 1 If, in the first round the default model passes the test, the model is accepted and the search stops.	0

For automatic identification of a model, there are two steps: First, the program identifies the degrees of differencing ( $IDIF=1,2,3,4,5$ ) and later, the program identifies an ARMA model for the differenced series ( $INIC=2,3,4$ ). If  $IDIF=1$ , then the program stops after obtaining the degrees of differencing. If  $IDIF=2$ , the program accepts the degrees of differencing entered by the user ( $D$  and  $BD$ ), together with the mean specification, and goes on to obtain the ARMA model identification ( $INIC=2,3,4$ ). If  $INIC=3$ , the program obtains the degrees of

differencing and goes on to obtain the ARMA model identification (*INIC*=2,3,4). *IDIF*=4 and 5 are as *IDIF*=1 and 3, respectively, but the program also checks for the presence of unit complex roots. With *IDIF*=1,3,4,5, the program generates mean correction if needed, so *IMEAN* should be input as 0. When the series is thought to contain many outliers, the use of *IMVX*=2 is recommended.

### 1.3.6 Estimation

<u>Parameter</u>	<u>Meaning</u>	<u>Default</u>
<i>INCON</i>	= 0 Exact maximum likelihood estimation = 1 Unconditional least squares (only to use with <i>IFILT</i> =1,2 or 3).	0
<i>INIT</i>	= 0 Estimation of unknown parameters and starting values computed by the program = 1 Estimation of unknown parameters with starting values input by the user = 2 No estimation.	0
<i>IFILT</i>	= 1 Square root filter = 2 Morf, Sidhu and Kailath algorithm, as improved by Mélard = 3 Ordinary Kalman filter = 4 Conditional least squares.	2
<i>IDENSC</i>	= 1 Denominator of residual sum of squares is that of Ansley and Newbold (1981) = number of non-initial observations minus number of unknown parameters (AR and MA parameters plus regression parameters, including outliers and initial missing observations) = 0 Denominator of residual sum of squares is equal to the number of non-initial observations.	1
<i>TOL</i>	= Convergence criterion in Gauss-Marquardt's method.	1.E-4
<i>ICONCE</i>	= 1 $\sigma^2$ and regression parameters (including outliers and missing initial observations) concentrated out of the likelihood = 0 Only $\sigma^2$ concentrated out of the likelihood.	1
<i>UBP</i>	= If an AR root found in the estimation of the ARMA model parameters is larger than <i>UBP</i> , it is set equal to one.	.97

<u>Parameter</u>	<u>Meaning</u>	<u>Default</u>
<i>M</i>	= # of autocorrelations and partial autocorrelations printed.	36
<i>IQM</i>	= # of autocorrelations used in computing <i>Q</i> -statistics.	24*
<i>IROOT</i>	= 1 Roots of all AR and MA polynomials are computed = 0 Roots not given = 2 Roots of all AR and MA polynomials are computed, and the former are set automatically as unit roots if their modulus is larger than <i>UBP</i> .	2
<i>IGRBAR</i>	= 1 Graph of autocorrelations.printed. = 0 Graph of autocorrelations not printed.	0
<i>TSIG</i>	= <i>t</i> -value under which the mean or the ARIMA parameters should be excluded from the model in the last step of the automatic model identification in TRAMO.	1

(\*) The default value of *IQM* depends on *MQ*. For *MQ* = 12, *IQM* = 24; for *MQ* = 2, 3, 4, 6, *IQM* = 4 × *MQ*; for *MQ* = 1, *IQM* = 8.

### 1.3.7 Forecasting

<i>NBACK</i>	= > 0 # of observations back from the end of the data that the multistep forecasts are to begin. = < 0 When <i>NBACK</i> < 0, then (- <i>NBACK</i> ) observations are omitted from the end of the series. The model is estimated for the shorter series, one-period-ahead forecast errors are sequentially computed for the last (- <i>NBACK</i> ) periods (without reestimation of the model), and an <i>F</i> -test is performed that compares the out-of-sample forecast errors with the in-sample residuals. The forecast function is printed, as well as the one-period-ahead forecasts, together with the associated forecast errors.	0 0
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When *SEATS* ≠ 0, the program automatically sets *NBACK* = 0. When *SEATS* = 0 and *NBACK* ≠ 0, the program sets *NPRED* = ABS(*NBACK*).

<i>NPRED</i>	= # of multistep forecast values to compute.	0 if <i>SEATS</i> =0; max(8,2× <i>MQ</i> ) if <i>SEATS</i> ≠ 0.
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When  $NPRED = 0$ , if  $SEATS \neq 0$ , the forecasts of the series, as well as their standard errors, are computed and printed, up to the  $TF$ -step-ahead forecast ( $TF = \max(8, 2 \times MQ)$ ).

<u>Parameter</u>	<u>Meaning</u>	<u>Default</u>
$LOGN$	= 0    Levels are obtained as exponents of the logs. = 1    Levels and Standard errors are obtained through the Lognormal distribution (only for LAM= 0).	1

Note 1: The forecast when  $LOGN = 1$  is larger than the forecast for  $LOGN = 0$ , and the difference will increase with the forecast horizon.

Note 2: At present, when  $SEATS \neq 0$ ,  $LOGN$  is set = 0.

### 1.3.8 Missing Observations

$INTERP$	= 0	No interpolation of unobserved values and missing observations treated using the skipping approach	1
	= 1	Interpolation of unobserved values and missing observations treated using the skipping approach	
	= 2	Missing observations are treated as additive outliers (initial values are constructed as the sum of the two adjacent observations; interpolation is always performed).	
$ICDET$	= 1	A proper correction is made in the determinantal term of the likelihood when missing observations are treated as additive outliers	1
	= 0	No correction is made in the determinantal term.	

Missing observations can be treated in two ways: Skipping approach ( $INTERP=0,1$ ) and additive outliers approach ( $INTERP=2$ ). If  $ICDET=1$  and  $INTERP=2$ , the determinantal term in the function to be minimized is adjusted so that it coincides with that of the function used in the skipping approach. When the model is identified with the automatic option, missing observations are estimated with the additive outlier approach ( $INTERP=2$ ).

### 1.3.9 Outliers

<u>Parameter</u>	<u>Meaning</u>	<u>Default</u>
<i>VA</i>	= If <i>IATIP</i> =1, it is used to set the critical value for outlier detection (not input if <i>IATIP</i> =0).	4.0
<i>IATIP</i>	= 1    Automatic detection and correction of four types of outliers ( <i>IO</i> , <i>AO</i> , <i>LS</i> , <i>TC</i> ) is performed. If <i>IMVX</i> =0, the fast method of Hannan–Rissanen is used for estimation of parameters. If <i>IMVX</i> =1,3 (see below), then maximum likelihood estimation is used.  After correcting for the outliers found in the first round, the program performs a new automatic model identification, and a new search for outliers if the model has been changed. In this second round, the critical value <i>VA</i> is reduced by the fraction <i>PC</i> .  If the second round does not provide a satisfactory model, a third round is carried out. (The model obtained with automatic identification is always compared with the default model.)  = 0    No outlier detection is performed.	0
<i>IMVX</i>	= 0    The fast method of Hannan–Rissanen is used for parameter estimation in the automatic detection and correction of outliers (not input if <i>IATIP</i> =0)  = 1    Maximum likelihood estimation is used for parameter estimation in the automatic detection and correction of outliers (not input if <i>IATIP</i> =0)  = 2    First, unconditional least squares and then exact maximum likelihood is used in the estimation of the unit roots in the automatic model identification. If <i>IATIP</i> >0, then estimation of outliers is made with the Hannan–Rissanen procedure  = 3    As <i>IMVX</i> =2, but, if <i>IATIP</i> >0, outliers correction is made with the exact maximum likelihood procedure. This procedure, although relatively time consuming, may be of interest when the series contains many outliers.	0
<i>PC</i>	= Percentage by which <i>VA</i> is reduced in the second round when <i>IATIP</i> =1.	.14286
<i>DELTATC</i>	= $\delta$ $0 < \delta < 1$ It affects only the <i>TC</i> outlier, which is equal to an impulse divided by $(1 - \delta B)$ .	.7

<u>Parameter</u>		<u>Meaning</u>	<u>Default</u>
<i>ISTDV</i>	= 0	The residual variance used in automatic outlier detection is obtained through the MAD estimator.	0
	= 1	The residual variance used in automatic outlier detection is obtained through the leave-one-out trimmed estimator.	
<i>AIO</i>	= 0	The program corrects for the four types of outliers described below.	2
	= 1	All outliers are treated as additive outliers or transitory changes (in this way the level of the series is preserved).	
	= 2	Additive Outliers, Transitory Changes, and Level Shifts are considered (Innovations Outliers are not included).	
	= 3	Only Level Shifts and Additive Outliers are considered.	

When TRAMO is run with  $SEATS \neq 0$ ,  $AIO = 1$  or  $2$  is now the standard option. When  $SEATS \neq 0$ , if  $AIO = 0$ , it is automatically set equal to  $2$ . Transitory Changes and Additive Outliers will be assigned in  $SEATS$  to the irregular component, and Level Shifts to the trend.

Two parameters,  $INT1$  and  $INT2$ , can be used to define the interval  $(INT1, INT2)$  over which outliers have to be searched. By default

$$INT1 = 1; \quad INT2 = NZ.$$

A facility has been introduced to **avoid outlier correction in the last observations of the series**, which may cause instability in the series forecasts. In particular:

When  $INT2 < 0$ , outliers are automatically detected and corrected in the interval  $(INT1, -INT2)$ . Then, the detection procedure is applied to the last  $NZ + INT2$  observations, and if some outlier is detected a warning is printed, but no correction is made. Example: if  $NZ = 200$  and  $INT2 = -194$ , outliers are detected and corrected for the interval  $(1, 194)$ . For the last 6 observations they are only detected.

Detection and correction of outliers is made with a procedure based on those of Tsay (1986) and Chen and Liu (1993). This procedure has some notable features (namely, exact residuals are used; estimation, based on two simple regressions, is fast; the parameter estimates are modified at each iteration; and it uses a robust method to incorporate or reject outliers which is similar to the stepwise regression procedure to select the “best” regression equation).

Four kinds of outliers can be identified and corrected by the program: innovational outliers (*IO*), additive outliers (*AO*), level shifts (*LS*) and temporary changes (*TC*). This last one being equal to an impulse divided by  $1-\delta B$ . If *IATIP*=1 and *INIC*=0, the program performs the identification and correction of the four kinds of outliers using the model entered by the user. Recommended critical values depend on the series length, and are given in Section 3.1.

If automatic outlier identification and correction (*IATIP*>0) is to be performed along with automatic model identification (*INIC*>2), the sequence of actions is as follows. After obtaining the degrees of differencing, either automatically (*IDIF*=3) or accepting those entered by the user (*IDIF*=2), if *IATIP*=1, the program obtains first a model using the BIC criterion and then performs the automatic identification and correction of outliers using the previously identified model. But if *IATIP*=2, there are two rounds: first, the program accepts the model entered by the user and corrects the series for the outlier effects. Then, it returns to model identification and further outlier identification and correction, using the model obtained in the second round and a critical level equal to  $(1-PC)$  times that of the first round.

Since innovational outliers (specially at the beginning of the series) may have very drastic effects on the level of the series, by default *AIO*=2, so that only level shifts are allowed to affect the trend. When the preservation of constraints between aggregates and components is an important consideration, the value *AIO* = 1 may be the most sensible choice.

### 1.3.10 Regression

The regression variables used to make the trading day or easter effect adjustment are generated by the program in the same way as that described in Hillmer, Bell, and Tiao (1983), or in Harvey (1989, p. 334). The aggregate trading day and Easter effects are normalized so as to preserve the mean level of the series.

#### a) Easter and Trading Day Effects

The program contains a **pretest for Easter and Trading Day effects**; this is done by running a regression on the default model. In automatic model identification, if the model is changed, both tests are then redone. (When these effects are to be estimated, if the starting year in the input file contains only the last two digits, the program adds 1900 to this number.)

The input parameters *IEAST* and *ITRAD* are as follows:

<u>Parameter</u>	<u>Meaning</u>	<u>Default</u>
<i>IEAST</i>	= 0 No Easter effect. = 1 Easter effect adjustment. = -1 The program pretests for Easter effect.	0
<i>IDUR</i>	= Duration of easter affecting period (# of days).	8
<i>ITRAD</i>	= 0 No Trading Day effect is estimated. = 1 # of (M, T, W, Th, F) - # (Sat, Sun) $\times \frac{5}{2}$ . = 2 As the previous case, but with length-of-month adjustment. = 6 # M - # Sun, # T - # Sun, ..., # Sat - # Sun. = 7 As the previous case, but with length-of-month correction. = -1 As <i>ITRAD</i> = 1, but a pretest is made. = -2 As <i>ITRAD</i> = 2, but a pretest is made. = -6 As <i>ITRAD</i> = 6, but a pretest is made. = -7 As <i>ITRAD</i> = 7, but a pretest is made.	0

Length-of-month correction = # (total days in month) - 365.25/12.

Two parameters, *INTD1* and *INTD2*, can be used to define the interval (*INTD1*, *INTD2*) over which the Trading Day effect is to be estimated. By default

$$INTD1 = 1; \quad INTD2 = NZ.$$

### b) Regression and Intervention Variables; Holiday Effect.

<i>IREG</i>	= # of regression variables (entered by the user or calculated by the program as intervention variables).	0
<i>RG</i>	= <i>IMEAN+IREG+ITRAD+IEAST</i> initial estimates of the regression parameters, not including initial missing observations (not input if there are not missing observations or <i>ICONCE</i> =1).	All 0.1

If *IREG* in namelist *INPUT* is greater than zero, then namelist *INPUT* should be followed by a certain number of namelist *REG*, to be specified below. Each namelist *REG* starts with \$*REG*, terminates with \$ and contains the set of instructions for the corresponding regression variable(s).

The total number of namelists *REG* is as follows: There must be as many namelists *REG* following namelist *INPUT* as there are regression variables not entered by the user, plus one namelist *REG* for each file containing regression variables entered by the user.

The parameters in namelist *REG* are:

<u>Parameter</u>	<u>Meaning</u>	<u>Default</u>
<i>IUSER</i>	= 1      The user will enter a series for this regression variable. After the present namelist <i>REG</i> , the user will write the series $X(I): I=1, ILONG$ (free format). After the series, next namelist <i>REG</i> should be written	0
	= -1     The program will read <i>NSER</i> series from the file whose name is written after the present namelist <i>REG</i> . There must be <i>NSER</i> columns of length <i>ILONG</i> in this file separated by blanks, containing the <i>NSER</i> series ( <i>NSER&gt;0</i> must be input)	
	= 0      The user does not provide any series	
	= 2      The user specifies the presence of some outliers. Then <i>NSER</i> is equal to the number of specified outliers, and is followed, in a new line, by a sequence of pairs of numbers (free format): $t_1 \ j_1 \ t_2 \ j_2 \dots t_{NSER} \ j_{NSER}$ where $t_1 \dots t_{NSER}$ denote the position of the outlier ( $t = 1, \dots, T$ ), and $j_1, \dots, j_{NSER}$ denote the type of outlier according to the following code:	
	$J_i$	= <i>IO</i> Innovation outlier = <i>AO</i> Additive outlier = <i>LS</i> Level shift = <i>TC</i> Temporary change.
	= -2	Holidays are incorporated in an external file.

The program contains a facility to incorporate in an external file **holidays** that do not fall on Sunday (when *ITRAD* = 6, 7, -6, -7), or on a Saturday or Sunday (when *ITRAD* = 1, 2, -1, -2). The input namelist should contain the parameter:

- a) when *ITRAD* = 6, 7, -6, -7,  
*IREG* = # of regression variables + 6,
- b) when *ITRAD* = 1, 2, -1, -2,  
*IREG* = # of regression variables + 1,

where # of regression variables includes those entered by the user and the ones generated by the program. Holidays are treated as non-working days. That is, for each month, the number of working days is decreased and the number of non-working days is increased by the amount of the holidays.

A namelist *REG* has to be added, with the parameter values:

*IUSER* = -2,

*NSER* = 6 or 1 and the value of *ILONG*. This namelist is followed by a line with the name of the file from which the holidays will be read.

<u>Parameter</u>	<u>Meaning</u>	<u>Default</u>
<i>NSER</i>	= <i>k</i> ( <i>k</i> a positive integer) number of series entered by the user in an external file (if <i>IUSER</i> =-1), or number of outliers specified by the user (if <i>IUSER</i> =2)	0
	= 0 No series entered by the user in any external file.	
<i>ILONG</i>	= Length of the series entered by the user if <i>IUSER</i> =1, -1, -2. If forecasts are to be computed, <i>ILONG</i> should be equal to <i>NZ</i> + <i>NPRED</i> , where <i>NZ</i> is the length of the series; if smaller, the rest of the series, up to a total length of <i>NZ</i> + <i>NPRED</i> is filled up with zeroes (not input if <i>IUSER</i> =0).	0
<i>ISEQ</i>	= <i>k</i> ( <i>k</i> = a positive integer). The program will generate one intervention variable of length <i>NZ</i> + <i>NPRED</i> consisting of <i>k</i> sequences of ones. After the present namelist <i>REG</i> , the user will write <i>k</i> pairs of numbers (free format); the <i>k</i> -th pair indicates the time index where the <i>k</i> -th sequence of ones is to begin and its length, respectively. The <i>k</i> pairs of numbers are to be followed by the next namelist <i>REG</i> (no input if <i>IUSER</i> =1,-1)	0
	= 0 The program will generate no regression variable.	
<i>DELTA</i>	= $\delta$ ( $0 < \delta \leq 1$ ); the filter $1/(1 - \delta B)$ will be applied to the <i>k</i> -sequences of ones generated by the program (no input if <i>IUSER</i> =1,-1).	0
<i>DELTAS</i>	= $\delta_s$ ( $0 < \delta_s \leq 1$ ); the filter $1/(1 - \delta_s B^s)$ , $s=MQ$ , will be applied to the <i>k</i> -sequences of ones generated by the program (no input if <i>IUSER</i> =1,-1).	0
<i>ID1DS</i>	= 1 The program will generate $1/(1-B)(1-B^s)$ , $s=MQ$ , of the <i>k</i> -sequences of ones generated by the program (no input if <i>IUSER</i> =1,-1).	0

<u>Parameter</u>	<u>Meaning</u>	<u>Default</u>
<i>REGEFF</i> = <i>k</i>	( <i>k</i> = 0, 1, ..., 5). Only active with <i>SEATS</i> ≠ 0. It determines the way the regression effects are allocated to the components of the series. See “Allocation of Regression Effects”; Section 2.3.1 in program <i>SEATS</i> .	0

Note 1: *IREG* should equal the number of namelists *REG* with *IUSER*=1, plus *NSER* for each namelist *REG* with *IUSER*=-1 or 2.

Note 2: When *IATIP* ≠ 0, the parameter *IUSER* should not be 2. The user could still impose outliers specified a priori by entering them as intervention variables in the usual way (i.e., *IUSER* = 0, and setting the parameters *ISEQ*, *DELTA*, *DELTAS*, *ID1DS*, *REGEFF*).

Note 3: The order of the regression variables in TRAMO is as follows. Mean, Missing Observations (when appropriate), Regression variables entered by the user or generated by the program, Trading Day variables, Easter variable, and Outliers.

Note 4: For the allocation of the regression effects to the series components, when TRAMO is used as a preadjustment program for *SEATS*, see Section 2.3.1 below.

### 1.3.11 Others

<u>Parameter</u>	<u>Meaning</u>	<u>Default</u>
<i>PG</i>	= 0 Creates output files in the subdirectory <i>GRAPH</i> = 1 No output files in <i>GRAPH</i> .	0
<i>SEATS</i>	= 0 No input file for <i>SEATS</i> is created = 1 Creates input file for <i>SEATS</i> redoing estimation in <i>SEATS</i> . The name of this file will be <b>SEATS.ITR</b> = 2 Creates input file for <i>SEATS</i> and no estimation is performed in <i>SEATS</i> . The name of this file will be <b>SEATS.ITR</b> .	0
<i>UR, XL</i>	= When <i>SEATS</i> =2, if the modulus of an estimated root in the AR polynomial falls in the range ( <i>XL</i> , 1), it is set equal to <i>UR</i> . If the root is in the MA polynomial, it is set equal to <i>XL</i> . (Used only when <i>SEATS</i> =2.)	1, .98

In order to execute *SEATS*, the file *seats.itr* should be passed on to the directory *SEATS* as “*serie*”.

### 1.3.12 Memory Constraints

The user should be aware of the following memory constraints:

$$\begin{array}{ll} IFILT=2 & 2+2 \times IMRTE \leq 64 \\ & IR+2 + ICON \leq 64 \end{array}$$

$$\begin{array}{ll} IFILT=3 & 1+2 \times IMRTE + IMISP \leq 64 \\ & MAX\{IR+1, ICON\} + ICON \leq 64 \end{array}$$

$$IFILT=1 \quad \text{like } IFILT=3$$

$$\begin{array}{ll} \text{In all cases} & MAX\{N, ICON\} + N+1 \leq 64, \\ & NZ \leq 600 \\ & NZ + NPRED \leq 664, \end{array}$$

where  $NZ$  is the length of the series,  $IMRTE = IMEAN + IREG + ITRAD + IEAST$ ,  $IMISP$  = number of initial missing values in the skipping approach,  $ICON = (MIN\{ICONCE, 1\}) \times (IMRTE + IMISP) + 1$ ,  $IR = MAX\{ID + IP, IQ + 1\}$  if  $IFILT = 1$  or  $3$ ,  $IR = MAX\{IP, IQ + 1\}$  if  $IFILT = 2$  or  $4$ ,  $ID = D + MQ \times BD$ ,  $IP = P + MQ \times BP$ ,  $N$  = number of parameters to be estimated by Gauss-Marquardt's method.

