

# **IRIS Toolbox Reference Manual**

Version #20130523

Runs in Matlab<sup>®</sup> R2010a or later

by

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23 May 2013



## Preface

IRIS is a Matlab<sup>®</sup> toolbox for macroeconomic modelling. It is free, open-source software distributed under BSD licence terms. The current version of IRIS runs in Matlab R2010a or later.

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## Preface

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Part I —  
**IRIS sessions**

# 1 Installing IRIS

## Requirements

- Matlab R2009a or later.

## Optional components

### —*Optimization Toolbox*

The Optimization Toolbox is needed to compute the steady state of non-linear models, and to run estimation.

### —*LaTeX*

LaTeX is a free typesetting system used to produce PDF reports in IRIS. We recommend MiKTeX, available from [www.miktex.org](http://www.miktex.org).

## Components not needed

Some components were needed in the past but are not any longer.

### —*X12-ARIMA*

Courtesy of the U.S. Census Bureau, the X12-ARIMA program is now incorporated in, and distributed with IRIS. You don't need to care about anything to be able to use it.

### —*Symbolic Math Toolbox*

IRIS is now equipped with its own symbolic/automatic differentiator, so you do not need to have the Symbolic Math Toolbox installed to be able to compute exact Taylor expansions.

## Installing IRIS

### —*Step 1*

Download the latest IRIS zip archive, IRIS\_Tbx\_#\_YYYYMMDD.zip, from [www.iris-toolbox.com](http://www.iris-toolbox.com), and save it in a temporary location on your disk.

### —*Step 2*

Unzip the archive into a folder on your hard drive, e.g. C:\IRIS\_Tbx. We will call this directory the IRIS root folder.

## Installing IRIS

Installing IRIS on a network drive may cause some minor problems, especially on MS Windows systems; check out help `changeNotification` in Matlab.

### —*Step 3*

After installing a new version of IRIS, we recommend that you remove all older versions of IRIS from the Matlab search path, and restart Matlab.

### —*Getting started*

Each time you want to start working with IRIS, run the following line

```
>> addpath C:\IRIS_Tbx; irisstartup
```

where `C:\IRIS_Tbx` needs to be, obviously, replaced with the proper IRIS root folder chosen in Step 2 above.

Alternatively, you can put the IRIS root folder permanently on the Matlab search path (using the menu File - Set Path), and only run the `irisstartup` command at the beginning of each IRIS session.

See also the section on [Starting and quitting IRIS](#) P10.

### **Syntax highlighting**

You can get the model files (i.e. the files that describe the model equations, variables, parameters) syntax-highlighted. Syntax highlighting improves enormously the readability of the files. It helps you understand the model better, and discover typos and mistakes more quickly.

Add any number of extensions you want to use for model files (such as `'mod'`, `'model'`, etc.) to the Matlab editor. Open the menu File - Preferences, and click on the Editor/Debugger - Language tab (make sure `'Matlab'` is selected at the top as the Language). Use the Add button in the File extensions panel to associate any number of new extensions with the editor. Re-start the editor. The IRIS model files will be syntax highlighted from that moment on.

## 2 Starting, quitting, and configuring IRIS

This section describes how to start and quit an IRIS session, and how to customise some of the IRIS configuration options.

The most common way of starting an IRIS session (after you have installed the IRIS files on your disk) is to run the following line in the Matlab command window:

```
addpath C:\IRIS_Tbx; irisstartup();
```

The first command, `addpath`, adds the IRIS root folder to the Matlab search path. The second command, `irisstartup`, initialises IRIS and puts the other necessary IRIS subfolders, classes, and internal packages on the search path. Never add these other subfolders, classes and packages to the search path by yourself.

### Starting and quitting IRIS

- `irisstartup` [P16](#) - Start an IRIS session.
- `irisfinish` [P11](#) - Close the current IRIS session.
- `iriscleanup` [P11](#) - Remove IRIS from Matlab and clean up.

### Getting information about IRIS

- `irisget` [P12](#) - Query current IRIS config options.
- `irisroot` [P14](#) - Current IRIS root folder.
- `irisrequired` [P13](#) - Throw error if the installed version of IRIS fails to comply with the required minimum.
- `irisversion` [P18](#) - Current IRIS version.