Note:  $IREG$  includes all outliers (and missing observations treated as additive outliers). In the case of automatic model identification,  $ITRAD$  and  $IEAST$  are the ones resulting after the testing process, that is, they are assigned non-negative values.

## 1.4 Input File and Examples

The input starts with the series to be modelled, comprising no more than 250 observations, followed by one set of control parameters for the series model plus a list of instructions for the regression variables.

To specify the set of control parameters for the series model, as well as the instructions for the regression variables, the NAMELIST facility is used, so that only those parameters which are not at their default values need to be set.

The series is set up as:

Card 1            TITLE (no more than 72 characters)  
Card 2            NZ NYER NPER NFREQ (free format)  
Card 3 et seq.    Z(I): I = 1, NZ (free format),

where NZ is the number of observations, NYER the start year, NPER the start period, and NFREQ is an instruction to control table format (the number of columns). Z(.) is the array of observations. For each missing observation, the code -99999. must be entered. (The first nonblank characters of TITLE are used by the program to create a file named \*\*\*\*\*.OUT in the subdirectory OUTPUT containing the output of the program.)

This is followed by namelist INPUT. The namelist starts with \$INPUT and terminates with \$.

Eight examples of input files for TRAMO are provided. They illustrate some of the most relevant features of the program.

Note: the format '\$INPUT ... \$' can be replaced by others such as '&INPUT ... /'.

**Warning:** the code -99999. for missing values must be entered exactly as described. For example, -99999.0 or -99999.00 would be read by the program as negative (and therefore not missing) values.

### Example 1

The series is the airline passengers series of Box and Jenkins (1970). The program performs first a test for the log/level specification, and fits the default model

$$\nabla \nabla_{12} \log z_t = (1 + \theta_1 B) (1 + \theta_{12} B) a_t$$

with automatic outlier detection and correction. Exact maximum likelihood estimation is used, with starting values computed by the program. A simplified Morf-Sidhu-Kailath algorithm is employed for likelihood evaluation. Three types of outliers are considered: additive outliers, transitory outliers and level shifts, with a relatively low critical level (notice that  $AIO = 2$  is unnecessary, since it is the default value).

A *seats.itr* file is created for SEATS, and if the ARIMA model passed by TRAMO does not accept an admissible decomposition, SEATS will replace it with a decomposable approximation.

## EXAMPLE 1

```
AIRLINE DATA (Box-Jenkins)
144 1949 1 12
112 118 132 129 121 135 148 148 136 119 104 118
115 126 141 135 125 149 170 170 158 133 114 140
145 150 178 163 172 178 199 199 184 162 146 166
171 180 193 181 183 218 230 242 209 191 172 194
196 196 236 235 229 243 264 272 237 211 180 201
204 188 235 227 234 264 302 293 259 229 203 229
242 233 267 269 270 315 364 347 312 274 237 278
284 277 317 313 318 374 413 405 355 306 271 306
315 301 356 348 355 422 465 467 404 347 305 336
340 318 362 348 363 435 491 505 404 359 310 337
360 342 406 396 420 472 548 559 463 407 362 405
417 391 419 461 472 535 622 606 508 461 390 432
$INPUT lam=-1,iatip=1,aio=2,va=3.3,
noadmiss=1,seats=2,$
```

### Example 2

The monthly series  $y_t$  of oxidant ( $O_3$ ) level recordings in downtown Los Angeles, for the period January 1955 / December 1972, is considered. The series was analysed by Box and Tiao (1975) and the identified model is of the form

$$y_t = \frac{\omega_1}{1 - B} \xi_{1t} + \frac{\omega_2}{1 - B^{12}} \xi_{2t} + \frac{\omega_3}{1 - B^{12}} \xi_{3t} + n_t$$

$$(1 + \phi B) \nabla_{12} n_t = (1 + \theta_{12} B^{12}) a_t,$$

where  $\xi_{1t}$ ,  $\xi_{2t}$  and  $\xi_{3t}$  are three "intervention" variables such that

$$\begin{aligned}\xi_{1t} &= \begin{cases} 1 & t = \text{January 1960}; \\ 0 & \text{otherwise}; \end{cases} \\ \xi_{2t} &= \begin{cases} 1 & \text{months June--October, beginning in 1966}; \\ 0 & \text{otherwise}; \end{cases} \\ \xi_{3t} &= \begin{cases} 1 & \text{months November--May, beginning in 1966}; \\ 0 & \text{otherwise}. \end{cases}\end{aligned}$$

Eight observations were randomly removed and estimated as missing values using the "additive outlier approach" with the appropriate determinantal correction in the likelihood. The missing observations can be identified by the number -99999. in the file. For this model, the three regression variables are constructed by the program. (For their particular meaning, see the paper by Box and Tiao.) The 1-to-36 periods-ahead forecast function (and associated standard errors) is computed. Estimation of the model will be made by exact ML; the regression parameters and (in this case) the additive outlier parameters corresponding to the missing observations, will be concentrated out of the likelihood.

## EXAMPLE 2

```
OZONE LEVEL L.A. (BOX-TIAO)
216 1955 1 12
2.7 2.0 -99999. 5.0 6.5 6.1 5.9 5.0 6.4 7.4 8.2 3.9
4.1 4.5 5.5 3.8 4.8 5.6 6.3 5.9 -99999. 5.3 5.7 5.7
3.0 3.4 4.9 4.5 4.0 5.7 6.3 7.1 8.0 5.2 5.0 4.7
3.7 3.1 -99999. 4.0 4.1 4.6 -99999. 4.2 5.1 4.6 4.4 4.0
2.9 2.4 4.7 5.1 4.0 7.5 7.7 6.3 5.3 5.7 4.8 2.7
1.7 2.0 3.4 4.0 4.3 5.0 5.5 5.0 5.4 3.8 2.4 2.0
2.2 2.5 2.6 3.3 2.9 4.3 4.2 4.2 3.9 3.9 2.5 2.2
2.4 1.9 2.1 4.5 3.3 3.4 4.1 5.7 4.8 5.0 2.8 2.9
1.7 3.2 2.7 3.0 3.4 3.8 5.0 4.8 4.9 3.5 2.5 2.4
1.6 2.3 2.5 3.1 -99999. 4.5 5.7 5.0 4.6 4.8 2.1 1.4
2.1 2.9 2.7 4.2 3.9 4.1 4.6 5.8 4.4 6.1 3.5 1.9
1.8 1.9 3.7 4.4 3.8 5.6 5.7 5.1 5.6 -99999. 2.5 1.5
1.8 2.5 2.6 1.8 3.7 3.7 4.9 5.1 3.7 5.4 3.0 1.8
2.1 2.6 2.8 3.2 3.5 3.5 4.9 4.2 4.7 3.7 3.2 1.8
2.0 -99999. 2.8 3.2 4.4 3.4 3.9 5.5 3.8 3.2 2.3 2.2
1.3 2.3 2.7 3.3 3.7 3.0 3.8 4.7 4.6 2.9 1.7 1.3
1.8 2.0 2.2 3.0 2.4 3.5 3.5 3.3 2.7 2.5 1.6 1.2
1.5 2.0 3.1 3.0 3.5 -99999. 4.0 3.8 3.1 2.1 1.6 1.3
&INPUT NPRED=36,LAM=1,IREG=3,INTERP=2,IMEAN=0,P=1,Q=0,D=0,/
&REG ISEQ=1, DELTA=1.D0,/
61 1
&REG ISEQ=8,DELTAS=1.D0, /
138 5 150 5 162 5 174 5 186 5 198 5 210 5 222 5
&REG ISEQ=8,DELTAS=1.D0, /
143 7 155 7 167 7 179 7 191 7 203 7 215 7 227 7
```

### Example 3

Example 3 is the same as in Harvey and Pierse (1984) and in Data Set 2 of Kohn and Ansley (1986). It consists of removing, from the 12 years of monthly data of the Airline passengers series of Example 1, all January through November data in the last 6 years. Since the estimation problem is identical when the missing values are placed at the beginning, the example illustrates an important possible application of the program: Interpolation of data for frequencies higher than the observed one.

There are no regressors, and the ARIMA model is the default model of Example 1 (the "Airline Model").

Interpolation of the missing values is made with the "skipping approach" and a simplified version of the fixed point smoother. Computation of the likelihood is made with the ordinary Kalman filter (*IFILT* = 3 is in this case unnecessary, since it would be set automatically by the program).

A file *seats.itr* is produced ready for SEATS. In this case, however, only the model orders are passed, and SEATS reestimates the ARIMA model parameters.

Note that the missing values are entered as -99999. and not as -99999.00. This last code would be read by the program as a negative value and not as missing value.

### EXAMPLE 3

```
(HARVEY-PIERSE) MONTHLY INTERPOLATION, AIRLINE MODEL
144 1949 1 12
112 118 132 129 121 135 148 148 136 119 104 118
115 126 141 135 125 149 170 170 158 133 114 140
145 150 178 163 172 178 199 199 184 162 146 166
171 180 193 181 183 218 230 242 209 191 172 194
196 196 236 235 229 243 264 272 237 211 180 201
204 188 235 227 234 264 302 293 259 229 203 229
-99999. -99999. -99999. -99999. -99999. -99999. -99999.
-99999. -99999. -99999. 278
-99999. -99999. -99999. -99999. -99999. -99999. -99999.
-99999. -99999. -99999. 306
-99999. -99999. -99999. -99999. -99999. -99999. -99999.
-99999. -99999. -99999. 336
-99999. -99999. -99999. -99999. -99999. -99999. -99999.
-99999. -99999. -99999. 337
-99999. -99999. -99999. -99999. -99999. -99999. -99999.
-99999. -99999. -99999. 405
-99999. -99999. -99999. -99999. -99999. -99999. -99999.
-99999. -99999. -99999. 432
$INPUT INTERP=1,IFILT=3,SEATS=1,$
```

#### Example 4

The series is the monthly series of sales in retail variety stores in Chen, Liu and Hudak (1990). The example illustrates what could be a standard way of executing TRAMO for a series for which there is no a priori information (other than the fact that Trading Day and Easter effect are surely not present).

The program pretests for the log/level specification, performs identification of the 3 types of outliers of Example 1 and of the ARIMA model, and joint exact maximum likelihood estimation of the model parameters. (Notice that after correction for the outliers, the full ARIMA model is identified again, and a second outlier detection and correction will be made.) It further computes the 1-to-24 periods-ahead forecast function (in this case,  $NPRED = 24$  would be automatically set by the program). The identified model is of the type

$$(1 + \phi_1 B + \phi_2 B^2) \nabla \nabla_{12} z_t = (1 + \theta_{12} B^{12}) a_t,$$

and 3 outliers have been detected and removed.

A *seats.itr* file is created (for use by SEATS) which includes the series forecasts, the outlier effects, the ARIMA model and the parameter estimates. *NOADMISS* = 1 guarantees that, if the model is nonadmissible, an approximation will be provided.

## EXAMPLE 4

RETAIL SALES VARIETY STORES (CHEN-LIU-HUDAK)

153	1967	1	12	296	303	365	363	417	421	404	436	421	429	499	915
331	361	402	426	460	457	451	478	492	469	501	459	494	548	1022	
345	364	427	445	478	492	469	510	485	527	536	553	621	1122		
370	378	453	470	534	510	485	525	494	537	513	521	596	1069		
394	411	482	484	550	525	494	537	513	521	596	1069				
393	425	503	529	581	558	547	588	549	593	649	1191				
463	459	554	576	615	619	589	637	601	642	737	1279				
490	490	598	615	681	654	637	694	645	684	749	1245				
489	511	612	623	726	692	623	734	662	684	781	1386				
503	537	636	560	607	585	559	608	556	596	665	1229				
427	450	573	579	615	601	608	617	550	616	673	1199				
438	458	548	584	639	616	614	647	588	648	713	1261				
483	483	593	620	672	650	643	702	654							

\$INPUT LAM=-1, IDIF=3, INIC=3, VA=3.5, IATIP=1, NPRED=24, SEATS=2, NOADMISS=1,\$

### Example 5

The series is the monthly sales os U.S. men's and boys' clothing stores in Hillmer, Bell and Tiao (1983). The program fits the model ( $z_t$  denotes the logged variable)

$$z_t = \alpha H(\tau, T) + \sum_{i=1}^7 \beta_i T_{it} + n_t,$$

where  $H(\cdot)$  denotes the easter effect,  $T_{1t}, \dots, T_{7t}$  are the trading day effects, and  $n_t$  follows the model

$$(1 + \phi_1 B) \nabla \nabla_{12} n_t = (1 + \theta_2 B^2)(1 + \theta_{12} B^{12}) a_t,$$

with  $\theta_1$  constrained to be zero. The Trading Day effect includes length-of-month correction. Estimation is carried out by exact maximum likelihood, and automatic detection and correction of outliers is made (in this case, maximum likelihood is used instead of the (default) Hannan–Rissanen method.) So as to preserve the level, all outliers are forced to be either additive outliers or transitory changes. Since SEATS  $\neq 0$ , by default, the 1-to-24 periods-ahead forecast function will be obtained. The original series and forecasts, and the Easter, Trading Day, and outlier effects, are passed on to SEATS, together with the ARIMA model, including the parameter estimates. SEATS will assign transitory changes and additive outliers to the irregular, and level shifts to the trend. After removing the mean effect, trading day and easter effect will go to the seasonal component.

## EXAMPLE 5

```
retailmen-EXAMP(HILL-BELL-TIAO)
153 1967 1 12
237 18.7 241 245 259 296 252 260 271 267 320 549
266 216 252 297 302 310 270 288 280 316 372 594
319 249 287 320 342 329 291 321 315 361 400 680
338 268 304 313 348 350 321 317 333 364 396 719
336 267 303 375 382 401 341 351 357 382 447 771
364 310 379 408 439 451 390 413 424 469 534 884
452 361 426 470 477 502 424 442 442 479 562 961
437 368 427 495 514 492 443 500 458 492 542 889
459 403 490 467 556 542 474 510 483 527 591 1044
495 404 463 540 518 552 505 502 496 558 629 1137
511 440 496 578 542 550 492 518 507 569 708 1141
480 421 532 536 542 563 508 554 552 609 763 1293
561 462 564 582 586 615 553 6120 570
$INPUT P=1,Q=2,JQR(1)=1,TH(1)=0,IEAST=1,IDUR=9,ITRAD=7,IMVX=1,
IATIP=1,VA=3.5,AIO=1,SEATS=2,$
```

### Example 6

The series is the Spanish monthly currency series for the period January 1962 / June 1996 (414 observations).

After pretesting for the log/level specification, and for the possible presence of trading and easter effects (*IDUR* = 8 is unnecessary, since it is the default value), the program estimates the model

$$(1 + \phi_1 B + \phi_3 B^3) \nabla \nabla_{12} z_t = (1 + \theta_{12} B^{12}) a_t,$$

and, if they are significant, Trading Day and Easter effect as in Example 5 without length-of-month correction. Automatic outlier detection considers 4 types of outliers: the 3 of Example 1, plus innovation outliers.

An out-of-sample forecasting test is performed by removing the last 36 observations and estimating the model for the shorter series. Since *SEATS* = 0 and the series is in logs, forecasts and their standard errors are obtained from the lognormal distribution.

## EXAMPLE 6

```

CURRENCY (SPAIN)
414 1962 1 12
$INPUT
 80749.0   81657.0   83087.0   84105.0   84349.0   86411.0   91068.0
 91106.0   93129.0   92934.0   92497.0   97939.0   93797.0   95108.0
 97981.0   97652.0   97646.0   100647.0   105937.0   107500.0   107928.0
106691.0   106928.0   112787.0   108410.0   110187.0   112182.0   112059.0
113323.0   115939.0   123244.0   123333.0   123324.0   124220.0   123265.0
131607.0   127102.0   128422.0   127429.0   131009.0   131344.0   134800.0
145869.0   143125.0   143381.0   143558.0   140657.0   150992.0   145175.0
146167.0   146731.0   150458.0   150990.0   153483.0   166238.0   162480.0
163716.0   162375.0   160782.0   174724.0   165948.0   168290.0   169464.0
175355.0   173243.0   177366.0   190555.0   184811.0   188206.0   183973.0
181084.0   198512.0   185297.0   184629.0   188044.0   187480.0   187482.0
196032.0   206040.0   203712.0   201853.0   201699.0   201175.0   217786.0
203241.0   205184.0   210139.0   209162.0   213486.0   219616.0   231983.0
228617.0   226438.0   226291.0   226557.0   242556.0   229587.0   231572.0
231640.0   232409.0   233821.0   239838.0   256887.0   246510.0   242589.0
242071.0   239784.0   262443.0   245681.0   247670.0   247572.0   252718.0
254556.0   261353.0   282739.0   270481.0   268609.0   270531.0   266021.0
293428.0   272572.0   274446.0   283718.0   286162.0   283087.0   294135.0
316972.0   301683.0   305644.0   300148.0   299126.0   333543.0   308943.0
310072.0   323361.0   325780.0   326073.0   345897.0   370499.0   355535.0
357633.0   346400.0   349015.0   385848.0   354006.0   360003.0   373985.0
373249.0   375170.0   395671.0   423729.0   410594.0   406391.0   402824.0
405173.0   445536.0   416308.0   420538.0   435008.0   434998.0   451074.0
464630.0   503855.0   487626.0   477471.0   485156.0   486591.0   522895.0
493089.0   499272.0   502081.0   517195.0   514108.0   533640.0   595271.0
557488.0   551964.0   559517.0   545659.0   613143.0   572375.0   580387.0
591155.0   605288.0   609262.0   635876.0   733017.0   685732.0   693714.0
687075.0   683418.0   774949.0   725403.0   730767.0   759548.0   779477.0
775237.0   821211.0   899950.0   850135.0   862509.0   847086.0   838964.0
941333.0   863132.0   889486.0   919678.0   916402.0   911226.0   951011.0
1011834.0   971615.0   965410.0   947635.0   949412.0   1034509.0   955952.0
969336.0   991731.0   1004983.0   1043806.0   1075890.0   1158956.0   1129516.0
1103354.0   1102569.0   1095916.0   1178749.0   1114695.0   1126970.0   1126251.0
1157901.0   1172236.0   1192817.0   1287438.0   1236819.0   1216405.0   1229796.0
1208277.0   1326169.0   1234957.0   1237795.0   1240812.0   1281810.0   1283614.0
1309776.0   1417090.0   1347697.0   1344917.0   1407518.0   1379432.0   1522492.0
1426039.0   1449417.0   1551421.0   1543814.0   1529508.0   1550461.0   1664231.0
1581117.0   1577438.0   1569263.0   1531475.0   1686025.0   1575002.0   1570508.0
1606137.0   1615848.0   1610194.0   1707524.0   1792333.0   1752320.0   1746958.0
1724439.0   1706245.0   1862317.0   1738270.0   1741670.0   1803989.0   1799391.0
1817325.0   1891098.0   1981484.0   1953517.0   1934181.0   1923631.0   1909981.0
2080475.0   1973705.0   1987698.0   2039946.0   2052700.0   2096532.0   2152733.0
2256375.0   2221750.0   2202084.0   2217482.0   2209439.0   2401538.0   2283857.0
2292791.0   2291027.0   2363031.0   2382624.0   2430718.0   2584309.0   2510903.0
2491158.0   2524560.0   2502926.0   2735085.0   2595287.0   2583233.0   2714407.0

```

```

2698838.0 2728301.0 2823803.0 3028582.0 2930976.0 2970772.0 2961751.0
2928581.0 3236372.0 3058637.0 3092100.0 3201705.0 3265178.0 3269589.0
3452948.0 3609238.0 3530098.0 3577245.0 3563007.0 3535416.0 3835085.0
3588928.0 3600298.0 3699697.0 3748496.0 3752974.0 3896207.0 4024489.0
4017622.0 4045448.0 4094299.0 4198839.0 4533315.0 4335905.0 4396405.0
4555778.0 4570908.0 4689841.0 4832722.0 5001618.0 4986642.0 5019116.0
5074417.0 5143576.0 5607216.0 5441625.0 5447093.0 5454243.0 5537138.0
5555099.0 5612722.0 5820069.0 5707524.0 5704235.0 5671382.0 5664833.0
6024621.0 5804886.0 5853287.0 5883084.0 5917969.0 5911491.0 6009142.0
6222621.0 6106814.0 6113668.0 6122138.0 6101660.0 6508926.0 6275246.0
6280564.0 6442236.0 6412478.0 6471637.0 6612456.0 6819418.0 6730737.0
6813779.0 6782683.0 6772993.0 7164429.4 6897069.0 6925122.4 7027932.7
7031466.0 7042994.7 7214445.5 7306794.4 7212305.0 7257089.9 7183808.0
7186599.5 7535256.9 7207819.9 7231233.6 7334642.1 7316523.3 7422156.8
7505553.6
$INPUT
p=3,itrad=-6,idur=8,ieast=-1,imean=0,jpr(2)=1,phi(2)=0,jqr(1)=1,th(1)=0,
aio=0,iatip=1,va=4,lam=-1,NBACK=-36,$

```

### Example 7

The series is the monthly series of the Spanish industrial production index for the period January 1983 / May 1996. First, there are missing observations that are interpolated. Second, a pretest is made for the log/level specification and for the Trading Day and Easter effects. (Notice that the Trading Day specification is the most parsimonious one, and different from the ones in examples 5 and 6). TRAMO performs full automatic model identification and MLE of the parameters.

The model contains two regression variables and is of the type

$$z_t = \beta_1 x_{1t} + \beta_2 x_{2t} + \nu_t$$

where  $\nu_t$  is found to follow the default Airline model, and:

- $x_{1t}$  is a regression variable that includes holidays (the forecast period is considered). It is provided in the external file *holidays*.
- $x_{2t}$  is a level shift outlier specified a priori. It corresponds to the date at which the base of the index was changed.

TRAMO will produce a file *seats.itr* for SEATS containing the ARIMA model, together with parameter estimators, the forecasts of the series, the Trading Day and Easter effects, plus the effect of the two regression variables. After being removed of the mean effects, the Trading Day, Easter, and holiday effects will be assigned to the seasonal component; the change in levels due to the new base will be assigned to the trend. (Trading Day, Easter, and outlier effects are automatically extended over the forecast period.)

Note that the missing values are entered as -99999. and not as -99999.0. This last code would be read by the program as a negative value and not as missing value.

## EXAMPLE 7

```
IPI(Spain)
161 1983 1 12
  83.6    83.3   -99999.   -99999.    89.3    86.9    82.8
  49.9    87.8    86.8    88.9    86.6    86.5    87.2
-99999.   -99999.    89.8    85.6    85.8    53.3    85.4
  91.6    90.2    82.6    88.6    84.6    89.2    84.8
  90.6    83.8    89.5    52.4    88.3    99.0    92.9
  86.2    88.4    88.0    87.5    94.6    91.2    92.5
  93.7    50.4    92.1   100.3    94.9    88.1    87.6
  91.9    96.6    91.4    96.3    97.3   102.9    53.1
  98.4   102.0   101.1    92.1    90.2    96.5   103.4
  95.0   101.2   100.3    99.6    56.4   100.8   100.9
 105.8    94.5   100.7    98.7   103.4   102.1   104.8
 107.7   104.6    60.0   105.0   107.3   108.8    92.7
 105.0    98.9   108.4    96.0   107.1   107.1   104.4
  59.8   102.4   105.7   109.2    92.4   103.7    99.0
  96.8   102.2   104.0   102.3   104.5    58.9   102.8
 111.8   106.1   95.3   100.3   101.1   104.3    98.3
 100.3   102.8   104.5    58.8    98.9   100.7    97.3
  86.7    88.2    90.3    98.0    90.2    95.3    96.8
  97.5    56.9    97.1    97.0    99.5    92.0    91.1
  95.2   103.5    97.0   102.1   -99999.   102.7    64.2
 104.9   104.4   109.2    99.9   104.2   101.5   113.9
  97.4   112.0   112.7   106.2    67.4   105.6   108.1
 110.4   95.2   102.7   102.4   106.4    98.4   108.4
$INPUT lam=-1,itrad=-1,ieast=-1,idif=3,inic=3,ireg=2,interp=1,
noadmiss=1,seats=2,$
$REG iuser=-1 nser=1 ilong=185 regeff=2 $
holidays
$REG iuser=2 nser=1 regeff=1 $
119 ls
```

### **FILE *holidays***

The file is read with free format, which means that the data can be organized in many different ways. For example, the data may consist of one column array.

1	0	0	0	0	2	1	1	0	1
1	1	1	0	1	0	1	1	1	1
0	1	1	1	1	0	1	0	1	1
1	1	0	0	1	1	2	0	0	0
2	0	1	1	0	0	0	2	2	0
1	0	1	1	0	0	0	1	0	2
2	0	0	0	0	1	1	1	0	1
1	2	1	0	0	0	2	0	1	1
0	1	1	3	1	0	1	0	1	0
0	1	0	1	1	2	2	0	1	0
1	0	1	1	0	0	1	2	2	0
1	0	1	0	0	0	0	1	0	3
2	0	1	0	0	0	0	0	0	1
1	2	1	0	0	0	1	0	1	1
0	1	1	3	1	0	0	0	1	0
1	1	0	1	1	3	1	0	1	0
1	0	0	1	0	0	1	2	2	0
1	0	1	0	1	1	0	1	0	2
2	0	1	0	1	1	0	1	0	2

### Example 8

The series consists of the aggregate index of “art price”, observed every 6 months, in Czujack et al (1996).

The example illustrates the use of TRAMO/SEATS for frequencies different from the quarterly and monthly ones. The program pretest for the log/level specification, does automatic outlier detection and correction, and automatic model identification (in this case, the regular AR and MA polynomials are constrained to a maximum order of 2).

The ARIMA model obtained is of the type

$$\nabla_2 z_t = (1 + \theta B) a_t,$$

and a level shift outlier is corrected.

By default, the missing observations are interpolated, and (since SEATS  $\neq 0$ ) the 1-to-8 periods-ahead forecast function is obtained. A file *seats.itr* is produced, ready for SEATS.

## EXAMPLE 8

```
ART PRICE INDEX (U.L.B)
53 1971 1 2
  0.006097    0.575264    0.236069    0.439334    0.135483
  0.690869    1.051329    0.486760    1.194987    0.600609
-99999.      0.997317 -99999.      0.997617    1.586138
  1.333425    1.530939    0.932150    1.196279    0.871909
  1.065290    1.200343    0.703766    1.006899    1.201516
  1.565287    1.572131    1.620713    1.745179    1.694186
  2.025192    2.083175    1.988166    2.128631    2.151246
  2.228820    2.349033    2.732166    2.712100    2.405184
  2.867629    2.807326    3.097908    3.274386    3.466686
  3.668304    3.824994    4.015861    3.930079    2.913271
  3.580308    3.062043    2.942187

$INPUT
inic=2,idif=3,aio=2,iatip=1,va=3.5,lam=-1,
MQ=2,seats=2,$
```

## 1.5 The File ‘*Seats.itr*’

When the input parameter *SEATS* is not zero, TRAMO creates the file ‘*seats.itr*’ as input file for SEATS. This file has the following structure.

First line: Title of series.

Second line: *NZ NYEAR NPER NFREQ*.

Next lines: “Linearized” series. This is the original series, with the missing observations interpolated, the outliers corrected, and the effect of regression and intervention variables removed, including Easter and Trading Day effects. Thus, it is the series corrected for deterministic effects (except for the mean), and hence is the series that will be decomposed by SEATS into stochastic components.

Next lines: Namelist *INPUT*, with the parameter values for SEATS.

Next lines: A ( $k \times 5$ ) matrix, where:  
 $k = NZ$  (the length of the series) +  $TF$ ,  
where  $TF = \max(8; 2 \times MQ)$ .

The first column of this matrix contains the original series for TRAMO.

The second column contains the Level Shift outliers.

The third column contains the aggregate effect of the Additive Outliers and the Transitory Changes.

The fourth column contains the Easter effect.

The fifth column contains the Trading Day effect.

For each column, the first *NZ* elements contain the “in-sample” values; the last *TF* elements contain the forecasts. (When *LAM* = 0, the effects are expressed as factors; when *LAM* = 1, as additive components.)

Next lines: (Only when *IREG* > 0).  
A ( $k \times 6$ ) matrix, where  $k$  is as before.

The first column contains the regression variable effects that are to be considered a separate component in SEATS.

The second column contains the regression variable effects that are assigned to the trend.

The third column contains the regression variable effects that are assigned to the seasonal component.

The fourth column contains the regression variable effects that are assigned to the irregular component.

The fifth column contains the regression variable effects that are to be considered an additional component of the seasonally adjusted series.

The sixth column contains the regression variable effects that are assigned to the cycle.

For each column, the first  $NZ$  elements are in-sample values; the last  $TF$  are forecasts.

**Note:** Recall that, for its execution by SEATS, the file ‘*seats.itr*’ should be transferred to the directory SEATS as ‘*serie*’.

### Example of a ‘Seats.itr’ File

The *seats.itr* file produced by TRAMO in example 7 (the monthly Spanish industrial production index) is presented.

The model contains a level shift outlier, to be assigned to the trend, Trading Day and Easter effects that, after being removed of the mean effect, will be assigned in SEATS to the seasonal component. Finally, the holiday effect is treated as a regression effect to be assigned also to the seasonal (after removing the mean). Notice that, since the decomposition is multiplicative, all effects are expressed as factors.

The file starts with the “linearized” series, that is, the series with the missing values interpolated and all deterministic effects removed. This will be the series that will be decomposed into stochastic components by SEATS. Then follows the INPUT namelist for SEATS, with the model orders and parameter estimates. Next comes a  $185 \times 5$  matrix. The first column is the original series entered in TRAMO, the second column contains the outlier affecting the trend (the LS outlier), the third column contains outliers assigned to the irregular; in this case there are none and the column has all elements equal to 1. The 4<sup>th</sup> and 5<sup>th</sup> columns contain the Easter and Trading Day effects, respectively.

The first 161 rows contain the values for the sample period; the last 24 rows are the 1-to-24 periods-ahead forecasts.

After this first matrix comes another  $185 \times 6$  matrix with the regression effects grouped according to the value of *REGEFF* (0, 1, 2, 3, 4, 5). Since in this example there is only one regression variable and it is assigned to the seasonal (*REGEFF* = 2), its effect appears in the 3<sup>rd</sup> column of the matrix; all elements of the other 4 columns are 1. As with the first matrix, the first 161 rows correspond to the sample period, and the last 24 contain the forecast function.

## EXAMPLE OF A *seats.itr* FILE

The following file is not exactly like the one produced by TRAMO. The formatting has been slightly changed in order to minimize the size of the file. This does not affect the results, however, since SEATS reads the data with free format.