### Changes in configuration

- `irisset` [P15](#) - Change configurable IRIS options.
- `irisreset` [P14](#) - Reset IRIS configuration options to start-up values.
- `irisuserconfig` [P17](#) - User configuration file called at the IRIS start-up.

## Getting on-line help on configuration functions

```
help config  
help function_name
```

---

### ■ **iriscleanup**

Remove IRIS from Matlab and clean up

#### Syntax

```
iriscleanup
```

#### Description

This script removes IRIS folders, including the root folder, from both the Matlab search path, and clears persistent variables in some of the backend functions. A short message is displayed with the list of folders removed from the path.

---

### ■ **irisfinish**

Close the current IRIS session

#### Syntax

```
irisfinish  
irisfinish -shutup
```

#### Description

This function removes all IRIS subfolders from the temporary Matlab search path, and clears persistent variables in some of the backend functions. A short message is displayed with the list of

subfolders removed from the path unless you call use the option `-shutup`. Note that the IRIS root folder stays on the permanent Matlab path.

## Example

---

## ■ `irisget`

Query current IRIS config options

### Syntax

```
Value = irisget(Option)
S = irisget()
```

### Input arguments

- `Option` [ char ] - Name of the queried IRIS configuration option.

### Output arguments

- `Value` [ ... ] - Current value of the queried configuration option.
- `S` [ struct ] - Structure with all configuration options and their current values.

### Description

You can view any of the modifiable options listed in [`irisset`](#) [P15], plus the following non-modifiable ones (these cannot be changed by the user):

- `'userConfigPath='` [ char ] - The path to the user configuration file called by the last executed [`irisstartup`](#) [P16].
- `'irisRoot='` [ char ] - The current IRIS root directory.
- `'version='` [ char ] - The current IRIS version string.

When called without any input arguments, the `irisget` function returns a struct with all options and their current values.

### Example

```
irisget('dateformat')
```

```
ans =
```

```
YFP
```

```
g = irisget();  
g.dateformat
```

```
ans =
```

```
YFP
```

---

## ■ irisrequired

Throw error if the installed version of IRIS fails to comply with the required minimum

### Syntax

```
irisrequired(V)
```

### Input arguments

- V [ char ] - Text string describing the oldest acceptable distribution of IRIS.

### Description

If the version of IRIS present on the computer does not comply with the minimum requirement v, an error is thrown.

### Example

All of the three calls are valid:

```
irisrequired(20111222);  
irisrequired('20111222');  
irisrequired 20111222;
```

---

## ■ irisreset

Reset IRIS configuration options to start-up values

### Syntax

```
irisreset
```

### Description

The `irisreset` function resets all configuration options to their default factory values, or to those in the active `irisuserconfig.m` file (if one exists).

---

## ■ irisroot

Current IRIS root folder

### Syntax

```
irisroot  
X = irisroot()
```

### Output arguments

- X [ char ] - Path to the IRIS root folder.

### Description

The `irisroot` function is equivalent to the following call to `irisget` P12

```
iriset('irisroot')
```

---

## ■ `iriset`

### Change configurable IRIS options

#### Syntax

```
iriset(Option,Value)
iriset(Option,Value,Option,Value,...)
```

#### Input arguments

- `Option` [ char ] - Name of the IRIS configuration option that will be modified.
- `Value` [ ... ] - New value that will be assigned to the option.

#### Modifiable IRIS configuration options

##### —*Dates and formats*

- `'dateFormat='` [ char | `'YPF'` ] - Date format used to display dates in the command window, CSV databases, and reports. Note that the default date format for graphs is controlled by the `'plotdateFormat='` option. The default `'YFP'` means that the year, frequency letter, and period is displayed. See also help on `dat2str` [P263](#) for more date formatting details. The `'dateFormat='` option is also found in many IRIS functions whenever it is relevant, and can be used to overwrite the `'iriset='` settings.
- `'freqLetters='` [ char | `'YHQBM'` ] - Five letters used to represent the five possible frequencies of the IRIS dates: yearly, half-yearly, quarterly, bi-monthly, and monthly, such as the `'Q'` in `'2010Q1'` denoting.
- `'months='` [ cellstr | {`'January',...,'December'`} ] - Twelve strings representing the names of the twelve months. This option can be used whenever you want to replace the default English names with your local language. .
- `'plotDateFormat='` [ char | `'Y:P'` ] - Date format used to display dates in graphs including graphs in reports. The default is `'Y:P'`, which is different from the `'dateFormat='` option.