IPI(Spai	161 1983 1 12	83.30000000000018	89.20040625035404
87.25379616670881	89.55652102474194	89.38420354568424	
84.31317774698576	50.03086631361259	86.79835492662872	
86.41883161008957	89.64596554945960	88.58815512731081	
90.59365439318574	86.70117317356838	90.91361105528229	
88.48585933617071	90.03550691307444	88.06899512122364	
85.60257569814021	53.43978305642386	87.88513518138967	
87.76978879819018	90.95687393207264	86.21009047093474	
91.84022754162157	84.60000000000007	91.71325210780084	
88.83235982737631	90.83760497020647	87.96574456729948	
85.09884091124451	53.60299455740283	89.06313331289694	
89.73472014164986	95.57955194815042	88.17897196275045	
97.31071463576690	88.00000000000010	92.25623461712712	
90.40693635211201	90.16223070379746	93.29943183967121	
90.75832790397787	52.60276706701101	91.04929941620165	
93.94573494159319	97.66158464536161	90.10012548213869	
98.58853210068106	91.90000000000012	95.89881997240978	
91.40582686022661	100.50885850303895	98.11645048326680	
93.10752935156006	54.33260958198771	97.27742738929686	
101.14416703050924	101.97375739449474	94.19093708178185	
104.34170696288334	95.94797260607052	103.17080529968084	
96.02771637924627	101.49070467753512	101.14162367391225	
94.39523180382847	56.54791302781067	99.65004756952369	
103.95308729909324	106.68777452342884	98.60560089373756	
105.30990470359944	98.70000000000020	104.72916350851153	
103.01186167806233	107.17926391064856	106.47133058767555	
101.96747564685005	60.15735428490494	105.90746316935646	
109.17161577796347	109.71294771407425	100.66576719117104	
109.76338389330765	98.90000000000015	107.61316858187604	
105.27536999858364	99.77692789274784	108.02561243274364	
99.77692789274784	59.95682977062189	105.37983422218154	
104.69989692030305	110.11630413949364	98.36985580313022	
105.97720579857413	99.00000000000014	104.10582723916204	
106.05429072074674	104.27274742716854	105.27692422782395	
98.04969462776471	60.25222098150815	103.68844965533195	
104.77405871287604	109.16028484067554	99.44035730341999	
109.89230198261355	102.56045355924653	103.54292881079034	
102.57710086105024	104.68368128613504	101.62723105304595	
100.13643474024462	60.16492360491297	97.77172326017747	
102.71686544886504	104.28541994628984	96.10679237884099	
103.01186167806233	99.77738932462627	101.32471997930774	
99.95359221629859	103.61733826927946	101.68709095671554	
97.63794544694581	60.63613477497307	102.00223689976325	

```

107.57795282873234 106.61677871734064 99.97946362696212
101.03455157420113 101.16037629005113 109.73625105938564
102.41691125811624 110.98313676298476 111.29417929569935
113.89954387124546 68.39840796008555 110.19603141900276
115.78493067339855 117.01057523551366 112.98499259395827
113.26584574635665 107.85481295630464 115.45189097207084
109.75179392750084 119.32432541323327 118.38982593824227
117.78122258156056 71.80767440046364 113.18129852341434
117.50516242976147 118.29640573260707 109.85314874418054
109.41614482088445 108.18870776997375 116.24716089829846
104.92920411018794 115.48890066780805
$INPUT D=1,BD=1,P=0,BP=0,Q=1,BQ=1,
LAM=0,IMEAN=0,PG=0,MQ=12,
MODEL=0,
INIT=2,
TH(1)= -0.551476,
BTH(1)= -0.440565,
TRAMO=1,
INTERP=1,
MOUTR=1,MOUR=0,NEAST=1,NPATD=1,NPAREG=1,
BLQT= 20.683690,
OUT=0,RSA=0,QMAX=50,NOADMISS= 1,BIAS= 1,
SMTR=0,THTR= -0.400000,RMOD= 0.500000,MAXBIAS= 0.500000,$
83.60000000 1.00000000 1.00000000 1.00000000 0.97731363
83.30000000 1.00000000 1.00000000 1.00000000 1.00000000
89.39856561 1.00000000 1.00000000 0.98512011 1.01735971
84.85335258 1.00000000 1.00000000 1.01510464 0.99143155
89.30000000 1.00000000 1.00000000 1.00000000 0.99713565
86.90000000 1.00000000 1.00000000 1.00000000 1.01153991
82.80000000 1.00000000 1.00000000 1.00000000 0.97731363
49.90000000 1.00000000 1.00000000 1.00000000 1.01735971
87.80000000 1.00000000 1.00000000 1.00000000 1.01153991
86.80000000 1.00000000 1.00000000 1.00000000 0.97731363
88.90000000 1.00000000 1.00000000 1.00000000 1.01153991
86.60000000 1.00000000 1.00000000 1.00000000 0.99713565
86.50000000 1.00000000 1.00000000 1.00000000 0.99713565
87.20000000 1.00000000 1.00000000 1.00000000 1.00575340
91.57834091 1.00000000 1.00000000 1.03043744 0.99713565
82.36219976 1.00000000 1.00000000 0.97046164 0.99143155
89.80000000 1.00000000 1.00000000 1.00000000 1.01735971
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(last 4 rows of 1<sup>st</sup> matrix)

## 1.6 Identification of the Arrays Produced by TRAMO

Description of the Files in GRAPH that can be plotted (all are in ASCII format).

### 1.6.1 Series

<u>Meaning</u>	<u>Title of Graph</u>	<u>Name of File</u>
Original series	Original Series	<i>xorig.out</i>
Series with missing observations interpolated	Interpolated series	<i>xint.reg</i>
Forecast of the series	Forecast of the series	<i>pred.out</i>
Forecast of the logged series (only if $LAM = 0$ )	Forecast of trans. series	<i>predl.out</i>
Interpolated series with the effect of regression variables removed (the regression variables are those included in the namelists REG)	Reg. corr. series	<i>xcreg.reg</i>
Interpolated series corrected for outliers	Outlier corr. series	<i>xcout.reg</i>
Interpolated series corrected for special effects (Easter and Trading Day)	S.E. corr. series	<i>xcetd</i>
Interpolated series corrected for outliers, special effects, and for the effect of regression variables, not including the mean. (This is the series passed on to the companion program SEATS.)	Linear series	<i>xlin.reg</i>
White-noise residuals	Residuals	<i>resid.out</i>

### 1.6.2 Autocorrelation Functions

ACF of white-noise residuals	ACF residuals	<i>auto.out</i>
Partial ACF of white-noise residuals	PACF residuals	<i>pauto.out</i>
ACF of differenced series	ACF diff. series	<i>dauto.out</i>

### 1 6.3 Regression, Outliers, and Special Effects

#### Meaning

#### Title of Graph

#### Name of File

Effect of the first regression variable	Reg1	<i>reg1.out</i>
...	...	...
Effect of the $n^{th}$ regression variable	Regn	<i>regn.out</i>

The ordering of the regression variables is determined by the order in which the REG namelists have been entered in the input file. Note that  $n$  should be equal to the total number of variables in the namelists REG of the input file.

Aggregate regression effect	Total Reg.	<i>regsum.out</i>
Effect of the first outlier identified by the program	outreg1	<i>out1.out</i>
...	...	...
Effect of the $k^{th}$ outlier	Outregk	<i>outk.out</i>

The ordering of outliers is determined by the order in which they are detected in the program (i.e., the order in which outliers appear in the output file).

Aggregate outlier effect	Total Outliers	<i>outsum.out</i>
First trading day effect	Trad 1	<i>trad 1.out</i>
...	...	...
Seventh trading day effect	Trad 7	<i>trad 7.out</i>
Aggregate trading day effect	Total Trad. Day	<i>tradsum.out</i>
Easter effect	East	<i>east.out</i>
Aggregate special effects (easter plus trading day)	Special Effects	<i>etdsum.out</i>
Aggregate regression, outlier, and special effects (i.e., difference between interpolated/original series and linearized series)	Total Reg-O-SE	<i>totrose.out</i>

## 2 Program SEATS

### 2.1 Brief Description of the Program

SEATS (“Signal Extraction in ARIMA Time Series”) is a program in Fortran for mainframes and MS-Dos computers. The program falls into the class of so-called ARIMA-model-based methods for decomposing a time series into its unobserved components (i.e., for extracting from a time series its different signals). The method was originally devised for seasonal adjustment of economic time series (i.e., removal of the seasonal signal), and the basic references are Cleveland and Tiao (1976), Box, Hillmer, and Tiao (1978), Burman (1980), Hillmer and Tiao (1982), Bell and Hiltner (1984), and Maravall and Pierce (1987). These approaches are closely related to each other, and to the one followed in this program. In fact, as already mentioned, SEATS developed from a program built by Burman for seasonal adjustment at the Bank of England (1982 version).

The program starts by fitting an ARIMA model to the series. Let  $x_t$  denote the original series, (or its log transformation), and let

$$z_t = \delta(B) x_t, \quad (5)$$

represent the “differenced” series, where  $B$  stands for the lag operator, and  $\delta(B)$  denotes the differences taken on  $x_t$  in order to (presumably) achieve stationarity. In SEATS,

$$\delta(B) = \nabla^d \nabla_s^D, \quad (6)$$

where  $\nabla = 1 - B$ , and  $\nabla_s^D = (1 - B^s)^D$  represents seasonal differencing of period  $s$ . The model for the differenced series  $z_t$  can be expressed as

$$\phi(B)(z_t - \bar{z}) = \theta(B) a_t, \quad (7)$$

where  $\bar{z}$  is the mean of  $z_t$ ,  $a_t$  is a white-noise series of innovations, normally distributed with zero mean and variance  $\sigma_a^2$ ,  $\phi(B)$  and  $\theta(B)$  are autoregressive (AR) and moving average (MA) polynomials in  $B$ , respectively, which can be expressed in multiplicative form as the product of a regular polynomial in  $B$  and a seasonal polynomial in  $B^s$ , as in

$$\phi(B) = \phi_r(B) \phi_s(B^s), \quad (8)$$

$$\theta(B) = \theta_r(B) \theta_s(B^s). \quad (9)$$

Putting together (1)–(5), the complete model can be written in detailed form as

$$\phi_r(B) \phi_s(B^s) \nabla^d \nabla_s^D x_t = \theta_r(B) \theta_s(B^s) a_t + c, \quad (10)$$

and, in concise form, as

$$\Phi(B) x_t = \theta(B) a_t + c, \quad (11)$$

where  $\Phi(B) = \phi(B) \delta(B)$  represents the complete autoregressive polynomial, including all unit roots. Notice that, if  $p$  denotes the order of  $\phi(B)$  and  $q$  the order of  $\theta(B)$ , then the order of  $\Phi(B)$  is  $P = p + d + D \times s$ .

The autoregressive polynomial  $\phi(B)$  is allowed to have unit roots, which are typically estimated with considerable precision. For example, unit roots in  $\phi(B)$  would be present if the series were to contain a nonstationary cyclical component, or if the series had been underdifferenced. They can also appear as nonstationary seasonal harmonics.

The program decomposes a series that follows model (7) into several components. The decomposition can be multiplicative or additive. Since the former becomes the second by taking logs, we shall use in the discussion an additive model, such as

$$x_t = \sum_i x_{it}, \quad (12)$$

where  $x_{it}$  represents a component. The components that SEATS considers are:

- $x_{pt}$  = the TREND component,
- $x_{st}$  = the SEASONAL component,
- $x_{ct}$  = the CYCLICAL component,
- $x_{ut}$  = the IRREGULAR component.

Broadly, the trend component represents the long-term evolution of the series and displays a spectral peak at frequency 0; the seasonal component, in turn, captures the spectral peaks at seasonal frequencies. Besides capturing periodic fluctuation with period longer than a year, associated with a spectral peak for a frequency between 0 and  $(2\pi/s)$ , the cyclical component also captures short-term variation associated with low-order MA components and AR roots with small moduli. Finally, the irregular component captures erratic, white-noise behavior, and hence has a flat spectrum. The components are determined and fully derived from the structure of the (aggregate) ARIMA model for the observed series, which can be directly identified from the data. The program is mostly aimed at monthly or lower frequency data and the maximum number of observations is 600.

The decomposition assumes orthogonal components, and each one will have in turn an ARIMA expression. In order to identify the components, we will require that (except for the irregular one) they be clean of noise. This is called the “canonical” property, and implies that no additive white noise can be extracted from a component that is not the irregular one. The variance of the latter is, in this way, maximized, and, on the contrary, the trend, seasonal and cycle are as stable as possible (compatible with the stochastic nature of model

(7)). Although an arbitrary assumption, since any other admissible component can be expressed as the canonical one plus independent white-noise, it seems sensible to avoid contamination of the component by noise, unless there are a-priori reasons to do so. (Moreover, the component estimates for any other admissible decomposition can be obtained from the canonical ones simply by removing a constant fraction of the irregular component estimate and adding it to the trend and/or the seasonal ones.)

The model that SEATS assumes is that of a linear time series with Gaussian innovations. In general, SEATS is designed to be used with the companion program, TRAMO ("Time Series Regression with ARIMA Noise, Missing Observations, and Outliers"), described in part 1 of this manual; besides ARIMA estimation, TRAMO "linearizes" the original series. To do that, TRAMO removes from the series special effects, such as Trading Day, Easter, holiday, and intervention or regression variable effects, identifies and removes several types of outliers, and interpolates missing observations. It also contains an automatic model identification facility. When used with TRAMO, estimation of the ARIMA model is made by the exact maximum likelihood method described in Gómez and Maravall (1994). When used by itself, SEATS uses the quasi-maximum likelihood method described in Burman (1980). In both cases, a (faster) least-squares algorithm is also available. SEATS contains a facility whereby the automatic model identification procedure of TRAMO is replaced by a faster, though rougher, automatic model identification procedure done in SEATS (see Section 3.1). This simplified procedure starts directly by fitting the default model and, if found appropriate, tries a sequence of models according to the results.

When used by itself, the program starts with estimation of the ARIMA model. The (inverse) roots of the AR and MA polynomials are always constrained to remain in or inside the unit circle. When the modulus of a root converges within a preset interval around 1 (by default (.98,1)), the program automatically fixes the root. If it is an AR root, the modulus is made 1; if it is an MA root, it is fixed to the lower limit. This simple feature, we have found, makes the program very robust to over- and under-differencing.

In the standard case in which SEATS and TRAMO are used jointly, SEATS does the control of the AR and MA roots mentioned above, uses the ARIMA model to filter the linearized series, obtains in this way new residuals, and produces a detailed diagnosis of them. The program proceeds then to decompose the ARIMA model. This is done in the frequency domain. The spectrum (or pseudospectrum) is partitioned into additive spectra, associated with the different components. (These are determined, mostly, from the AR roots of the model.) The canonical condition on the trend, seasonal, and cyclical components identifies a unique decomposition, from which the ARIMA models for the components are obtained (including the component innovation variances).

For a particular realization  $[x_1, x_2, \dots, x_T]$ , the program yields the Minimum Mean Square Error (MMSE) estimators of the components, computed with a Wiener–Kolmogorov-type of filter applied to the finite series by extending the latter with forecasts and backcasts (see Burman, 1980). For  $i = 1, \dots, T$ , the estimate  $\hat{x}_{it|T}$ , equal to the conditional expectation  $E(x_{it}|x_1, \dots, x_T)$ , is obtained for all components.

When  $T \rightarrow \infty$ , the estimator  $\hat{x}_{it|T}$  becomes the “final” or “historical” estimator, which we shall denote  $\hat{x}_{it}$ . (In practice, it is achieved for large enough  $k = T - t$ , and the program indicates how large  $k$  can be assumed to be.) For  $t = T$ , the concurrent estimator,  $\hat{x}_{iT|T}$ , is obtained, i.e., the estimator for the last observation of the series. The final and concurrent estimators are the ones of most applied interest. When  $T - k < t < T$ ,  $\hat{x}_{it|T}$  yields a preliminary estimator, and, for  $t > T$ , a forecast. Besides their estimates, the program produces several years of forecasts of the components, as well as standard errors (SE) of all estimators and forecasts. For the last two and the next two years, the SE of the revision the preliminary estimator and the forecast will undergo is also provided. The program further computes MMSE estimates of the innovations in each one of the components.

The joint distributions of the (stationary transformations of the) components and of their MMSE estimators are obtained; they are characterized by the variances and auto- and cross-correlations. The comparison between the theoretical moments for the MMSE estimators and the empirical ones obtained in the application yields additional elements for diagnosis (see Maravall, 1987). The program also presents the Wiener–Kolmogorov filter for each component and the filter which expresses the weights with which the different innovations  $a_j$  in the observed series contribute to the estimator  $\hat{x}_{it|T}$ . These weights directly provide the moving average expressions for the revisions. Next, an analysis of the estimation errors for the trend and for the seasonally adjusted series (and for the cycle, if present) is performed. Let

$$\begin{aligned} d_{it} &= x_{it} - \hat{x}_{it}, \\ d_{it|T} &= x_{it} - \hat{x}_{it|T}, \\ r_{it|T} &= \hat{x}_{it} - \hat{x}_{it|T}, \end{aligned}$$

denote the final estimation error, the preliminary estimation error, and the revision error in the preliminary estimator  $\hat{x}_{it|T}$ . The variances and autocorrelation functions for  $d_{it}$ ,  $d_{it|t}$ ,  $r_{it|t}$  are displayed. (The autocorrelations are useful to compute SE of linearized rates of growth of the component estimator.) The program then shows how the variance of the revision error in the concurrent estimator  $r_{it|t}$  decreases as more observations are added, and hence the time it takes in practice to converge to the final estimator. Similarly, the program computes the deterioration in precision as the forecast moves away from the

concurrent estimator and, in particular, what is the expected improvement in Root MSE associated with moving from a once-a-year to a concurrent seasonal adjustment practice. Finally, the SE of the estimators of the linearized rates of growth most closely watched by analysts are presented, for the concurrent estimator of the rate and its successive revisions, both for the trend and seasonally adjusted series. All SE computed are exact given that the ARIMA model for the observed series is correct. Further details can be found in Maravall (1988, 1995) and Maravall and Gómez (1992).

The default model in SEATS is the so-called Airline Model, analysed in Box and Jenkins (1970). The Airline Model is often found appropriate for actual series, and provides very well behaved estimation filters for the components. It is given by the equation

$$\nabla \nabla_{12} x_t = (1 + \theta_1 B)(1 + \theta_{12} B^{12}) a_t + c,$$

with  $-1 < \theta_1 < 1$  and  $-1 < \theta_{12} \leq 0$ , and  $x_t$  is the log of the series. The implied components have models of the type

$$\begin{aligned}\nabla^2 x_{pt} &= \theta_p(B) a_{pt}, \\ S x_{st} &= \theta_s(B) a_{st},\end{aligned}$$

where  $S = 1 + B + \dots + B^{11}$ , and  $\theta_p(B)$  and  $\theta_s(B)$  are of order 2 and 11, respectively. Compared to other fixed filters, the default model allows for the observed series to estimate 3 parameters:  $\theta_1$ , related to the stability of the trend component;  $\theta_{12}$ , related to the stability of the seasonal component; and  $\sigma_a^2$ , a measure of the overall predictability of the series. Thus, to some extent, even in this simple fixed model application, the filters for the component estimators adapt to the specific structure of each series.

Programs TRAMO and SEATS provide a fully model-based method for forecasting and signal extraction in univariate time series. (The relation between them is somewhat similar to the one between the programs REGARIMA and X11 ARIMA that form the new method X12 ARIMA; see Findley et al, 1996). The procedure is flexible, yet robust and reliable. Due to the model-based features, it becomes a powerful tool for detailed analysis of important series in short-term policy making and monitoring (as is done, for example, at the Bank of Spain; see Bank of Spain (1996)). Yet TRAMO-SEATS can efficiently be used for routine application to a large number of series (as is done, for example, at Eurostat (see EUROSTAT, 1996)). For this routine-application case, fully automatic procedures are available, as described in Section 3. The standard procedure pretests for the log-level specification and, if appropriate, for the possible presence of Trading Day and Easter effects; it further performs an automatic model identification and outlier detection and correction procedures (for several types of outliers), interpolates the missing values if any, and

decomposes the series net of the previous (deterministic) effects into a seasonal, trend, cyclical, and irregular components (If the identified ARIMA model does not accept an admissible decomposition, it is automatically replaced by a decomposable approximation).

Finally, the components (and forecasts thereof) estimated by SEATS are modified to reincorporate the deterministic effects that were removed by TRAMO.

As mentioned earlier, a simple-and-fast or a more sophisticated automatic model identification procedures can be used. In practice, the difference does not amount to much. Using, for example, a 133 Mhz Pentium, it is rather unlikely that execution of either program in the automatic mode will take more than a very few seconds.

Finally, the program contains a relatively complete graphics facility.

## 2.2 Decomposition of the ARIMA Model

Let the total AR polynomial,  $\Phi(B)$ , of the ARIMA model (11) be factored as

$$\Phi(B) = \phi_r(B)\phi_s(B^s)\nabla^d\nabla_s^D.$$

The roots of  $\Phi(B)$  are assigned to the unobserved components as follows:

Roots of  $\nabla^d = 0 \Rightarrow$  Assigned to trend component.

Roots of  $\nabla_s^D = 0 \Rightarrow$  Factorizing it as  $(\nabla S)^D = 0$ , where  $S = 1 + B + \dots + B^{s-1}$ :

- the root of  $\nabla = 0$  goes to the trend;
- the roots of  $S = 0$  go to the seasonal component.

Roots of  $\phi_r(z), \Rightarrow$  Real positive roots:  
where  $z = B^{-1}$ .

- If modulus  $\geq k$ , assigned to trend.
- If modulus  $< k$ , assigned to cycle.

Real negative roots:

- If  $s \neq 1$ , assigned to seasonal.
- If  $s = 1$ , assigned to cycle.

Complex roots: Let  $w$  denote the frequency of the root.

- If  $w \in [ \text{a seasonal frequency} \pm \epsilon ]$ , assigned to seasonal.
- Otherwise, assigned to cycle.

Roots of  $\phi_s(z^*)$ ,  $\Rightarrow$   
where  $z = B^{-1}$ .

Letting  $\phi$  denote the real positive root of  
 $(-BPHI)^{\frac{1}{MQ}}$ :

- when  $\phi \geq k$ , the AR root  $(1 - \phi B)$  is assigned to the trend;
- when  $\phi < k$ , it is assigned to the cycle.

(Note: The parameters  $k$  and  $\epsilon$  can be entered by the user.)

The factorization of  $\Phi(B)$  can be rewritten as

$$\Phi(B) = \phi_p(B)\phi_s(B)\phi_c(B),$$

where  $\phi_p(B)$ ,  $\phi_s(B)$  and  $\phi_c(B)$  are the AR polynomials with the trend, seasonal, and cyclical roots, respectively. Let  $P$  and  $Q$  denote the orders of the polynomials  $\Phi(B)$  and  $\theta(B)$  in (11):

a) Consider first the case  $P \geq Q$ . A polynomial division of the spectrum (or pseudospectrum) of model (11) yields a first decomposition of the type

$$\frac{\theta(B)}{\Phi(B)}a_t = \frac{\tilde{\theta}(B)}{\Phi(B)}a_{1t} + v_1,$$

where the order of  $\tilde{\theta}(B)$  is  $\min(Q, P - 1)$ , and  $v_1$  is a constant (0 if  $P > Q$ ).

A partial fraction expansion of the spectrum of  $[\tilde{\theta}(B)/\Phi(B)]a_{1t}$  yields the decomposition

$$\frac{\tilde{\theta}(B)}{\Phi(B)}a_{1t} = \frac{\tilde{\theta}_p(B)}{\phi_p(B)}\tilde{a}_{pt} + \frac{\tilde{\theta}_s(B)}{\phi_s(B)}\tilde{a}_{st} + \frac{\tilde{\theta}_c(B)}{\phi_c(B)}\tilde{a}_{ct},$$

where, letting  $j = p, s, c$ , we have  $\text{order}(\tilde{\theta}_j) \leq \text{order}(\phi_j)$ . If  $\tilde{g}_j(w)$  denotes the spectrum of  $[\tilde{\theta}_j(B)/\phi_j(B)]\tilde{a}_{jt}$ , let

$$v_j = \min \{\tilde{g}_j(w) : 0 \leq w \leq \pi\};$$

Imposing the canonical condition

$$g_j(w) = \tilde{g}_j(w) - v_j, \quad j = p, s, c,$$

$$v = v_1 + \sum_j v_j,$$

the spectrum of the final components are obtained, which give the models for the components:

$$\begin{aligned}\phi_p(B)p_t &= \theta_p(B)a_{pt} \\ \phi_s(B)s_t &= \theta_s(B)a_{st} \\ \phi_c(B)c_t &= \theta_c(B)a_{ct} \\ u_t &= \text{white noise } (0, v)\end{aligned}$$

All components have balanced models, in the sense that the order of the AR polynomial equals that of the MA one.

b) When  $(Q > P)$ , the decomposition proceeds as follows.

A first decomposition is performed, whereby

$$\text{ARIMA}(P, Q) = \text{ARIMA}(P, P - 1) + \text{MA}(Q - P).$$

The first component falls under case a), and hence can be decomposed in the previous way. Let this decomposition be, in general,

$$\text{ARIMA}(P, P - 1) = p_t + s_t + c_t + u_t,$$

where  $p_t$ ,  $s_t$ ,  $c_t$  and  $u_t$  denote the trend, seasonal, cyclical, and irregular component. The  $\text{MA}(Q - P)$  component, which represents stationary short-term deviations, is added to the cyclical component. The series is decomposed then, into a balanced trend model, a balanced seasonal model, a top-heavy cycle model, and a white-noise irregular. The first three components are made canonical (i.e., noise-free).

As a general rule, it is recommended that balanced models be favored, since they tend to display good decomposition properties. Models for which  $Q$  is much larger than  $P$  are discouraged because the excess MA structure may provoke awkward, often nonadmissible, decompositions.

Example: The monthly model

$$(1 + .4B - .32B^2)\nabla\nabla_{12}x_t = \theta(B)a_t,$$

with  $\theta(B)$  of order  $Q = 16 (> P = 15)$ , would decompose as follows. Factorizing the AR(2), it can be rewritten as  $(1 - 4B)(1 + .8B)$ , and hence the first factor goes to the cycle (assuming  $k > .4$ ), and the second factor to the seasonal component (a peak for  $w = \pi$ ). Therefore, the models for the components will be of the type:

Trend:  $\nabla^2 p_t = \theta_p(B) a_{pt}$

Seasonal:  $(1 + .8B) S s_t = \theta_s(B) a_{st}$

Cycle:  $(1 - .4B) c_t = \theta_c(B) a_{ct}$

Irregular: White noise.

The orders of the polynomials  $\theta_p(B)$ ,  $\theta_s(B)$ , and  $\theta_c(B)$  would be 2, 12, and 1, respectively.

## 2.3 Instructions for the User

Section 1.2 of the previous TRAMO user instructions, that refers to hardware requirements, installation, execution, graphics, printing, editing, and downloading of the program, apply to SEATS in a straightforward manner, simply by replacing the word TRAMO by SEATS.

## 2.4 Description of the Input Parameters

### 2.4.1 Allocation of Regression Effects

Each *REG* namelist in TRAMO contains a value for the parameter *REGEFF*, that determines to which component each of the regression effects should be assigned. The parameter can take the following values.

<u>Parameter</u>	<u>Meaning</u>	<u>Default</u>
<i>REGEFF</i> = 0	The regression effect is a separate additional component; it is not included in the seasonally adjusted series.	0
= 1	Regression effect assigned to trend. (An example could be the case of two alternating regimes, as captured for instance by the following regression variable in TRAMO: \$REG ISEQ = 2, \$ 50 20 150 20 which creates a series of zeros, except for two stretches of 20 ones, starting at $T = 50$ and $T = 150$ .)	
= 2	Regression effect assigned to seasonal component. (An example could be a variable including national festivities.)	
= 3	Regression effect assigned to irregular component. (An example could be an effect similar to that of a transitory change with positive parameter; that is, with effects having alternating signs.)	
= 4	Regression effect is assigned to the seasonally adjusted series, but as an additional separate component. (An example could be if one wished to remove the effect of exchange rate variations before looking at the underlying trend of a variable.)	
= 5	Regression effect is assigned to the cycle (an example could be a leading indicator).	

Note 1: The regression variables with  $REGEFF = 2, 3$ , and  $5$ , are centered by the program.

Note 2: When in a *REG* Namelist,  $IUSER = -1$  and the external file has  $NSER > 1$ , the same  $REGEFF$  value will apply to all series in the file.

Note 3: The parameter  $REGEFF$  is entered in TRAMO through the *REG* namelist.

#### 2.4.2 Specification of the ARIMA Model

If  $MQ$  denotes the number of observations per year, the general model considered is the multiplicative  $(P, D, Q) \times (BP, BD, BQ)_{MQ}$  ARIMA model, subject to the constraints  $P \leq 3$ ,  $D \leq 3$ ,  $Q \leq 3$ ,  $BP \leq 1$ ,  $BD \leq 2$ ,  $BQ \leq 1$ .

The model can be written as

$$\phi_P(B) \Phi_{BP}(B^{MQ}) (z_t - \mu) = \theta_Q(B) \Theta_{BQ}(B^{MQ}) a_t,$$

where

$$z_t = \nabla^D \nabla_{MQ}^{BD} x_t,$$

and  $\mu$  is the mean of the differenced series  $z_t$ . For the most general case,

$$\begin{aligned} \nabla^D &= (1 - B)^D \\ \nabla_{MQ}^{BD} &= (1 - B^{MQ})^{BD} \\ \phi_P(B) &= 1 + PHI(1) \times B + PHI(2) \times B^2 + PHI(3) \times B^3 \\ \Phi_{BP}(B^{MQ}) &= 1 + BPHI(1) \times B^{MQ} \\ \theta_Q(B) &= 1 + TH(1) \times B + TH(2) \times B^2 + TH(3) \times B^3 \\ \Theta_{BQ}(B^{MQ}) &= 1 + BT(1) \times B^{MQ}. \end{aligned}$$

For seasonal adjustment, it is required that  $BPHI(1) \leq 0$ , since  $BPHI(1) > 0$  implies a two-year periodic component (with its twelve harmonics).

<u>Parameter</u>	<u>Meaning</u>	<u>Default</u>
$MQ$	= Number of observations per year (12 for monthly, 6 for bimonthly, 4 for quarterly, 1 for annual, ...)	12
$LAM$	= 0 Logs are taken	0
$IMEAN$	= 0 No mean correction ( $\mu = 0$ ) = 1 Mean correction ( $\mu \neq 0$ )	1
$D$	= # of regular differences	1
$BD$	= # of seasonal differences	1
$P$	= # of regular autoregressive terms	0
$BP$	= # of seasonal autoregressive terms	0
$Q$	= # of regular moving average terms	1
$BQ$	= # of seasonal moving average terms	1
$PHI$	= $P$ initial estimates of the regular autoregressive parameters (not input if $INIT = 0$ )	-
$TH$	= $Q$ initial estimates of the regular moving average parameters (not input if $INIT = 0$ )	-
$BPHI$	= $BP$ initial estimates of the seasonal autoregressive parameters (not input if $INIT = 0$ )	-
$BTH$	= $BQ$ initial estimates of the seasonal moving average parameters (not input if $INIT = 0$ )	-

Note: When  $INIT = 1$  or  $2$ , the input parameters are entered as  $PHI(i)$ ;  $TH(i)$ ;  $BPHI(i)$ ;  $BTH(i)$ , as detailed above.

The default model is thus the ARIMA model

$$\nabla \nabla_{12} \log x_t = (1 + \theta_1 B) (1 + \theta_{12} B^{12}) a_t + \mu,$$

the so-called Airline Model, analysed in Box and Jenkins (1970).

### 2.4.3 Estimation of the ARIMA Model

<u>Parameter</u>	<u>Meaning</u>	<u>Default</u>
<i>INIT</i>	= 0 Starting values for parameters computed by the program = 1 Starting values for parameter input = 2 Starting values for parameter input and no parameter estimation is done.	0
<i>TYPE</i>	= 0 Maximum likelihood estimation = 1 Constrained least squares	0
<i>MAXIT</i>	= A positive integer. Number of iterations in ARIMA estimation	20
<i>EPSIV</i>	= A small positive number. Convergence criteria for estimation of ARIMA	$10^{-3}$
<i>M</i>	= A positive number ( $M \leq 48$ ). Number of ACF and PACF printed in tables	36
<i>IQM</i>	= A positive number. Number of autocorrelations used in computing Q-statistics	24*
<i>SEK</i>	= A positive number. Number of standard deviations used for the detection of outliers in residuals	3
<i>XL</i>	= When the modulus of an estimated root falls in the range $(XL, 1)$ , it is set equal to <i>UR</i> (see below) if root is in AR polynomial. If root is in MA polynomial, it is set equal to <i>XL</i>	.98
<i>UR</i>	= Parameter to fix roots of AR polynomial (see <i>XL</i> )	-1
<i>CRMEAN</i>	= 0 Compute mean on total # of observations = 1 Compute mean on # of observations equal to the largest multiple of <i>MQ</i>	0

(\*) The default value of *IQM* depends on *MQ*. For *MQ* = 12, *IQM* = 24; for *MQ* = 2,3,4,6, *IQM* = 4*MQ*; for *MQ* = 1, *IQM* = 8.

#### 2.4.4 Forecasts and Signal Extraction

<u>Parameter</u>	<u>Meaning</u>	<u>Default</u>
<i>L</i>	= 0 ARIMA estimation only.	-1
	= A positive integer. ARIMA estimation, plus the 1- to <i>L</i> -periods-ahead forecast	
	= -1 ARIMA estimation, plus signal extraction, plus forecasting (determined by the program)	
<i>FH</i>	= A positive integer. Minimum number of forecast horizon for series and components when <i>L</i> = -1. When TRAMO has been used as a preadjustment program, <i>FH</i> = max (8, 2 × <i>MQ</i> )	8
<i>EPSPHI</i>	= When $\phi_P(B)$ contains a complex root, it is allocated to the seasonal if its frequency differs from the seasonal frequencies by less than <i>EPSPHI</i> (measured in degrees). Otherwise, it goes to the cycle.	3
<i>NOSERIE</i>	= 0 Usual case	0
	= 1 No series is used. An ARIMA model is entered ( <i>INIT</i> = 2, <i>PHI</i> (1) = ,...), and the program performs the decomposition of the model and the subsequent model-based analysis	
<i>NOADMISS</i>	= 0 When model does not accept an admissible decomposition, no approximation is made	0
	= 1 When model does not accept an admissible decomposition, it is automatically replaced with a decomposable model	

#### 2.4.5 Bias Correction

The next parameters correct for the bias that may occur in multiplicative decomposition when the period-to-period changes are relatively large when compared to the overall mean. This bias implies an underestimation of the seasonally adjusted series and of the trend in levels, caused by the fact that geometric means underestimate arithmetic means.

<u>Parameter</u>		<u>Meaning</u>	<u>Default</u>
<i>BIAS</i>	= 0	Parameter inactive; no correction is made	1
	= 1	A correction is made for the overall bias for the full length of the series and the forecasting period. (Only when <i>LAM</i> = 0.)	
	= -1	A correction is made so that, for every year (including the forecasting period), the annual average of the original series equals the annual average of the seasonally adjusted series, and also (very approximately) equals the annual average of the trend. (Only when <i>LAM</i> = 0.)	
<i>MAXBIAS</i>	= k	A positive number.	.5

When the average value of the differences (in absolute value) between the annual means of the original and seasonally adjusted series is larger than *MAXBIAS*, the parameter *BIAS* is set automatically equal to  $-1$ , and the correction is enforced. The number *k* is expressed in

#### 2.4.6 Cyclical Component

As mentioned in Section 2.2, a cyclical component can emerge from a variety of reasons. It can be the effect of a complex AR root associated with a cyclical frequency, but it can also contain stationary deviations due to a pure MA component, or to a real positive AR root of small modulus.

A cutting point is defined for the modulus of the AR root; above that point, the root is part of the trend, below that point the root is part of the cycle. The cutting point is controlled by the following parameter:

$$RMOD = k \quad (0 \leq k \leq 1) \text{ Cutting point for the modulus of an AR root.} \quad .5$$

Thus, for example, by default the AR root  $(1 - .8B)$  would be assigned to the trend, while the AR root  $(1 - .4B)$  would go to the cycle. (Recall that this cutting point also affects the real positive root of a the seasonal AR polynomial).

As a consequence, added to the irregular, the cyclical component represents the deviations with respect to the trend of a seasonally adjusted series, more in line with the concept of a business cycle (see, for example, Stock and Watson, 1988). Care should be taken, however with this interpretation. For some ARIMA

models, the derived trend may contain (as the trend–cycle component of X11) short-term variation thought undesirable by business cycle analysts. The cycle in SEATS should be seen more as a way to absorb part of the stationary variation, so as to improve estimation of the trend.

When a cycle is present, the series is decomposed (in its additive form) into a trend, seasonal, cyclical, and irregular component. The cyclical component is also made canonical and the irregular component is white noise. Of course, in most applications the irregular component can be added to the cycle to provide a “stationary” component containing short-term variations.

#### 2.4.7 Smoothing of the Trend; Use of SEATS as a “Fixed Filter”

For the default model, a facility has been introduced to obtain a smoother trend without significantly affecting the seasonally adjusted series. This is done by simply decreasing the value of the parameter  $TH(1)$  of the MA factor  $(1 + \theta B)$ . It is controlled by two input parameters:

<u>Parameter</u>		<u>Meaning</u>	<u>Default</u>
$SMTR$	= 0 = 1	Inactive The trend is further smoothed.	0
$THTR$	= $k$	$-1 < k < 0$	-.4

When  $TH(1) \leq THTR$ , nothing is done since the trend is already smooth enough. When  $TH(1) > THTR$ , it is replaced by  $THTR$ .

Note: Typically, the changes in  $TH(1)$  have little effect on the seasonal component estimator, and hence on the seasonally adjusted series. Varying  $TH(1)$  amounts thus to a redistribution of the latter into “trend + irregular” where, as the trend becomes smoother, the irregular component increases its variance and exhibits low-order autocorrelation, and hence displays more and more the characteristics of a cyclical component.

Even without the automatic model identification procedures, the use of TRAMO/SEATS with the default model,  $SMTR = 1$ , and some chosen (negative) value for  $THTR$  (that reflects the prior belief on how smooth a trend should be), provides well-behaved filters for the components, and can produce results close to those obtained with many ad-hoc filters, with the advantage of preserving a considerable capacity to adapt to the particular type of seasonality present in

the series. This way of proceeding can be seen as the simplest way SEATS can be used as a “fixed filter”.

#### 2.4.8 Other Parameters

*OUT* and *PG* = See TRAMO User Instructions (Sections 1.3.1 and 1.3.11, respectively).

<u>Parameter</u>	<u>Meaning</u>	<u>Default</u>
<i>NDEC</i>	= A positive number. Controls the number of printed decimals in some of the tables	2
<i>NDEC1</i>	= As <i>NDEC</i> , but for another set of tables	3
<i>HS</i>	= A positive number. Sets the scale for the vertical axis of the spectral graphs	1.5
<i>NANNUA</i>	= 0 Rates of Growth are not annualized = 1 Rates of Growth are annualized	1
<i>SQG</i>	= 0 Fourier Transform of component estimation filter (for graphs) = 1 (Squared) Gain of component estimation filter (for graphs)	1

## 2.5 Output File

In the most general case, the decomposition of the series that TRAMO/SEATS provide is the following one. (We use the additive version; the multiplicative one is identical, with “+” replaced by “ $\times$ ”, and “component” replaced by “factor”.) Letting  $SA$  denote “seasonally adjusted”,

serie = final  $SA$  series + final seasonal component + separate regression component;

the latter is associated with the regression variables for which  $REGEFF = 0$ . Then,

final  $SA$  series = final trend + final irregular component + final cyclical component + other regression effects included in the  $SA$  series;

the latter is associated with the regression variables for which  $REGEFF = 4$ . Next,

final trend = stochastic trend + level-shift outliers + trend regression component ( $REGEFF = 1$ );

final irregular = stochastic irregular + additive outliers + transitory-change outliers + irregular regression component ( $REGEFF = 3$ );

final cyclical = stochastic cyclical component + cyclical regression component ( $REGEFF = 5$ );

final seasonal = stochastic seasonal component + trading day + easter effect + seasonal regression component ( $REGEFF = 2$ ).

The decomposition covers the sample period and the  $\max(8, 2 \times MQ)$ -period-ahead forecast function.

In accordance with the previous decomposition, the end of the output file in SEATS contains (for the most general case) the following tables.

### ORIGINAL (UNCORRECTED) SERIES

PREADJUSTMENT COMPONENT (aggregate one from TRAMO)

LINEAR SERIES (generated by ARIMA model)

Stochastic Components

SEASONAL COMPONENT

CYCLICAL COMPONENT

IRREGULAR COMPONENT  
TREND COMPONENT  
SEASONALLY ADJUSTED SERIES.

First, the table with the point estimators is given, followed by the table with the associated STANDARD ERRORS. Next, the program prints the tables of the stochastic components' FORECASTS, as well as of the associated STANDARD ERRORS. Then follow the tables of

Deterministic Components

LEVEL-SHIFT OUTLIERS  
TRANSITORY OUTLIERS (the sum of *AO* and *TC*)  
TRADING DAY EFFECT  
EASTER EFFECT  
TREND REGRESSION COMPONENT  
SEASONAL REGRESSION COMPONENT  
IRREGULAR REGRESSION COMPONENT  
CYCLICAL REGRESSION COMPONENT  
OTHER REGRESSION COMPONENT IN *SA* SERIES  
SEPARATE REGRESSION COMPONENT (not in *SA* series).

From the combination of the stochastic and deterministic components, the tables of FINAL COMPONENTS are obtained and printed, as well as those of their FORECASTS. This ends the program.

## 2.6 Input File and Examples

The input starts with the series to be modelled, comprising no more than 600 observations, followed by one set of control parameters. To specify the set of control parameters for the series model, the NAMELIST facility is used, so that only those parameters which are not at their default values need to be set.

The series is set up as:

Card 1            TITLE (no more than 72 characters)  
Card 2            NZ NYER NPER NFREQ (free format)  
Card 3 et seq.    Z(I): I = 1, NZ (free format),

where NZ is the number of observations, NYER the start year, NPER the start period, and NFREQ is an instruction to control table format (the number of columns). Z(.) is the array of observations. (The first nonblank characters of TITLE are used by the program to create a file named \*\*\*\*\*.OUT in the subdirectory OUTPUT containing the output of the program.)

This is followed by namelist INPUT. The namelist starts with \$INPUT and terminates with \$. Other formats, such as "&INPUT ... ,/" can also be used.

### **Example 9**

The series is the monthly series of Italian production of manufactured metal from January 1990 to February 1996 (source: Eurostat).

The example illustrates some of the estimation capabilities of SEATS. In this case, SEATS fits the default model of Example 1, with the mean constrained to be zero, using the quasi-ML method in Burman (1980).

The model obtained yields a decomposition with a negative irregular spectrum and is replaced by a relatively close decomposable model. (The comparison between the components obtained with this approximation and the ones produced by X12-ARIMA is discussed in Fiorentini and Planas, 1996).

## EXAMPLE 9

PROD OF MANUFAC METAL (ITALY)

74	1990	1	12
4.5991521		4.7211739	4.6950109
4.6041697		4.7140246	4.6922649
4.6606049		3.2347492	4.7431915
4.7335634		4.6672056	4.5293685
4.6986605		4.7782828	4.7723781
4.7604631		4.7808028	4.7613189
4.6681450		3.4045252	4.8202816
4.7974421		4.7561731	4.5315236
4.8048404		4.8441871	4.8331023
4.8089270		4.7924793	4.7664383
4.7158167		3.5055574	4.8146204
4.7899886		4.8015590	4.5196123
4.7974421		4.8315086	4.7891570
4.8138091		4.7941363	4.8015590
4.8210877		3.6349511	4.8449742
4.8489004		4.8481164	4.4761998
4.8210877		4.9265288	4.8933521
4.9351931		4.8880909	4.8582608
4.8354879		3.8372995	4.9074945
4.8559289		4.8644528	4.6405373
4.7774414		4.9308703	4.9801761
4.9067552		4.9452075	4.9265288
4.8706066		3.8836235	4.9272537
4.8782461		4.8613616	4.7131273
4.7621739		4.8888442	

\$INPUT  
NOADMISS=1,imean=0,\$

### Example 10

This example illustrates the use of SEATS to analize the decomposition of an ARIMA model. No series is entered and the model parameters are, of course, fixed. The file can be created directly or by typing INPUT, then 77, and then the parameters (as explained in Section 1.2.4).

The model is given by

$$(1 - .5B^3)\nabla_{12}z_t = (1 + .2B)(1 - .4B^{12})a_t,$$

and is similar to the model used by Cleveland and Tiao (1976) as an example of X11 inadequacy.

Since  $RMOD = .8$ , the root  $1 - .794B$  in the AR polynomial of the model ( $.794 = 5^{1/3}$ ) goes to the cycle, and hence the series is decomposed into a trend, seasonal, irregular, and cyclical component. (The cycle should be interpreted simply as transitory deviations from the trend, other than pure white noise.)

## EXAMPLE 10

```
NOSERIE
      0          0          0          0
      0          0          0          0
$INPUT
NOSERIE=1,
INIT=2,rmod=.8,
LAM=1,
P=3,D=0,
PHI(1)=0,
PHI(2)=0,
PHI(3)=-.5,
TH(1)=.2,
BTTH(1)=-.4,$
```

### Example 11

The series is the quarterly series of US GNP (seasonally adjusted) in Lippi and Reichlin (1994). This example illustrates the capacity of SEATS to approximate “ad hoc” filters, and to produce more stable estimators.

SEATS fixes the ARIMA model to

$$\nabla^2 z_t = (1 - 1.7771B + .7994B^2)a_t,$$

and decomposes the series into a trend and an irregular component with the filters derived from that model.

It can be seen that the model is the one for which the Hodrick–Prescott filter is optimal (in a minimum MSE sense) to estimate a trend of the type

$$\nabla^2 p_t = b_t,$$

contaminated by noise  $u_t$  (for the standard value  $\lambda = v_u/v_b = 1600$ ). The trend component generated by SEATS is “canonical” and, as a consequence, the Hodrick–Prescott trend will be equal to the trend of SEATS + orthogonal white noise. Thus, for the same aggregate series, the SEATS trend will be smoother and the SEATS irregular will contain all white-noise variation.

## EXAMPLE 11

GNP (USA)

165	1947	1	4				
1056.5	1063.2	1067.1	1080.0	1086.8	1106.1	1116.3	
1125.5	1112.4	1105.9	1114.3	1103.3	1148.2	1181.0	
1225.3	1260.2	1286.6	1320.4	1349.8	1356.0	1369.2	
1365.9	1378.2	1406.8	1431.4	1444.9	1438.2	1426.6	
1406.8	1401.2	1418.0	1438.8	1469.6	1485.7	1505.5	
1518.7	1515.7	1522.6	1523.7	1540.6	1553.3	1552.4	
1561.5	1537.3	1506.1	1514.2	1550.0	1586.7	1606.4	
1637.0	1629.5	1643.4	1671.6	1666.8	1668.4	1654.1	
1671.3	1692.1	1716.3	1754.9	1777.9	1796.4	1813.1	
1810.1	1834.6	1860.0	1892.5	1906.1	1948.7	1965.4	
1985.2	1993.7	2036.9	2066.4	2099.3	2147.6	2190.1	
2195.8	2218.3	2229.2	2241.8	2255.2	2287.7	2300.6	
2327.3	2366.9	2385.3	2383.0	2416.5	2419.8	2433.2	
2423.5	2408.6	2406.5	2435.8	2413.8	2478.6	2478.4	
2491.1	2491.0	2545.6	2595.1	2622.1	2671.3	2734.0	
2741.0	2738.3	2762.8	2747.4	2755.2	2719.3	2695.4	
2642.7	2669.6	2714.9	2752.7	2804.4	2816.9	2828.6	
2856.8	2896.0	2942.7	3001.8	2994.1	3020.5	3115.9	
3142.6	3181.6	3181.7	3178.7	3207.4	3201.3	3233.4	
3157.0	3159.1	3199.2	3261.1	3250.2	3264.6	3219.0	
3170.4	3179.9	3154.5	3159.3	3186.6	3258.3	3306.4	
3365.1	3451.7	3498.0	3520.6	3535.2	3568.7	3587.1	
3623.0	3650.9	3698.8	3704.7	3718.0	3731.5	3772.2	
3795.3	3835.9	3880.8	3915.4				