## Starting, quitting, and configuring IRIS: irisstartup

- 'tseriesFormat=' [ char | empty ] - Format string for displaying time series data on the screen. See help on the Matlab sprintf function for how to set up format strings. If empty the default format of the num2str function is used.
- tseriesMaxWSpace=' [ numeric | 5 ] - Maximum number of white spaces printed between individual columns of a multivariate tseries object on the screen.
- 'standinMonth=' [ 'first' | 'last' | numeric ] - This option specifies which month will be used to represent lower-frequency periods (such as a quarters) when a month-displaying format is used in 'dateformat='.

### —External tools used by IRIS

- 'pdflatexPath=' [ char ] - Location of the pdflatex.exe program. This program is called to compile report and publish m-files. By default, IRIS attempts to locate pdflatex.exe by running TeX's kpsewhich, and which on Unix platforms.
- 'epstopdfPath=' [ char ] - Location of the epstopdf.exe program. This program is called to convert EPS graphics files to PDFs in reports.

### —Other options

- 'extensions=' [ cellstr | {'model','s','q'} ] - List of extensions that are automatically associated with the Matlab editor. The advantage of such associations is that the IRIS [model files](#) [P23], [steady-state files](#) [P182], and [quick-report](#) [P421] files get syntax-highlighted.

## Description

## Example

---

## ■ irisstartup

Start an IRIS session

## Syntax

```
irisstartup
irisstartup -shutup
```

## Description

We recommend that you keep the IRIS root directory on the permanent Matlab search path. Each time you wish to start working with IRIS, you run `irisstartup` from the command line. At the end of the session, you can run `irisfinish` [P11](#) to remove IRIS subfolders from the temporary Matlab search path, and to clear persistent variables in some of the backend functions.

The `irisstartup` [P16](#) performs the following steps:

- Adds necessary IRIS subdirectories to the temporary Matlab search path.
- Removes redundant IRIS folders (e.g. other or older installations) from the Matlab search path.
- Resets IRIS configuration options to default, updates the location of TeX/LaTeX executables, and calls `irisuserconfig` [P17](#) to modify the configuration option.
- Associates the default IRIS extensions with the Matlab Editor. If they had not been associated before, Matlab must be re-started for the association to take effect.
- Prints an introductory message on the screen unless `irisstartup` is called with the `-shutup` input argument.

---

## ■ irisuserconfig

User configuration file called at the IRIS start-up

### Syntax

```
function c = irisuserconfig(c)
    c.option = value;
    c.option = value;
    ...
end
```

### Description

You can create your own configuration file to modify the general IRIS options of your choosing at each IRIS start-up. The file must be saved as `irisuserconfig.m` on the Matlab search path.

The `irisuserconfig.m` file must be an m-file function taking one input argument (a struct with the factory settings), and returning one output argument (a struct with the user-modified settings); see [irisset](#) [P15] for the list of options you can change. In addition, you can also add your own new options, which will be then also accessible through [irisset](#) [P15] and [irisget](#) [P12].

### Example

If you want the names of months to be displayed in Finnish, create the following m-file and save it in a folder which is on the Matlab search path:

```
function c = irisuserconfig(c)
    c.months = { ...
        'Tammikuu','Helmikuu','Maaliskuu', ...
        'Huhtikuu','Toukokuu','Kesakuu', ...
        'Heinakuu','Elokuu','Syyskuu', ...
        'Lokakuu','Marraskuu','Joulukuu'};
end
```

This modification will take effect after you next run [irisstartup](#) [P16]. Your graphs will be then fluent in Finnish:

```
x = tseries(mm(2009,1):mm(2009,6),@rand);
plot(x,'dateformat','MmmYY');
```

---

## ■ irisversion

Current IRIS version

### Syntax

```
irisversion
X = irisversion()
```

### Output arguments

- X [ char ] - String describing the currently installed IRIS version.