```
$INPUT
MQ=4, lam=1, imean=0,
D=2,
BD=0,
Q=2,
BQ=0,
TH(1)=-1.7771,
TH(2)=.7994,
INIT=2,
$
```

### Example 12

The series is the annual historical series of wheat price in the Toulouse market, discussed in Grenier and Mathis (1991). The example illustrates the use of SEATS outside the context of seasonal adjustment.

The model fitted is of the type:

$$(1 + \phi_1 B + \phi_2 B^2) \nabla z_t = (1 + \theta_1 B) a_t + \mu.$$

The AR(2) polynomial contains a stationary root for a cyclical frequency (of period close to 4 years), and the series is decomposed into a trend, irregular and cyclical components, and the cyclical component represents transitory deviations from a trend, that exhibit now a periodic cycle. The use of SEATS in the context of trend estimation is discussed in Maravall (1993).

## EXAMPLE 12

WHEAT PRICE TOULOUSE (France)

241	1550	1	4				
14.00	14.00	15.00	16.00	23.00	27.00	26.00	
28.00	16.00	15.00	20.00	23.00	30.00	43.00	
32.00	36.00	37.00	25.00	21.00	21.00	24.00	
34.00	63.00	71.00	41.00	57.00	54.00	38.00	
30.00	42.00	53.00	43.00	45.00	48.00	43.00	
50.00	53.00	45.00	44.00	47.00	54.00	48.00	
87.00	90.00	52.00	73.00	48.00	60.00	83.00	
74.00	41.00	30.00	29.00	37.00	50.00	65.00	
52.00	58.00	44.00	40.00	31.00	33.00	51.00	
53.00	66.00	33.00	37.00	38.00	46.00	53.00	
54.00	52.00	61.00	46.00	39.00	34.00	35.00	
45.00	63.00	55.00	94.00	114.00	62.00	47.00	
34.00	33.00	48.00	53.00	40.00	35.00	37.00	
40.00	41.00	77.00	98.00	58.00	50.00	49.00	
47.00	54.00	66.00	82.00	111.00	144.00	94.00	
51.00	57.00	47.00	50.00	70.00	64.00	62.00	
72.00	52.00	50.00	53.00	56.00	49.00	50.00	
66.00	61.00	50.00	52.00	43.00	41.00	50.00	
57.00	62.00	66.00	60.00	57.00	45.00	45.00	
57.00	56.00	69.00	62.00	52.00	46.00	36.00	
42.00	66.00	75.00	87.00	113.00	62.00	62.00	
76.00	80.00	89.00	91.00	85.00	74.00	73.00	
79.00	65.00	57.00	51.00	72.00	147.00	114.00	
74.00	114.00	126.00	85.00	63.00	62.00	56.00	
57.00	90.00	133.00	70.00	74.00	95.00	113.00	
108.00	68.00	64.00	92.00	103.00	82.00	69.00	
68.00	83.00	91.00	88.00	77.00	98.00	98.00	
95.00	85.00	91.00	92.00	75.00	73.00	71.00	
77.00	128.00	145.00	120.00	128.00	124.00	129.00	
84.00	74.00	75.00	92.00	100.00	113.00	141.00	
132.00	109.00	91.00	102.00	128.00	125.00	157.00	
147.00	145.00	154.00	151.00	165.00	159.00	177.00	
159.00	141.00	126.00	146.00	186.00	132.00	127.00	
146.00	181.00	167.00	136.00	146.00	152.00	144.00	
166.00	199.00	186.00					

\$INPUT

p=2, imean=1, mq=1,\$

### Example 13

The series is the monthly series of Japanese exports, from January 1972 to July 1992 (source: Datastream); it is discussed in Planas (1995). The example further illustrates the allocation of the AR roots to the components and some other features of SEATS.

The model fitted is

$$(1 + \phi_1 B + \phi_2 B^2 + \phi_3 B^3) \nabla \nabla_{12} z_t = (1 + \theta_{12} B^{12}) a_t.$$

The AR(3) polynomial has one root for the 0 frequency (with modulus .64) and a pair of complex conjugate roots for the frequency  $\omega = 129^\circ$  (with modulus .75), close to the 4-times-a-year seasonal frequencies. Since, by default,  $RMOD = .5$ , the first root is assigned to the trend. As for the complex root, given that  $EPSPHI = 10$ ,  $\omega \in (120 - EPSPHI, 120 + EPSPHI)$ , and hence the root is assigned to the seasonal. Notice that, by default,  $\omega$  would not have been considered “close to a seasonal frequency” and, since it would represent non-seasonal, non-white noise transitory deviations from the trend, the complex root would have been assigned to the cycle.

In this example, the original series and the seasonally adjusted one are constrained to have identical annual means for every year of the sample and of the forecasting period (notice that the presence of the log makes the decomposition multiplicative). By default and in this case, the correction would not have been enforced.

The reduced output file is produced, instead of the full one obtained by default. This reduced output file should be enough for most applications.

### EXAMPLE 13

#### EXPORTS (JAPAN)

	252	1970		1		12			
	393.0	489.0	600.0	550.0	537.0	589.0	616.0	574.0	625.0
	639.0	562.0	781.0	452.0	594.0	772.0	682.0	683.0	736.0
	778.0	744.0	729.0	706.0	680.0	838.0	481.0	629.0	785.0
	693.0	651.0	678.0	754.0	747.0	814.0	770.0	778.0	1026.0
	562.0	800.0	798.0	747.0	749.0	791.0	878.0	791.0	882.0
	887.0	964.0	1181.0	763.0	1020.0	1227.0	1185.0	1286.0	1365.0
	1484.0	1499.0	1439.0	1630.0	1532.0	1791.0	1109.0	1320.0	1463.0
	1404.0	1283.0	1303.0	1420.0	1304.0	1358.0	1474.0	1337.0	1798.0
	1113.0	1451.0	1795.0	1596.0	1597.0	1713.0	1760.0	1581.0	1761.0
	1757.0	1652.0	2155.0	1386.0	1688.0	2019.0	1889.0	1702.0	1837.0
	1942.0	1733.0	1812.0	1838.0	1724.0	2077.0	1364.0	1793.0	2078.0
	1750.0	1751.0	1806.0	1714.0	1540.0	1699.0	1595.0	1522.0	1914.0
	1193.0	1547.0	1925.0	1674.0	1795.0	1906.0	1935.0	1797.0	2055.0
	2006.0	2049.0	2650.0	1656.0	2304.0	2655.0	2535.0	2494.0	2435.0
	2495.0	2336.0	2553.0	2501.0	2349.0	3071.0	1925.0	2464.0	2903.0
	2725.0	2748.0	2857.0	3083.0	2784.0	3028.0	3093.0	2692.0	3166.0
	2284.0	2704.0	3196.0	3032.0	2750.0	2862.0	3060.0	2684.0	3010.0
	2974.0	2741.0	3135.0	2134.0	2616.0	3070.0	2912.0	2738.0	2935.0
	3030.0	2824.0	3130.0	3032.0	2908.0	3581.0	2384.0	3098.0	3557.0
	3252.0	3256.0	3418.0	3536.0	3244.0	3560.0	3680.0	3410.0	3931.0
	2795.0	3321.0	3783.0	3783.0	3629.0	3614.0	3759.0	3298.0	3534.0
	3560.0	3242.0	3639.0	2584.0	2913.0	3177.0	3173.0	2988.0	2957.0
	3076.0	2609.0	2948.0	2953.0	2712.0	3201.0	2362.0	2635.0	2963.0
	2863.0	2606.0	2685.0	2942.0	2655.0	2910.0	2986.0	2619.0	3070.0
	2188.0	2603.0	2923.0	2826.0	2576.0	2762.0	3039.0	2776.0	3109.0
	3095.0	2842.0	3202.0	2437.0	2876.0	3392.0	3068.0	2908.0	3247.0
	3320.0	3061.0	3529.0	3286.0	3151.0	3548.0	2699.0	3190.0	3876.0
	3445.0	3380.0	3624.0	3626.0	3340.0	3686.0	3573.0	3302.0	3717.0

\$INPUT p=3,imean=0,q=0,bias=-1,epsphi=10,out=1,\$

## 2.7 Identification of the Arrays Produced by SEATS

Description of the Files in GRAPH

### 2.7.1 Series

<u>Meaning</u>	<u>Title of Graph</u>	<u>Name of File</u>
<b>Original linearized series (from TRAMO)</b>	Original series	<i>serie.t</i>
Transformed series (logs)	Transformed series (logs)	<i>tserie.t</i>
Rate of growth of original series	Series: Rate of growth	<i>rserie.t</i>
Differenced series	Differenced series	<i>differ.t</i>
<b>Seasonally adjusted series</b>	SA series	<i>seasadjo.t</i>
Seasonally adjusted series (logs)	SA series (logs)	<i>seasadjt.t</i>
Rate of growth of seasonally adjusted series	SA series: rate of growth	<i>sarate.t</i>
<b>Seasonal factors (levels)</b>	Seasonal factors	<i>seasfac.t</i>
Seasonal component (logs)	Seasonal component	<i>seas.t</i>
<b>Trend (level)</b>	Trend	<i>trendo.t</i>
Trend component (logs)	Trend component	<i>trendt.t</i>
Rate of growth of trend	Trend: Rate of growth	<i>trate.t</i>
<b>Cyclical factors (levels)</b>	Cyclical factors	<i>cyclefac.t</i>
Cyclical component (logs)	Cyclical component	<i>cycle.t</i>
<b>Irregular factors (levels)</b>	Irregular factors	<i>irregfac.t</i>
Irregular component (logs)	Irregular component	<i>irreg.t</i>
<b>ARIMA residuals</b>	Residuals	<i>resid.t</i>
<b>Pseudoinnovations in the components</b>		
Seasonally adjusted series	Pseudo-inn.: SA series	<i>pisa.t</i>
Trend	Pseudo-inn.: Trend	<i>pitrend.t</i>
Seasonal	Pseudo-inn.: Seasonal	<i>piseas.t</i>
Cyclical	Pseudo-inn.: Cycle	<i>picycle.t</i>

When TRAMO has been used as a preadjustment program, the directory GRAPH \SERIES also contains the following series:

<u>Meaning</u>	<u>Title of Graph</u>	<u>Name of File</u>
<b>Original uncorrected series (from TRAMO)</b>	Orig. uncorrect. series	<i>xorig.t</i>
<b>Aggregate Preadjustment factor</b>	Preadjustment factor	<i>preadf.t</i>
<b>Preadjustment factors (or components) from TRAMO</b>		
Level Shifts		<i>paotrf.t</i>
Transitory Outliers		<i>paoirf.t</i>
Easter Effect		<i>paeasf.t</i>
Trading Day Effect		<i>patdf.t</i>
Regression effect allocated to seasonal component ( <i>REGEFF</i> = 2)		<i>sregf.t</i>
Regression effect allocated to trend ( <i>REGEFF</i> = 1)		<i>tregf.t</i>
Regression effect is part of the irregular component ( <i>REGEFF</i> = 3)		<i>iregf.t</i>
Regression effect is allocated to the cycle ( <i>REGEFF</i> = 5)		<i>cyregf.t</i>
Regression effect is allocated to the seasonally adjusted series, as an additional component ( <i>REGEFF</i> = 4)		<i>saregf.t</i>
Regression effect is a separate component ( <i>REGEFF</i> = 0)		<i>spregf.t</i>

Note: When *LAM* = 1, the factors are the components, and the 'f' before the '.' becomes a 'c' (for ex., *paotrc.t*).

### Final Components

Seasonally Adjusted series	<i>safin.t</i>
Trend	<i>trfin.t</i>
Irregular factor (component)	<i>irfin.t</i>
Seasonal factor (component)	<i>sfin.t</i>
Cyclical factor (component)	<i>cfin.t</i>

When *OUT* = 2 (short summary output), the directory GRAPH only contains the files *series.t*, *seasadjo.t*, *trendo.t*, *irregfac.t*, and *seasfac.t*.

### 2.7.2 Autocorrelation Functions

Note: ST denotes “Stationary Transformation”.

<u>Meaning</u>	<u>Title of Graph</u>	<u>Name of File</u>
Differenced series	ACF of differenced series	<i>dauto.t2</i>
Residuals	ACF of residuals	<i>autores.t2</i>
Squared residuals	ACF of sqd residuals	<i>autosres.t2</i>
<b>Theoretical component (ST)</b>		
SA series	Comp: ACF of SA series	<i>acfitsadj.t2</i>
Seasonal	Comp: ACF of seasonal	<i>acfseas.t2</i>
Trend	Comp: ACF of trend	<i>acfotre.t2</i>
Cycle	Comp: ACF of cycle	<i>acfrcyc.t2</i>
<b>Theoretical MMSE estimator (ST)</b>		
SA series	E-tor: ACF of SA series	<i>acfrradj.t2</i>
Seasonal	E-tor: ACF of seasonal	<i>acfrrseas.t2</i>
Trend	E-tor: ACF of trend	<i>acfrrtre.t2</i>
Cycle	E-tor: ACF of cycle	<i>acfrrcyc.t2</i>
Irregular	E-tor: ACF of irregular	<i>acfrrir.t2</i>
<b>Empirical estimate (ST)</b>		
SA series	E-te: ACF of SA series	<i>acfesadj.t2</i>
Seasonal	E-te: ACF of seasonal	<i>acfeseas.t2</i>
Trend	E-te: ACF of trend	<i>acfetre.t2</i>
Cycle	E-te: ACF of cycle	<i>acfecyc.t2</i>
Irregular	E-te: ACF of irregular	<i>acfeir.t2</i>

### 2.7.3 Spectra

Aggregate ARIMA model	Spectrum series	<i>spect.t3</i>
<b>Theoretical component</b>		
SA series	Spectrum SA series	<i>spectsa.t3</i>
Seasonal component	Spectrum seasonal	<i>spects.t3</i>
Trend	Spectrum trend	<i>spectt.t3</i>
Cycle	Spectrum cycle	<i>spectc.t3</i>
<b>Theoretical MMSE estimator</b>		
SA series	Spectrum SA series est.	<i>spectesa.t3</i>
Seasonal component	Spectrum seas. est.	<i>spectses.t3</i>
Trend	Spectrum trend est.	<i>spectet.t3</i>
Cycle	Spectrum cycle est.	<i>spectec.t3</i>
Irregular	Spectrum irreg. est.	<i>spectei.t3</i>

#### 2.7.4 Filters

**Wiener–Kolmogorov filters** (estimator as function of observed series)  
 Note: TD denotes “Time Domain”; FD denotes “Frequency Domain”.

<u>Meaning</u>	<u>Title of Graph</u>	<u>Name of File</u>
SA series (TD)	SA series filter (TD)	<i>filtadj.t4</i>
SA series (FD)	SA series filter (FD)	<i>filtfadj.t4f</i>
Seasonal component (TD)	Seasonal comp. filter (TD)	<i>filts.t4</i>
Seasonal component (FD)	Seasonal comp. filter (FD)	<i>filts.t4f</i>
Trend (TD)	Trend filter (TD)	<i>filtt.t4</i>
Trend (FD)	Trend filter (FD)	<i>filtf.t4f</i>
Cyclical component (TD)	Cyclical comp. filter (TD)	<i>filtc.t4</i>
Cyclical component (FD)	Cyclical comp. filter (FD)	<i>filfc.t4f</i>
Irregular component (TD)	Irregular comp. filter (TD)	<i>filti.t4</i>
Irregular component (FD)	Irregular comp. filter (FD)	<i>filfi.t4f</i>

Note: Given that the filters are symmetric, only one side of the filter is kept.

**Psi–weights** (estimator as function of innovations in observed series)

SA series	Psi–weights: SA series	<i>psisa.t4</i>
Seasonal	Psi–weights: seasonal	<i>psiseas.t4</i>
Trend	Psi–weights: trend	<i>psitre.t4</i>
Cycle	Psi–weights: cycle	<i>psicyc.t4</i>

Note: The Psi arrays contain  $4MQ + 1$  elements, and are centered around the coefficient for  $B^0$ . Thus for the estimation of the component at period  $t$ ,  $2MQ$  weights refer to innovations prior to  $t$ , and the last  $2MQ$  weights refer to innovations posterior to  $t$ .

#### 2.7.5 Forecasts

Original series	Forecasts of orig. series	<i>forx.t5</i>
Series in logs	Forecasts of series (logs)	<i>forlx.t5</i>
Seasonal factors	Forecasts of seasonal factors	<i>forsf.t5</i>
Seasonal component	Forecasts of seas. comp.	<i>forsc.t5</i>
Trend (level)	Forecasts of trend	<i>fort.t5</i>
Trend component	Forecasts of trend comp.	<i>foric.t5</i>
Cyclical factors	Forecasts of cyclical factors	<i>forcf.t5</i>
Cyclical component	Forecasts of cyclical comp.	<i>forcc.t5</i>

<u>Meaning</u>	<u>Title of Graph</u>	<u>Name of File</u>
Preadjustment factor or component (when TRAMO has been used as a preadjustment program)	Forecast of preadjustment factor or component	<i>fdef.t5</i>
Forecast of Regression Effect	Forecast of Regression Effect	<i>freq.t5</i>

Note: Each array of component forecasts consists of three consecutive series: first, the lower and upper limits of the 95% probability interval, and then the point estimators. (The three lines displayed in the graphs.) Thus, if there are  $N$  elements in the array, the point estimator series consists of the last  $N_1 = N/3$  elements.  $N_1$  is always odd, and the center element corresponds to the last observed period. Therefore, of these last  $N_1$  elements, the first  $(N_1 + 1)/2$  are estimates (or observations) for recent periods, and the last  $(N_1 - 1)/2$  form the forecast function.

When  $L$  = a positive integer, it determines the number of forecasts computed. When  $L = -1$  (i.e., when signal extraction is performed), the number of forecasts for the series and components is equal to  $\max(2MQ, FH)$ , where  $FH = 8$  by default; see Section 2.4.4.

For example, for the default (monthly) model, the length of the array is 147. The last 49 represent the point estimates, of which the first 25 represent past and present values, and the last 24 the two-year-ahead forecast function.

### Forecasts of the Final Components

Original uncorrected series	<i>funorig.t5</i>
Seasonally Adjusted series	<i>fsafin.t5</i>
Trend	<i>ftrfin.t5</i>
Irregular factor (component)	<i>firfin.t5</i>
Seasonal factor (component)	<i>fsfin.t5</i>
Cyclical factor (component)	<i>fcycfin.t5</i>

Note: The one-to- $\max(2 \times MQ, FH)$ -period-ahead forecast function is given by the last  $\max(2 \times MQ, FH)$  elements of each array. (For example, if  $MQ = 12$ , the forecast function of the final trend consists of the last 24 elements of the array *ftrfin.t5*).

### 3 Routine use on Many Series

#### 3.1 The RSA Parameter

The programs contain a facility for routine treatment (for example, routine seasonal adjustment) of perhaps a very large number of series. This is controlled by the three input parameters *RSA*, *QMAX*, and *DVA*.

<u>Parameter</u>	<u>Meaning</u>	<u>Default</u>
<i>QMAX</i> = k	A positive number, which controls the sensitivity of the routine procedure (see below). The parameter <i>QMAX</i> is only active when <i>RSA</i> ≠ 0.	50 <sup>(*)</sup>
(*) The default value of <i>QMAX</i> depends on <i>MQ</i> . For <i>MQ</i> ≥ 6, <i>QMAX</i> = 50; for <i>MQ</i> = 4, 3, and 2, <i>QMAX</i> = 36, 30, and 24, respectively.		
<i>DVA</i> = k	A (small) number to control the criteria for outlier detection in automatic applications (see below).	0
<i>RSA</i> = 0	Parameter inactive.	0
= 1	Fast routine procedure. The program TRAMO automatically sets the following parameters: <i>LAM</i> = -1, <i>INTERP</i> = 1, <i>IATIP</i> = 1, <i>AIO</i> = 2, <i>VA</i> = see below, <i>NOADMISS</i> = 1, <i>SEATS</i> = 2.	
= 2	As before, but the following parameters are added: <i>IEAST</i> = -1, <i>ITRAD</i> = -1.	
= 3	Detailed routine procedure. As <i>RSA</i> = 1, but the following parameters are added: <i>INIC</i> = 3, <i>IDIF</i> = 3.	
= 4	As <i>RSA</i> = 3, but the following parameters are added: <i>IEAST</i> = -1, <i>ITRAD</i> = -1.	

The parameter *VA* is also set, but its value depends on the number of observations (*NZ*), in the following way:

$$\begin{aligned} NZ \leq 50, \quad VA &= 3 + DVA \\ 50 < NZ \leq 250, \quad VA &= 3.5 + DVA \\ 250 < NZ \leq 500, \quad VA &= 3.8 + DVA \\ 500 < NZ, \quad VA &= 4 + DVA. \end{aligned}$$

By default, *DVA* = 0.

Therefore, when  $RSA = 1$ , the program automatically tests for the log/level specification, interpolates missing values, corrects for three types of outliers, and estimates the default (“Airline”) model, which is passed on to SEATS. SEATS checks the autocorrelation of the residuals. If the Ljung-Box  $Q$  statistics is larger than  $QMAX$ , three other models are estimated, within SEATS, to the series linearized by TRAMO, and the results are compared. The one that provides the best fit is chosen. If the model does not provide an admissible decomposition, it is automatically approximated by a decomposable one.

When  $RSA = 2$ , the same fast routine procedure is followed, except that the pretests for Trading Day and Easter effects are included. This is done by running a regression on the Trading Day and Easter variables, with the noise following the default model.

When  $RSA = 3$  (Detailed Routine Adjustment), the program TRAMO automatically sets the same parameters for the case  $RSA = 1$ , and adds:

$$INIC = 3, \quad IDIF = 3.$$

In this case, thus, the automatic model identification procedure in TRAMO is used to determine the model. As before, nondecomposable models are approximated in SEATS. When  $RSA = 4$ , the detailed procedure is followed, but pretests for Trading Day and Easter effects are included. (The model ultimately selected will be retested for both types of effects.)

Note 1: When  $RSA \neq 0$ , the user can still enter the following parameters:  
 $MQ, DVA, OUT, MAXBIAS, XL, QMAX, IMVX, IDUR, ITER, VA$ ,  
plus the parameters for regression variables entered by the user.

Note 2:  $RSA \neq 0$       requires     $MQ \neq 1$   
 $RSA = 2,4$       requires     $MQ = 12$ .

Note 3: If there are missing observations,  $LAM = -1$  and/or  $ITRAD < 0$  and/or  $IEAST = -1$ ,  $INTERP$  should not be 1.

Two examples of an  $RSA$  input file are presented.

### Example 14

The series is the quarterly series of Austrian employment for the full period 1964–1994 (source: Institute of Economic Research, Vienna).

Setting  $RSA = 1$  implies for this series, the following parameter configuration:

$$\begin{aligned} LAM &= -1, & IATIP &= 1, & AIO &= 2, \\ SEATS &= 2, & NOADMISS &= 1, & QMAX &= 36 \text{ (since } MQ = 4) \\ VA &= 3.5 \text{ (since } NZ = 124) \end{aligned}$$

Therefore, after determining the appropriate transformation fo the data, TRAMO uses the default model for outlier removal and the results are passed on to SEATS. SEATS filters the linearized series with the model passed by TRAMO, and looks at the  $Q$ -Box-Ljung statistics for (in this case) 24 autocorrelations. If  $Q < QMAX$ , the model is accepted; otherwise SEATS tries a sequence of 3 more models and chooses the best one.

This parameter configuration could be adequate for a very robust and fast procedure for routine adjustment of very large numbers of series. It is based on the close to 50% probability of finding a model that can fit the “Airline Model” (default) structure (see Section 3.3.3), and on considering alternative models that decompose well or can be well approximated if their decomposition is non-admissible.

The parameter  $INT2 = -120$  implies that, for the last  $NZ + INT2$  ( $= 124 - 120 =$ ) 4 observations, outliers are detected but not corrected. (This may avoid unpleasant features of some outliers corrected at the end of the series.)

## EXAMPLE 14

EMPLOYMENT (Austria)

124	1964	1	4
	0.228823300000000D+07	0.236829900000000D+07	0.241292533333333D+07
	0.238563666666667D+07	0.231188466666667D+07	0.238593633333333D+07
	0.242979566666667D+07	0.23982503333333D+07	0.233790933333333D+07
	0.240194200000000D+07	0.242880800000000D+07	0.237785066666667D+07
	0.230560966666667D+07	0.23646043333333D+07	0.240656833333333D+07
	0.236141866666667D+07	0.22708103333333D+07	0.234188400000000D+07
	0.239312600000000D+07	0.235145500000000D+07	0.227850066666667D+07
	0.235907066666667D+07	0.241391200000000D+07	0.237913533333333D+07
	0.231464700000000D+07	0.23789873333333D+07	0.243716333333333D+07
	0.242598200000000D+07	0.238329066666667D+07	0.244352200000000D+07
	0.250278700000000D+07	0.248983300000000D+07	0.244354433333333D+07
	0.249960866666667D+07	0.255487300000000D+07	0.255284533333333D+07
	0.252470100000000D+07	0.259748900000000D+07	0.265455266666667D+07
	0.265648000000000D+07	0.260244066666667D+07	0.264554000000000D+07
	0.269293866666667D+07	0.268676966666667D+07	0.262494133333333D+07
	0.264241866666667D+07	0.268857800000000D+07	0.266982233333333D+07
	0.262152633333333D+07	0.26659083333333D+07	0.273306766666667D+07
	0.27229443333333D+07	0.268329866666667D+07	0.272307666666667D+07
	0.278266400000000D+07	0.275955000000000D+07	0.271692833333333D+07
	0.274134866666667D+07	0.280030100000000D+07	0.277224333333333D+07
	0.272760700000000D+07	0.276356766666667D+07	0.281539666666667D+07
	0.278830500000000D+07	0.274047100000000D+07	0.277315733333333D+07
	0.283681966666667D+07	0.280449900000000D+07	0.275880233333333D+07
	0.279190700000000D+07	0.284703866666667D+07	0.279648100000000D+07
	0.273225800000000D+07	0.276568766666667D+07	0.281190400000000D+07
	0.275554933333333D+07	0.269503700000000D+07	0.272404233333333D+07
	0.278567700000000D+07	0.273416133333333D+07	0.268498000000000D+07
	0.273323900000000D+07	0.280625766666667D+07	0.275354633333333D+07
	0.26963333333333D+07	0.274959033333333D+07	0.282475133333333D+07
	0.276795466666667D+07	0.271999500000000D+07	0.277405933333333D+07
	0.284555266666667D+07	0.278120700000000D+07	0.272500300000000D+07
	0.278169600000000D+07	0.28503443333333D+07	0.27843866666667D+07
	0.274614400000000D+07	0.279867700000000D+07	0.287390200000000D+07
	0.282319033333333D+07	0.27974343333333D+07	0.284603400000000D+07
	0.29277883333333D+07	0.287790600000000D+07	0.28572783333333D+07
	0.290986066666667D+07	0.299522000000000D+07	0.29522883333333D+07
	0.292687400000000D+07	0.298097600000000D+07	0.307062066666667D+07
	0.301093600000000D+07	0.299102500000000D+07	0.304995466666667D+07
	0.312956233333333D+07	0.30526973333333D+07	0.300399466666667D+07
	0.305177266666667D+07	0.31202133333333D+07	0.30436593333333D+07
	0.301064733333333D+07	0.30640363333333D+07	0.313829466666667D+07
	0.306995033333333D+07		

\$INPUT

MQ=4,

RSA=1, int2=-120,

\$

### Example 15

The series is the industrial production index of Example 7.

Setting  $RSA = 4$  implies the same configuration of parameters of the previous Example 14 ( $QMAX$  becomes irrelevant), and adding the more sophisticated automatic model identification procedure of TRAMO and the pretesting for log/level specification and for Trading Day and Easter effects.

Compared to Example 7, automatic outlier detection is now included (it yields precisely the “*a priori*” outlier of Example 7.) Further, holidays are treated as the “holiday effect” of Section 1.3.10, part (b), and implies simply a modification of the Trading Day variable, in the sense that, for each month, the number of working days is decreased and the number of non-working days is increased by the amount of the holidays. (In Example 7, holidays were a separate regression variable, and therefore the results of Examples 7 and 15 should not be identical, even if there were no missing observations in the former.)

## EXAMPLE 15

IPI (Spain)  
161 1983 1 12

83.60	83.30	90.60	84.50	89.30
86.90	82.80	49.90	87.80	86.80
88.90	86.60	86.50	87.20	89.90
81.60	89.80	85.60	85.80	53.30
85.40	91.60	90.20	82.60	88.60
84.60	89.20	84.80	90.60	83.80
89.50	52.40	88.30	99.00	92.90
86.20	88.40	88.00	87.50	94.60
91.20	92.50	93.70	50.40	92.10
100.30	94.90	88.10	87.60	91.90
96.60	91.40	96.30	97.30	102.90
53.10	98.40	102.00	101.10	92.10
90.20	96.50	103.40	95.00	101.20
100.30	99.60	56.40	100.80	100.90
105.80	94.50	100.70	98.70	103.40
102.10	104.80	107.70	104.60	60.00
105.00	107.30	108.80	92.70	105.00
98.90	108.40	96.00	107.10	107.10
104.40	59.80	102.40	105.70	109.20
92.40	103.70	99.00	96.80	102.20
104.00	102.30	104.50	58.90	102.80
111.80	106.10	95.30	100.30	101.10
104.30	98.30	100.30	102.80	104.50
58.80	98.90	100.70	97.30	86.70
88.20	90.30	98.00	90.20	95.30
96.80	97.50	56.90	97.10	97.00
99.50	92.00	91.10	95.20	103.50
97.00	102.10	105.50	102.70	64.20
104.90	104.40	109.20	99.90	104.20
101.50	113.90	97.40	112.00	112.70
106.20	67.40	105.60	108.10	110.40
95.20	102.70	102.40	106.40	98.40
108.40				

\$INPUT Rsa=4 va=3 ireg=1 \$  
\$REG iuser=-2 nser=1 ilong=185 \$  
holidays

## 3.2 The *ITER* Parameter

The programs contains a facility to handle in a single file many series, perhaps with different models each. This is controlled by the parameter *ITER*, which can take the following values

<u>Parameter</u>	<u>Meaning</u>	<u>Default</u>
<i>ITER</i> = 0	One series, one model (the usual input file)	0
= 1	several models are provided by the user to be applied by the program to the same series	
= 2	Several series are to be treated by the program with the same model	
= 3	Several series, each with its own specified model, are treated by the program	

When *ITER* = 1 the names of the output file are *MODEL1.OUT*, ..., *MODELn.OUT*, where *n* is the number of models (if *ITER* = 2,3 the usual *serienname.OUT*).

The structure of the input file *serie* if *ITER* > 0 is the following:

<i>ITER</i> = 1	You have to append (in any format) at the end of the usual input file the number of namelists <i>INPUT</i> (and eventually namelists <i>REG</i> ) that you want; remember that the structure of the namelists <i>INPUT</i> and <i>REG</i> is the following: <i>\$ INPUT parameter-name=parameter-value, ...,</i> <i>parameter-name=parameter-value, \$</i> <i>\$ REG parameter-name=parameter-value, ...,</i> <i>parameter-name=parameter-value, \$</i>
<i>ITER</i> = 2	You have to append (in any format) at the end of the usual input file the number of series that you want, according to the following convention: <i>1<sup>st</sup> line:</i> title <i>2<sup>nd</sup> line:</i> number of observations starting year starting period Nfreq <i>3<sup>rd</sup> to n<sup>th</sup> line:</i> observations in any format

*ITER* = 3 You have to append (in any format) at the end of the usual input file the number of pairs series-namelist that you want; the convention for the series is the same as in *ITER* = 2, and for the namelist the same as in the case *ITER* = 1

When *ITER*  $\neq$  0, TRAMO sends the output file to the subdirectory OUTPUT. The files in GRAPH \ SERIES are

if <i>ITER</i> = 1	<i>model#.</i> <i>ser</i>	original series;
	<i>model#.</i> <i>lin</i>	linearized series;
if <i>ITER</i> = 2, or <i>ITER</i> = 3	<i>title.</i> <i>ser</i>	original series;
	<i>title.</i> <i>lin</i>	linearized series;

When *ITER*  $\neq$  0, SEATS puts the output in the directory OUTPUT. For every iteration it creates the following files in the directory GRAPH \ SERIES:

if <i>ITER</i> = 1	<i>model#.</i> <i>ser</i>	series;
	<i>model#.</i> <i>tre</i>	final trend component;
	<i>model#.</i> <i>cyc</i>	final cyclical component;
	<i>model#.</i> <i>sa</i>	final seasonally adjusted series;
if <i>ITER</i> = 2, or <i>ITER</i> = 3	<i>title.</i> <i>ser</i>	original series;
	<i>title.</i> <i>tre</i>	final trend component;
	<i>title.</i> <i>cyc</i>	final cyclical component;
	<i>title.</i> <i>sa</i>	final seasonally adjusted series,

and, similarly, in the subdirectory GRAPH \ FORECAST:

<i>****.</i> <i>fx</i>	forecast of series;
<i>****.</i> <i>ftr</i>	forecast of final trend;
<i>****.</i> <i>fcy</i>	forecast of final cyclical;
<i>****.</i> <i>fsa</i>	forecast of final SA series,

where \*\*\*\* denotes '*model#*' when *ITER* = 1 and 'series *title*' when *ITER* = 2 or 3.

Five examples of *ITER* input files are given next.

Warning: When *ITER*  $\neq$  0, the program INPUT should not be executed. The input file is entered directly in "serie", and then SEATS can be run.

### Example 16

This example consists of an *ITER* file containing 4 quarterly series. The first series is the Gross Fixed Capital Formation: Building and Construction for the Total Economy. The second series is the Gross Fixed Capital Formation: Residential Building, in the private sector. The third series is the Gross Fixed Capital Formation: Other Building and Construction, in the private sector. All 3 series are for Germany. The fourth series is Employment in Agriculture, Forestry and Fishery in Italy. The source for the 4 series is Eurostat.

With  $ITER = 2$ , the same input namelist will apply to all series, and in this case they will be treated with  $RSA = 1$ . The parameter  $QMAX = 25$  will imply a more stringent requirement on the cleanliness of the residuals for the model to be accepted.

The default model turns out to be comfortably appropriate for the German series. For the Italian series, it is not, but the model

$$\nabla^2 \nabla_4 \log z_t = (1 + \theta_1 B + \theta_2 B^2)(1 + \theta_4 B^4) a_t$$

is found to be quite appropriate.

## EXAMPLE 16

BUILDING AND CONSTR (TOTAL ECON):GF Capital Form.(Germany)

106 1968 1 4				
14560.00	19660.00	20910.00	21120.00	15040.00
22430.00	24270.00	23570.00	17060.00	28710.00
30410.00	29990.00	23010.00	32960.00	34010.00
33470.00	27600.00	36080.00	35960.00	36790.00
30880.00	38760.00	37980.00	36370.00	31520.00
37130.00	36220.00	35480.00	28370.00	33860.00
34440.00	34690.00	27660.00	37130.00	37310.00
37470.00	31620.00	38590.00	38660.00	38240.00
31470.00	42670.00	42600.00	42410.00	32560.00
49730.00	50000.00	50420.00	43650.00	55090.00
55250.00	51250.00	41000.00	56950.00	56440.00
49940.00	39750.00	54520.00	54400.00	51170.00
40090.00	55220.00	57050.00	53500.00	43710.00
57310.00	57760.00	54760.00	37130.00	54830.00
57880.00	52940.00	37700.00	57650.00	60230.00
57030.00	37450.00	58720.00	62110.00	58070.00
45310.00	60880.00	62650.00	58600.00	51740.00
65130.00	65460.00	62720.00	58370.00	71840.00
73400.00	69600.00	60290.00	80570.00	82470.00
75990.00	70510.00	86820.00	88060.00	83930.00
71920.00	90650.00	92350.00	83550.00	76740.00
95530.00				

\$INPUT mq=4 rsa=1 qmax=25 iter=2 \$

RESID BUILDING (PRIVATE SECTOR):GF Capital Form (Germany)

106 1968 1 4				
7260.00	9560.00	9920.00	10330.00	7100.00
10220.00	10830.00	10870.00	7510.00	12190.00
12650.00	13090.00	10120.00	14530.00	15040.00
15650.00	13430.00	17330.00	17220.00	18210.00
15740.00	19470.00	18520.00	17850.00	14910.00
17340.00	16400.00	16230.00	12860.00	15290.00
15190.00	15770.00	13030.00	17020.00	17040.00
17690.00	15290.00	18360.00	18340.00	18300.00
15510.00	20560.00	20150.00	20140.00	16380.00
24150.00	23870.00	24150.00	21740.00	26850.00
26370.00	24570.00	20600.00	27920.00	27200.00
24090.00	19890.00	26580.00	26420.00	24930.00
20900.00	28360.00	29120.00	27390.00	23620.00
30290.00	29520.00	27610.00	19580.00	27460.00
28140.00	25670.00	19000.00	27570.00	28370.00
26890.00	18840.00	27630.00	28760.00	27350.00
22320.00	28980.00	29500.00	27810.00	25240.00
31540.00	31170.00	29980.00	29210.00	35890.00
36390.00	34370.00	31150.00	40760.00	41390.00
38130.00	36680.00	45010.00	45600.00	43670.00
39070.00	48870.00	50210.00	45920.00	43680.00

54910.00				
OTHER BUILDING AND CONSTR (PRIVATE SECTOR):GF Capital form.(Germany)				
106 1968 1 4				
3940.00	5060.00	5570.00	5440.00	4500.00
6320.00	6790.00	6670.00	5600.00	8550.00
8960.00	8720.00	7410.00	9960.00	10110.00
9630.00	8340.00	10420.00	10370.00	10150.00
9030.00	10780.00	10650.00	10090.00	9300.00
10370.00	10080.00	9420.00	8110.00	9290.00
9590.00	9230.00	8040.00	10580.00	10590.00
9860.00	9540.00	11060.00	10930.00	10220.00
9180.00	11820.00	12030.00	11830.00	9690.00
13570.00	13960.00	13990.00	12550.00	15410.00
15710.00	14760.00	12260.00	16250.00	16470.00
14940.00	12590.00	16650.00	16410.00	15600.00
12580.00	16660.00	17100.00	16230.00	13610.00
17230.00	17650.00	16960.00	12030.00	17290.00
18470.00	17180.00	12820.00	18810.00	19670.00
18730.00	13070.00	19660.00	20680.00	19460.00
15620.00	20490.00	21050.00	19940.00	17640.00
21820.00	22120.00	21250.00	19690.00	23660.00
24020.00	23220.00	19970.00	26230.00	26790.00
24830.00	23150.00	27480.00	27560.00	26210.00
22260.00	27140.00	27250.00	24470.00	22370.00
26550.00				
EMPLOYMENT AGRIC-FORES-FISH (Italy)				
97 1970 1 4				
3740.00	3822.00	3819.00	3744.00	3776.00
3867.00	3808.00	3603.00	3489.00	3512.00
3485.00	3378.00	3357.00	3442.00	3455.00
3376.00	3334.00	3378.00	3368.00	3266.00
3208.00	3240.00	3237.00	3151.00	3135.00
3234.00	3276.00	3185.00	3113.00	3126.00
3108.00	3032.00	3038.00	3131.00	3151.00
3059.00	3011.00	3079.00	3089.00	2999.00
2954.00	3018.00	3039.00	2965.00	2898.00
2901.00	2849.00	2733.00	2659.00	2704.00
2716.00	2655.00	2655.00	2758.00	2816.00
2753.00	2695.00	2723.00	2716.00	2611.00
2543.00	2585.00	2629.00	2566.00	2520.00
2567.00	2606.00	2555.00	2513.00	2537.00
2531.00	2450.00	2407.00	2437.00	2421.00
2320.00	2252.00	2282.00	2307.00	2266.00
2236.00	2257.00	2252.00	2195.00	2198.00
2266.00	2280.00	2205.00	2158.00	2178.00
2147.00	2045.00	1980.00	2000.00	2005.00
1951.00	1925.00			

### **Example 17**

The file contains two series, and the same input line applies to both. SEATS is to be run entirely by default and the Airline model will be fit to the log of both series.

The first series is the Spanish consumer price index and the second series is the same price index seasonally adjusted by SEATS run by default. (Both series are monthly). The example illustrates the idempotency properties of the default filter of SEATS. The adjusted CPI and the adjusted adjusted CPI are indistinguishable.

## EXAMPLE 17