**Description**

The version string consists of the generation number, followed by a dot and the distribution date (yyyymmdd).

The irisversion function is equivalent to the following call to calling irisget('version').

### 3 Getting on-line help

Use either help or idoc to get help on IRIS functions:

- help displays the help topic in the command window,
- idoc displays the help topic in an HTML browser window.

The following help topics are available:

```
help dates
help dates/function_name
help dbase
help dbase/function_name
help modellang
help modellang/keyword
help model
help model/function_name
help plan
help plan/function_name
help poster
help poster/function_name
help logdist
help logdist/function-name
help sstatelang
help sstatelang/keyword
help sstate
help sstate/function_name
help tseries
help tseries/function_name
help VAR
help VAR/function_name
help SVAR
help SVAR/function_name
help BVAR
help BVAR/function_name
help FAVAR
help FAVAR/function_name
help report
help report/function_name
help qreportlang
help qreportlang/keyword
```

## Getting on-line help

```
help qreport  
help qreport/keyword  
help grfun  
help grfun/function_name
```

You can use idoc instead of help in the above list.

Part II —  
**Modelling**

## 4 Model file language

Model file language is used to write model files. The model files are plain text files (saved under any filename with any extension) that describes the model: its equations, variables, parameters, etc. The model file, on the other hand, does not describe what to do with the model. To run the tasks you want to perform with the model, you need first to load the model file into Matlab using the `model` [P119](#) function. This function creates a model object. Then you write your own m-files using Matlab and IRIS functions to perform the desired tasks with the model object.

Why do all the keywords (except pseudofunctions) start with an exclamation point? Why do the comments have the same style as in Matlab? Why do substitutions and steady-state references use the dollar sign? Because this way, you can get the model files syntax-highlighted in the Matlab editor. Syntax highlighting improves enormously the readability of the files, and helps understand the model more quickly. See [the setup instructions](#) [P8](#) for more details.

### Variables, parameters, substitutions and functions

- `!transition_variables` [P52](#) - List of transition variables.
- `!transition_shocks` [P51](#) - List of transition shocks.
- `!measurement_variables` [P44](#) - List of measurement variables.
- `!measurement_shocks` [P43](#) - List of measurement shocks.
- `!exogenous_variables` [P31](#) - List of exogenous variables.
- `!parameters` [P46](#) - List of parameters.
- `!autoexogenise` [P29](#) - Definition of variable/shock pairs for use in autoexogenised simulation plans.

### Equations

- `!transition_equations` [P50](#) - Block of transition equations.
- `!measurement_equations` [P42](#) - Block of measurement equations.
- `!dtrends` [P30](#) - Block of deterministic trend equations.
- `!links` [P40](#) - Define dynamic links.

### Linearised and log-linearised variables

- `!log_variables` [P41](#) - List of log-linearised variables.
- `!allbut` [P29](#) - Inverse list of log-linearised variables.
- `<...>` [P56](#) - Regular expression in log-variable list.

### Model pseudofunctions

Pseudofunctions do not start with an exclamation point.

- `min` [P60](#) - Define the loss function in a time-consistent optimal policy model.

### Special operators

- `!!` [P28](#) - Steady-state version of an equation.
- `!!` [P27](#) - Beginning of aliasing in descriptions and labels.
- `!ttrend` [P54](#) - Linear time trend in deterministic trend equations.
- `{...}` [P64](#) - Lag or lead.
- `&` [P55](#) - Reference to the steady-state level of a variable.
- `=#` [P56](#) - Mark an equation for exact non-linear simulation.

### Preparser pseudofunctions

Pseudofunctions do not start with an exclamation point.

- `diff` [P57](#) - First difference pseudofunction.
- `dot` [P59](#) - Gross rate of growth pseudofunction.
- `difflog` [P58](#) - First log-difference pseudofunction.
- `movavg` [P61](#) - Moving average pseudofunction.
- `movprod` [P63](#) - Moving product pseudofunction.
- `movsum` [P62](#) - Moving sum pseudofunction.

### Preparser control commands

- `!substitutions` [P47] - Define text substitutions.
- `!import` [P39] - Include the content of another model file.
- `!export` [P32] - Create a carry-around file to be saved on the disk.
- `!if...!elseif...!else...!end` [P37] - Choose block of code depending on a condition.
- `!switch...!case...!end` [P48] - Switch among several branches of the model code depending on the value of an expression.
- `!for...!do...!end` [P32] - For loop for automated creation of model code.
- `%` [P54] - Line comments.
- `%{...%}` [P54] - Block comments.

### Getting on-line help on model file language

When getting help on model file language, type the names of the keywords and commands without the exclamation point:

```
help modellang
help modellang/!keyword
help modellang/!command
help modellang/pseudofunction
```

### Matlab functions and user functions in model files

You can use any of the built-in functions (Matlab functions, functions within the Toolboxes you have on your computer, and so on). In addition, you can also use your own functions (written as an m-file) as long as the m-file is on the Matlab search path or in the current directory.

In your own m-file functions, you can also (optionally) supply the first derivatives that will be used to compute Taylor expansions when the model is being solved, and also the second derivatives that will be used when the function occurs in a loss function. Functions in which you wish to use your own derivative must be listed in a `!userdiff` [P??] section in the model file.

Furthermore, the function itself must comply with the following requirements. When asked for the derivatives, the function is called with two extra input arguments on top of that function's regular input arguments. The first extra input argument is a text string 'diff' (indicating the call to the function is supposed to return a derivative). The second extra input argument is a number or a

## Model file language

vector of two numbers; it determines with respect to which input argument or arguments the first derivative or the second derivative is requested.

For instance, your function takes three input arguments, `myfunc(x,y,z)`. To be able to supply derivatives avoiding thus numerical differentiation, the function must be written so that the following three calls

```
myfunc(x,y,z,'diff',1)
myfunc(x,y,z,'diff',2)
myfunc(x,y,z,'diff',3)
```

return the first derivative wrt to the first, second, and third input argument, respectively, while

```
myfunc(x,y,z,'diff',[1,2])
```

returns the second derivative wrt to the first and second input arguments. Note that second derivatives are only needed for functions that occur in an equation defining optimal policy objective, [min](#) P60.

If any of these calls fail, the respective derivative will be simply evaluated numerically.

### Basic rules IRIS model files

- There can be four types of equations in IRIS models: transition equations which are simply the endogenous dynamic equations, measurement equations which link the model to observables, deterministic trend equations which can be added at the top of measurement equations, and dynamic links which can be used to link some parameters or steady-state values to each other.
- There can be two types of variables and two types of shocks in IRIS models: transition variables and shocks, and measurement variables and shocks.
- Each model must have at least one transition (aka endogenous) variable and one transition equation.
- Each variable, shock, or parameter must be declared in the appropriate declaration section.
- The declaration sections and equations sections can be written in any order.
- You can have as many declaration sections or equations sections of the same kind as you wish in one model file; they all get combined together at the time the model is being loaded.
- Transition variables can occur with lags and leads in transition equations. Transition variables cannot, though, have leads in measurement equations.

## Model file language: !!

- Measurement variables and the shocks cannot have any lags or leads.
  - Transition shocks cannot occur in measurement equations, and the measurement shocks cannot occur in transition equations.
  - Exogenous variables can only occur in dtrends (deterministic trend equations), and must be always supplied in the input database to commands like `model/simulate`, `model/jforecast`, `model/filter`, `model/estimate`, etc. They are not returned in the output databases.
  - You can choose between linearisation and log-linearisation for each individual transition and measurement variable. Shocks are always linearised. Exogenous variables must be always introduced so that their effect on the respective measurement variable is linear.
- 

### ■ !!

#### Beginning of aliasing in descriptions and labels

#### Syntax in descriptions of variables, shocks, and parameters

```
'Description !! Alias' Name
```

#### Syntax in equations labels

```
'Label !! Alias' Equation;
```

#### Description

When used in descriptions of variables, shocks, and parameters, or in equation labels, the double exclamation mark starts an alias (but the exclamation marks are not included in it). The alias can be used to specify, for example, a LaTeX code associated with the variable, shock, parameter, or equation. The aliases can be retrieved from the model code by using the appropriate query in the function `model/get` [P100](#).