```

CPI (Spain)
180 1978 1 12
25.5449980 25.7959900 26.1269990 26.6769870 26.9439850
27.2159880 27.8060000 28.2909850 28.5239870 28.7849880
28.9109950 29.3029940 29.8060000 30.0369870 30.3489990
30.8069920 31.1669920 31.4419860 32.1209870 32.4369960
32.8639980 33.3049930 33.3849950 33.8719940 34.8039860
35.1149900 35.3039860 35.6449890 35.8919980 36.4489900
36.9639890 37.3969880 37.7949980 38.0979920 38.4870000
39.0249940 39.8179930 40.0199890 40.8169860 41.2229920
41.4149930 41.4509890 42.2629850 42.7780000 43.1179960
43.6029970 43.9809880 44.6469880 45.5719910 45.9269870
46.3779910 46.9879910 47.6679990 48.1259920 48.7439880
49.0819850 49.1389920 49.6309970 49.7929990 50.9009860
51.7609860 52.0209960 52.3369900 53.0560000 53.2759860
53.5879970 53.7789920 54.5009920 54.9369960 55.6819920
56.2489930 57.1219940 58.0059970 58.2269900 58.6959990
58.9729920 59.2919920 59.7119900 60.6289980 61.0499880
61.1739960 61.5429990 61.8589940 62.2780000 63.4379880
63.8969880 64.2959900 64.9590000 65.1629940 65.0519870
65.4219970 65.5199890 66.2389980 66.5799870 67.0929870
67.3709870 69.3079990 69.6169890 69.8519900 70.0219880
70.2169950 70.8620000 71.5699920 71.7729950 72.5159910
72.7869870 72.6199950 72.9299930 73.4889980 73.8019870
74.2309880 74.3989870 74.3069920 74.3249970 75.0779880
75.0449980 75.7370000 76.1869960 76.0119930 76.2839970
76.7679900 76.9779970 77.5359950 77.2659910 77.2619930
77.5619960 78.5859990 79.3629910 80.0599980 80.1499940
80.1049960 80.7419890 81.6799930 81.7379910 82.2599950
82.4809880 82.5979920 83.0479890 84.3959960 84.5899960
85.4849850 85.8299870 85.9689940 86.3039860 87.1439970
87.6969910 88.0179900 88.2179870 88.2109990 88.4829860
89.6719970 90.0649870 91.0129850 91.8209990 91.7289890
91.9549870 93.0249940 92.8949890 93.1969910 93.3989870
93.6639860 93.9339900 95.0999910 95.4529880 96.2329860
96.8379970 96.9849850 97.0379940 98.5759890 99.2329860
99.5919950 99.4849850 99.7449950 99.7259980 100.0499990
100.9619900 101.7950000 101.8559900 101.9209900 102.2269900