#### Example

```
!transition_variables  
  'Output gap !!  $\hat{y}_t$ ' Y_GAP
```

## Model file language: !!

In the resulting model object, the description of the variables `Y_GAP` will be

```
Output gap
```

while its alias will be

```
 $\hat{y}_t$ .
```

---

### ■ !!

Steady-state version of an equation

#### Syntax

```
Equation !! Steady_state_equation;
```

#### Description

For each transition or measurement equation, you can provide a separate steady-state version of it. The steady-state version is used when you run the `sstate` [P138](#) function. This is useful when you can substantially simplify some parts of the dynamic equations, and help therefore the numerical solver to achieve faster and more accurate results.

Why is a double exclamation point, `!!`, used to start the steady-state versions of equations? Because if you associate your model file extension with the Matlab editor, anything after an exclamation point is displayed red making it easier to spot the steady-state equations.

#### Example 1

The following steady state version will be, of course, valid only in stationary models where we can safely remove lags and leads.

```
Lambda = Lambda{1}*(1+r)*beta !! r = 1/beta - 1;
```

## Example 2

```
log(A) = log(A{-1}) + epsilon_a !! A = 1;
```

---

## ■ !allbut

Inverse list of log-linearised variables

### Syntax

```
!log_variables  
  !allbut  
  VARIABLE_NAME, VARIABLE_NAME,  
  VARIABLE_NAME, ...
```

### Description

See help on [!log\\_variables](#) [P41](#).

---

## ■ !autoexogenise

Definition of variable/shock pairs for use in autoexogenised simulation plans

### Syntax

```
!autoexogenise  
  Variable_Name := Shock_Name; Variable_Name := Shock_Name;  
  Variable_Name := Shock_Name;
```

### Description

The section !autoexogenise defines variable/shock pairs that can be used to automate the creation of exogenise-endogenise types of [simulation plans](#) [P152](#) using the function [autoexogenise](#) [P153](#).

## Example

---

### ■ !dtrends

Block of deterministic trend equations

#### Syntax for linearised measurement variables

```
!dtrends
  Variable_Name += Expression;
  Variable_Name += Expression;
  Variable_Name += Expression;
  ...
```

#### Syntax for log-linearised measurement variables

```
!dtrends
  log(Variable_Name) += Expression;
  log(Variable_Name) += Expression;
  log(Variable_Name) += Expression;
  ...
```

#### Syntax with equation labels

```
!dtrends
  'Equation label' Variable_Name += Expression;
  'Equation label' LOG(Variable_Name) += Expression;
```

## Description

### Example

```
!dtrends
  Infl += pi_;
  Rate += rho_ + pi_;
```

## ■ !exogenous\_variables

List of exogenous variables

### Syntax

```
!exogenous_variables
  Variable_Name, Variable_Name, ...
  ...
```

### Syntax with descriptors

```
!exogenous_variables
  Variable_Name, Variable_Name, ...
  'Description of the variable...' Variable_Name
```

### Syntax with steady-state values

```
!exogenous_variables
  Variable_Name, Variable_Name, ...
  Variable_Name = Value
```

### Description

The `!exogenous_variables` keyword starts a new declaration block for exogenous variables, i.e. variables that can appear only in `!dtrends` [\[P30\]](#) equations. The names of the variables must be separated by commas, semi-colons, or line breaks. You can have as many declaration blocks as you wish in any order in your model file: They all get combined together when you read the model file in. Each variable must be declared (exactly once).