&INPUT ITER=2,/
SA-CPI
180 1978 1 12
25.414259 25.761105 26.115735 26.617996 26.965040
27.311301 27.745434 28.221437 28.507689 28.801040
29.084870 29.404541 29.646123 29.988956 30.328751
30.743201 31.196269 31.555145 32.061744 32.374499
32.857653 33.330664 33.583299 33.981385 34.600998
35.040593 35.258253 35.567519 35.925574 36.581213
36.911006 37.346890 37.808336 38.143135 38.712876

```

39.141112	39.577262	39.923908	40.740441	41.121396
41.443656	41.599941	42.218694	42.742797	43.155315
43.668488	44.236697	44.769211	45.289826	45.803918
46.280718	46.871734	47.693474	48.287856	48.705087
49.063179	49.194963	49.709648	50.071714	51.028308
51.431498	51.861944	52.213141	52.929376	53.317147
53.779310	53.763124	54.511909	54.997375	55.758735
56.535185	57.263924	57.635524	58.030128	58.538042
58.843340	59.358648	59.938853	60.615149	61.080835
61.213361	61.607073	62.149520	62.457372	63.048215
63.671117	64.106125	64.829757	65.258189	65.317282
65.414155	65.577146	66.238426	66.609576	67.376804
67.577069	68.903495	69.373184	69.643074	69.924360
70.369648	71.179580	71.555250	71.828875	72.442308
72.746896	72.877345	73.139605	73.097830	73.569848
74.016578	74.342674	74.523905	74.703814	75.069530
75.095074	75.601282	76.082917	76.234291	76.480182
76.380557	76.752858	77.322625	77.255417	77.539008
78.002069	78.585594	79.400897	79.866663	79.995883
80.301153	80.935910	81.272745	81.502903	82.046209
82.501777	82.922125	83.546063	84.406610	84.631473
85.253255	85.628986	86.141026	86.508387	86.709417
87.436472	87.795227	88.260064	88.568205	89.034661
89.712229	90.120812	90.757352	91.582015	91.882259
92.175232	92.551480	92.604017	92.958889	93.454310
94.036563	94.524930	95.177398	95.520815	95.964966
96.593089	97.143888	97.285629	98.068905	98.897638
99.315530	99.535808	100.12312	100.34933	100.16202
101.03657	101.50792	101.60950	102.09001	102.49188

### Example 18

This example presents a case in which two different models are estimated for the same series, namely the monthly series of the Spanish monetary aggregate, ALP. The first model is the default one, and the second model is given by

$$\nabla^2 \nabla_{12} \log z_t = (1 + \theta_1 B + \theta_2 B^2)(1 + \theta_{12} B^{12}) a_t.$$

The example illustrates robustness of the results with respect to overdifferencing: the estimates of the components obtained with the two models are practically indistinguishable. Moderate amounts of overdifferencing cause hardly any problem.

## EXAMPLE 18

Monetary Aggregate ALP (Spain)		
234 1972 1 12		
2.45151700000000E-001	2.46398000000000E-001	2.49882900000000E-001
2.54443000000000E-001	2.58470500000000E-001	2.62143100000000E-001
2.69077100000000E-001	2.72612600000000E-001	2.75186300000000E-001
2.80486900000000E-001	2.84322900000000E-001	2.93022400000000E-001
3.01949200000000E-001	3.04240600000000E-001	3.09505700000000E-001
3.16344499999999E-001	3.21471600000000E-001	3.28697400000000E-001
3.39187200000001E-001	3.44358600000000E-001	3.48021600000000E-001
3.54395200000000E-001	3.59398000000001E-001	3.69259800000000E-001
3.77669900000000E-001	3.78084800000000E-001	3.83849300000000E-001
3.91140100000000E-001	3.95713400000000E-001	4.01779500000000E-001
4.12035800000000E-001	4.14382400000000E-001	4.16244900000000E-001
4.22773000000000E-001	4.27728500000000E-001	4.39612100000000E-001
4.51085600000000E-001	4.49781500000000E-001	4.56186200000000E-001
4.61744000000000E-001	4.66608000000000E-001	4.74741200000000E-001
4.88983400000000E-001	4.95576300000000E-001	4.99342300000000E-001
5.04541200000000E-001	5.10723000000000E-001	5.25554400000000E-001
5.37838599999999E-001	5.36534800000000E-001	5.42338100000000E-001
5.49126200000000E-001	5.56099500000000E-001	5.64486700000000E-001
5.80678800000001E-001	5.86461100000000E-001	5.89051000000000E-001
5.98320200000000E-001	6.05535800000000E-001	6.23240900000000E-001
6.39436800000000E-001	6.38701600000000E-001	6.45861000000000E-001
6.56627600000000E-001	6.63820000000000E-001	6.74635600000000E-001
6.95185400000000E-001	7.03772300000000E-001	7.08703400000000E-001
7.15599300000000E-001	7.20438200000000E-001	7.41514500000000E-001
7.56035100000000E-001	7.54273900000001E-001	7.64310500000000E-001
7.78869799999999E-001	7.90874200000000E-001	8.05085300000000E-001
8.33962400000000E-001	8.40376900000000E-001	8.48253600000001E-001
8.58041900000000E-001	8.64137100000000E-001	8.89867800000000E-001
9.11915999999999E-001	9.13572300000000E-001	9.27603900000000E-001
9.44107700000000E-001	9.50533300000000E-001	9.65733000000000E-001
9.97845800000000E-001	9.99156000000000E-001	1.00223100000000
1.01527890000000	1.02322410000000	1.05994590000000
1.079427801682360	1.07459400000000	1.08945090000000
1.10956550000000	1.11433460000000	1.12910570000000
1.16288590000000	1.17652350000000	1.18383290000000
1.19792870000000	1.20490630000000	1.23519230000000
1.25272800000000	1.24965790000000	1.26505840000000
1.28502910000000	1.29760860000000	1.30854950000000
1.34930810000000	1.36719290000000	1.37393650000000
1.39200730000000	1.40016850000000	1.44129890000000
1.46845350000000	1.46751290000000	1.49002850000000
1.52063790000000	1.54112280000000	1.55876820000000
1.60433110000000	1.61986100000000	1.63400960000000
1.65761830000000	1.66380140000000	1.69705700000000
1.73566450000000	1.73364760000000	1.75626540000000
1.78614410000000	1.80195430000000	1.81144910000000

1.861327900000000	1.873137100000000	1.888286200000000
1.905671800000000	1.910385500000000	1.965745500000000
2.000236200000000	1.990424800000000	2.009817800000000
2.031432100000000	2.039603800000000	2.067762200000000
2.142653400000000	2.150785300000000	2.167796900000000
2.190538400000000	2.184826600000000	2.248718100000000
2.274066400000000	2.283329700000000	2.311432800000000
2.343535500000000	2.364475500000000	2.394538300000000
2.443022369092340	2.441784700000000	2.463420300000000
2.482427000000000	2.485065600000000	2.547335200000000
2.574159000000000	2.582804100000000	2.619072000000000
2.642971000000000	2.655233900000000	2.695839800000000
2.743640504111572	2.730694500000000	2.751568900000000
2.772322300000000	2.775471700000000	2.854814300000000
2.887130500000000	2.888820200000000	2.926423500000000
2.966250500000000	2.987823300000000	3.012782900000000
3.075060700000000	3.107470300000000	3.139458900000000
3.184725600000000	3.194557000000000	3.272019499999999
3.313497700000000	3.305462700000000	3.349010400000000
3.393362200000000	3.410465900000000	3.429108600000000
3.493090400000000	3.505486400000000	3.532134800000000
3.569820500000001	3.580141700000000	3.669777700000000
3.722117100000000	3.726806100000000	3.764234899999999
3.817833600000000	3.852147299999999	3.906767000000000
4.000905100000000	3.992481400000000	4.013749400000000
4.028433300000000	4.011368300000000	4.067253376256384
4.077508500000000	4.057360000000000	4.098987200000000
4.164747800000000	4.198894200000000	4.261137400000000
4.343988400000000	4.347833500000000	4.368389800000000
4.389004500000000	4.400961600000000	4.526939100000000
4.586332500000000	4.603505900000001	4.674752900000001
4.720417500000000	4.730497800000000	4.767853200000001

\$INPUT ITER=1,\$  
 \$INPUT D=2,Q=2,IMEAN=0,\$

### Example 19

This example applies the default model to 3 series: the Spanish series of exports, of imports, and the trade balance (measured as the ratio of the former two). The example illustrates the behaviour of the default filter with respect to aggregation of series (i.e. with respect to seasonal adjustment of composite series). The difference between direct and indirect adjustment is minor.

## EXAMPLE 19

```

EXPORTS (Spain)
 155 1976 1   12
 49444.0000 48682.0000 45133.0000 38067.0000 39767.0000 47488.0000
 52028.0000 41625.0000 45400.0000 44329.0000 55267.0000 76312.0000
 51291.0000 62050.0000 63352.0000 56173.0000 68656.0000 54479.0000
 60236.0000 60335.0000 61916.0000 73630.0000 71528.0000 91661.0000
 77158.0000 88518.0000 80183.0000 86899.0000 84819.0000 83798.0000
 84636.0000 70119.0000 66863.0000 80402.0000 93158.0000 105046.0000
 92036.0000 103368.0000 98925.0000 94260.0000 101168.0000 104374.0000
103109.0000 95722.0000 77345.0000 92269.0000 119921.0000 138740.0000
 96795.0000 119534.0000 126831.0000 120935.0000 123494.0000 123797.0000
103653.0000 96898.0000 105899.0000 133477.0000 125616.0000 216258.0000
 97572.6875 129616.0000 141593.0000 132478.0000 161804.0000 176383.0000
212728.0000 150908.0000 126844.0000 151760.0000 175499.0000 231237.0000
146088.0000 203651.0000 196633.0000 170473.0000 183629.0000 160610.0000
220743.0000 130827.0000 171692.0000 168126.0000 225863.0000 279671.0000
162446.9375 188385.0625 269524.2500 173623.1250 283792.0000 252020.3750
234237.7500 196265.9375 228235.8125 251133.4375 292554.4375 306381.5625
300383.0000 304328.0000 332838.0000 290566.0000 332370.0000 329840.0000
318266.0000 238763.0000 279975.0000 339210.0000 316525.0000 348064.0000
319779.0625 315178.0000 334498.0000 312250.0000 387798.0000 306971.0000
373121.2500 266327.3125 280446.9375 380393.8750 366700.0000 460679.6875
262048.0000 324444.1250 301816.2500 357067.3125 309480.2500 337888.8750
358475.6250 202038.0000 261781.7500 360970.5000 346161.0000 378053.0000
292547.0000 339213.0000 339605.6875 331736.0000 393349.0000 345999.0000
403641.0000 239238.1875 347911.4375 345673.0000 398127.0000 418583.0000
294990.0000 406433.0000 419178.0000 374945.0000 414450.0000 397143.0000
401256.0000 259475.0000 437628.0000 374514.0000 456696.0000
$INPUT ITER=2,$
IMPORTS
 155 1976 1   12
 81340.0000 90740.0000 87283.0000 92280.0000 108751.0000 98371.0000
 96072.0000 97390.0000 95857.0000 93761.0000 105296.0000 123209.0000
 77842.0000 108640.0000 102936.0000 107108.0000 126357.0000 114519.0000
103206.0000 121754.0000 122954.0000 118206.0000 122513.0000 124490.0000
122322.0000 131534.0000 103278.0000 110231.0000 129592.0000 136299.0000
127650.0000 96058.0000 108285.0000 126094.0000 124969.0000 115226.0000
118058.0000 137256.0000 116264.0000 125669.0000 141187.0000 123371.0000
159249.0000 130306.0000 138853.0000 163418.0000 171654.0000 178722.0000
159990.0000 189853.0000 192576.0000 224908.0000 189324.0000 207563.0000
188045.0000 152988.0000 245218.0000 208279.0000 224281.0000 267627.0000
174331.0000 225444.0000 247724.0000 244997.0000 272892.0000 269039.0000
258690.0000 227697.0000 206856.0000 323611.0000 231887.0000 287270.0000
244025.0000 261139.0000 295343.0000 298748.0000 270346.0000 299403.0000
292100.0000 228846.0000 266101.0000 238904.0000 361268.0000 409316.0000
312048.1875 336754.2500 355977.6250 341221.2500 382700.5000 347066.5625
329253.5000 300734.4375 286826.8750 336327.6250 394985.2500 452574.0000
395458.6250 380705.3750 370659.1250 340281.0000 416519.8750 364381.8750

```

466714.0000 298013.6250 331545.0000 444087.0000 422288.8125 398336.3750  
 429676.8750 404920.0000 400468.0000 436364.3750 466257.0000 414403.0000  
 393292.8125 345976.8125 374880.7500 437928.7500 413940.0000 555129.5625  
 329502.0625 374747.0625 372795.6875 416947.0625 390024.6875 459939.6875  
 456881.8125 279095.0000 384625.3125 512148.7500 451016.0000 463044.0000  
 368530.0000 495839.0000 500334.1250 503945.0000 513999.0000 484132.0000  
 589572.0000 371218.5000 513396.4375 601960.0000 538550.0000 548363.0000  
 428556.0000 559184.0000 608968.0000 576878.0000 592526.0000 607677.0000  
 565997.0000 482257.0000 643753.0000 624850.0000 654830.0000

EXP-IMP

	155	1976	1	12
6.0786821e-01	5.3649989e-01	5.1708809e-01	4.1251625e-01	3.6567020e-01
4.8274390e-01	5.4155217e-01	4.2740528e-01	4.7362217e-01	4.7278719e-01
5.2487274e-01	6.1937034e-01	6.5891164e-01	5.7115243e-01	6.1545038e-01
5.2445196e-01	5.4334940e-01	4.7572019e-01	5.8364824e-01	4.9554840e-01
5.0357044e-01	6.2289562e-01	5.8384008e-01	7.3629207e-01	6.3077778e-01
6.7296669e-01	7.7638026e-01	7.8833540e-01	6.5450799e-01	6.1481009e-01
6.6303173e-01	7.2996523e-01	6.1747241e-01	6.3763541e-01	7.4544887e-01
9.1165188e-01	7.7958292e-01	7.5310369e-01	8.5086527e-01	7.5006565e-01
7.1655322e-01	8.4601730e-01	6.4747031e-01	7.3459396e-01	5.5702794e-01
5.6461956e-01	6.9862048e-01	7.7628943e-01	6.0500656e-01	6.2961344e-01
6.5860232e-01	5.3770875e-01	6.5228920e-01	5.9643096e-01	5.5121381e-01
6.3336994e-01	4.3185655e-01	6.4085674e-01	5.6008311e-01	8.0805748e-01
5.5969786e-01	5.7493657e-01	5.7157562e-01	5.4073315e-01	5.9292321e-01
6.5560383e-01	8.2232788e-01	6.6275796e-01	6.1319952e-01	4.6895810e-01
7.5682984e-01	8.0494657e-01	5.9865997e-01	7.7985670e-01	6.6577843e-01
5.7062474e-01	6.7923698e-01	5.3643417e-01	7.5571037e-01	5.7168139e-01
6.4521366e-01	7.0373874e-01	6.2519515e-01	6.8326428e-01	5.2058286e-01
5.5941406e-01	7.5713818e-01	5.0882858e-01	7.4155116e-01	7.2614421e-01
7.1142068e-01	6.5262209e-01	7.9572673e-01	7.4669286e-01	7.4067180e-01
6.7697562e-01	7.5958136e-01	7.9937931e-01	8.9796251e-01	8.5390016e-01
7.9796912e-01	9.0520419e-01	6.8192940e-01	8.0118149e-01	8.4445550e-01
7.6383682e-01	7.4954626e-01	8.7379416e-01	7.4423149e-01	7.7837104e-01
8.3526774e-01	7.1557171e-01	8.3172585e-01	7.4075477e-01	9.4871108e-01
7.6978370e-01	7.4809639e-01	8.6862047e-01	8.8587718e-01	8.2985976e-01
7.9528486e-01	8.6576829e-01	8.0960231e-01	8.5638525e-01	7.9348887e-01
7.3463735e-01	7.8461347e-01	7.2390405e-01	6.8061498e-01	7.0481574e-01
7.6751379e-01	8.1645157e-01	7.9382140e-01	6.8411924e-01	6.7875780e-01
6.5827819e-01	7.6527192e-01	7.1467905e-01	6.8463394e-01	6.4446731e-01
6.7766625e-01	5.7424580e-01	7.3925726e-01	7.6333195e-01	6.8833478e-01
7.2683231e-01	6.8834159e-01	6.4995545e-01	6.9946298e-01	6.5354292e-01
7.0893662e-01	5.3804299e-01	6.7980732e-01	5.9936625e-01	6.9742681e-01

### **Example 20**

This example illustrates the case in which each series has a different input. The first series is the Spanish monthly series of car registrations. The automatic treatment of TRAMO is enforced (pretesting for log transformation, automatic model identification, and automatic outlier detection). The second series is the quarterly aggregate of the first one. A similar treatment is made to this series, except that the quarterly frequency has to be specified. The example illustrates the consistency versus time aggregation of the programs.

## EXAMPLE 20

### CAR-REGISTRATION (Spain)

240	1971	1	12
.2883500	.3392800	.4326900	.4072800
.4114200	.4497600	.4566700	.3018800
.2967100	.3259600	.3220400	.2986300
.3196600	.3841000	.5040700	.4121700
.4454100	.4963700	.4969800	.3427400
.3753500	.4241600	.4203400	.4456400
.5091500	.4493300	.5770900	.5063600
.4997700	.5338200	.5198100	.3361700
.4293500	.5479400	.5456500	.4973200
.4776000	.4765400	.5977800	.5025400
.4930800	.5473700	.6100300	.3765300
.4037000	.4430300	.4296900	.3993400
.4394800	.4721400	.4639400	.5148800
.4365800	.5213600	.6198100	.4059000
.3596800	.5069300	.4851700	.4960100
.4976100	.4276200	.5965000	.5836500
.5690000	.5220000	.6350600	.3025800
.4309300	.5344900	.5333000	.5640300
.4997600	.5922100	.6905500	.5955400
.6492600	.6359200	.6537700	.3746700
.4670200	.4993800	.5005900	.4699200
.5063600	.5096200	.6945600	.7280700
.6018800	.5880100	.5371600	.4141600
.4801600	.5181700	.5222600	.4399200
.5937400	.4342800	.5609800	.5167900
.6707900	.5596000	.5472200	.4383400
.4700500	.4495500	.5994900	.3656900
.3790500	.4519400	.5083300	.4751800
.5825400	.4436300	.5182100	.3547800
.4568400	.5994300	.5035700	.4679900
.3950200	.3913700	.4077500	.4758100
.4936800	.4499700	.4868700	.3049400
.3464800	.4291000	.3993300	.4768400
.4187300	.4309100	.5372900	.4487500
.4566900	.4693100	.5323600	.3069400
.3378800	.4584300	.4893200	.4707200
.4860200	.4233100	.5512100	.4500200
.5360800	.4594500	.4982100	.3696700
.3528800	.4601700	.4419000	.4754400
.4764300	.3971600	.4642200	.5040400
.5064300	.4174400	.5641200	.3619200
.3069700	.4325700	.4026600	.3883300
.4674400	.3754900	.5418500	.5164300
.4378100	.4272000	.6648900	.3339100
.3292700	.5752100	.4904700	.5905500
.2933000	.4108800	.5573200	.5238800

.5940800	.6753700	.8271600	.4439400
.4573400	.7129100	.6844900	.7098400
.5951000	.6865000	.8438000	.8609500
.8028800	.7987800	1.1054300	.5950100
.5576400	.7869000	.7844500	.8652000
.8101200	.8171300	1.0475600	.7591200
.9786800	1.0241900	1.0674100	.7749300
.6943100	.8657600	.8908900	.9621000
.8680300	.9721500	1.0972700	.9481700
1.0078000	1.1788300	1.1387700	.7561000
.7258600	.9460900	.9154300	.9392300
.8548500	.8487200	1.0581000	.9107600
.9656300	.9394200	1.0785700	.7520800
.5184700	.7725800	.7070200	.6637400

\$INPUT RSA=3,ITER=3,\$

QUAT-CAR REG

80	1971	1	4
1.0603200e+00	1.2684600e+00	1.0552600e+00	9.4663000e-01
1.2078300e+00	1.3539500e+00	1.2150700e+00	1.2901400e+00
1.5355700e+00	1.5399500e+00	1.2853300e+00	1.5909100e+00
1.5519200e+00	1.5429900e+00	1.3902600e+00	1.2720600e+00
1.3755600e+00	1.4728200e+00	1.3853900e+00	1.4881100e+00
1.5217300e+00	1.6746500e+00	1.3685700e+00	1.6318200e+00
1.7825200e+00	1.8807200e+00	1.4954600e+00	1.4698900e+00
1.7105400e+00	1.9179600e+00	1.4314800e+00	1.4803500e+00
1.5890000e+00	1.7471800e+00	1.4556100e+00	1.4147300e+00
1.3393200e+00	1.5013500e+00	1.3298300e+00	1.5709900e+00
1.1941400e+00	1.4194600e+00	1.1382900e+00	1.3052700e+00
1.3869300e+00	1.3747500e+00	1.1771800e+00	1.4184700e+00
1.4605400e+00	1.4455500e+00	1.2207600e+00	1.3775100e+00
1.3378100e+00	1.4279100e+00	1.2330100e+00	1.2235600e+00
1.3847800e+00	1.3814400e+00	1.3280700e+00	1.6562300e+00
1.2615000e+00	1.7933300e+00	1.7284400e+00	2.1072400e+00
2.1254000e+00	2.4626100e+00	2.2580800e+00	2.4365500e+00
2.6748100e+00	2.7619900e+00	2.5366500e+00	2.7187500e+00
2.9374500e+00	3.1348000e+00	2.6207300e+00	2.8007500e+00
2.7616700e+00	2.8158100e+00	2.3491200e+00	2.1433400e+00

\$INPUT MQ=4,RSA=3,\$

### 3.3 An Application

The performance of TRAMO / SEATS, applied in an entirely automatic manner with the more sophisticated model identification procedure of TRAMO, has been analysed in some detail by Börn Fischer and Berthold Feldmann at Eurostat on 13227 series. The series were short-term indicators (all activities) for all 15 European Union member states, the European aggregates, USA, and Japan. We summarize some of their findings.

- 64% of the series follow a multiplicative model; for 36% the components are additive.
- 50% of the series can be modelled with the default model (i.e., an Airline-type model).
- For 87% of the series the fit obtained was good, for an additional 11% the fit was reasonably acceptable, and only for 2% the fit was poor. In fact, the authors concluded “(Automatic) modelization works much better than expected !”.
- 15% of the series showed a stationary behaviour; for 2% of all series the order of the regular differencing was larger than 1.
- 50% of the series did not require outlier adjustment; 27% presented one outlier; 23% presented two or more outliers,

Split into four groups of indicators, the results are the following

	Production	Other Indicators	Foreign Trade	Business Surveys	TOTAL
No. of Series	2627	2577	6976	1047	13227
Mult/addit model (%)	63/37	59/41 <sup>a)</sup>	75/25	7/93 <sup>b)</sup>	64/36
Airline model $(0, 1, 1) \times (0, 1, 1)_s$ (%)	71	37	49	31	50
Differencing order < 1 / > 1 (%)	8/0.4	5/7	19 /0.3	32/0	15/2
AR or MA regular polynomial > 2 (%)	5	11	6	3	7
Ljung Box: good/ bad (%)	88/1	77/7	90/1	92/0.6	87/2
No seasonality found (%)	1	9	7	47	9
Outliers none/one/more (%)	44/22/34	43/23/34	54/30/26	54/25/21	50/27/23

- a) splitted up into indicators, the percentage of the **multiplicative** model is  
employment: 29% / turnover: 77% / new orders: 76%
- b) since the balance can be negative, the model for most of the series is **additive**

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BPHI 14, 67	JPR 14
JPS 14	JQR 14
JQS 14	

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INCON 17	INIT 17, 68
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IGRBAR 18	TSIG 18

## **Forecasting**

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LOGN 19	

## **Missing Observations**

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## **Outliers**

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DELTATC 20	ISTDV 21
AIO 21	INT1 21
INT2 21	

## **Regression**

### **a) Easter and Trading Day Effects**

IEAST 23	IDUR 23
ITRAD 23	INTD1 23
INTD2 23	

### **b) Regression and Intervention Variables; Holiday Effect**

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IUSER 24	NSER 25
ILONG 25	ISEQ 25
DELTA 25	DELTAS 25
ID1DS 25	REGEFF 26, 65

## **Others**

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UR 26, 68	XL 26, 68

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THTR 71

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