You can add descriptors to the variables (enclosed in single or double quotes, preceding the name of the variable); these will be stored in, and accessible from, the model object. You can also assign steady-state values to the variables straight in the model file (following an equal sign after the name

Model file language: !for...!do...!end

of the variable); this is, though, rather rare and unnecessary practice because you can assign and change steady-state values more conveniently in the model object.

### Example

```
!exogenous_variables
  X, 'Tax effects' Y
  'Population growth effects' Z = 0 + 0.5i;
```

---

## ■ !export

Create a carry-around file to be saved on the disk

### Syntax

```
!export(FILENAME)
  FILE_CONTENTS
!end
```

### Description

You can include in the model file the contents of files you need or want to carry around together with the model; a typical example is your own m-file functions used in the model equations.

The file or files are created and save under the name specified in the !export keyword at the time you load the model using the function [model](#) [P119]. The contents of the export files is are also stored in the model objects. You can manually re-create and re-save the files by running the function [export](#) [P90].

Note that if no filename is provided or FILENAME is empty, the corresponding !export block is discarded without an error or warning.

---

## ■ !for...!do...!end

For loop for automated creation of model code

### Short-cut syntax

```
!for
  List_of_Tokens
!do
  Template
!end
```

### Full syntax

```
!for
  ?Control_Name = List_of_Tokens
!do
  Template
!end
```

### Description

Use the '!for...!do...!end' command to specify a template and let the IRIS preparser automatically create multiple instances of the template by iterating over a list of tokens. The preparser cycles over the individual strings from the list; in each iteration, the current string is used to replace all occurrences of the control variable in the template. The name of the control name is either a question mark, '?', in the abbreviated syntax, or any string (not to blank spaces) specified by the user starting with a question mark in the full syntax, such as '?x', '?#', '?NAME', etc.

The tokens (text strings) in the list must be separated by commas, blank spaces, or line breaks and they themselves must not contain any of those. In each iteration,

- all occurrences of the control variable in the template are replaced with the currently processed string;
- all occurrences in the template of ?.Control\_Name are replaced with the currently processed string converted to lower case; this option is NOT available with the short-cut syntax;
- all occurrences in the template of ?:Control\_Name are replaced with the currently processed string converted to upper case; this option is NOT available with the short-cut syntax;

The list of tokens can be based on Matlab expressions. The expressions must be enclosed in square brackets, and must evaluate into either a numeric vector, a char vector, or a cell array of numerics and/or strings.

Model file language: !for...!do...!end

### Example 1

In a model code file, instead of writing a number of definitions of growth rates like the following ones

```
dP = P/P{-1} - 1;  
dW = W/W{-1} - 1;  
dX = X/X{-1} - 1;  
dY = Y/Y{-1} - 1;
```

you can use '!for...!do...!end' as follows:

```
!for  
  P, W, X, Y  
!do  
  d? = ?/?{-1} - 1;  
!end
```

### Example 2

We redo the example 1, but using now the fact that you can have as many variable declaration sections or equation sections as you wish. The '!for...!do...!end' structure can therefore not only produce the equations for you, but also make sure all the growth rate variables are properly declared.

```
!for  
  P, W, X, Y  
!do  
  !transition_variables  
    d?  
  !transition_equations  
    d? = ?/?{-1} - 1;  
!end
```

The preparser expands this structure to the following :

```
!transition_variables  
  dP  
!transition_equations
```

Model file language: !for...!do...!end

```
dP = P/P{-1} - 1;
!transition_variables
dW
!transition_equations
dW = W/W{-1} - 1;
!transition_variables
dX
!transition_equations
dX = X/X{-1} - 1;
!transition_variables
dY
!transition_equations
dY = Y/Y{-1} - 1;
```

Obviously, you now do not include the growth rate variables in the section where you declare the rest of the variables.

### Example 3

In a model code file, instead of writing a number of autoregression processes like the following ones

```
X = rhox*X{-1} + ex;
Y = rhoY*Y{-1} + ey;
Z = rhoz*Z{-1} + ez;
```

you can use '!for...!do...!end' as follows:

```
!for
?# = X, Y, Z
!do
?# = rho?.#*?{-1} + e?.#;
!end
```

### Example 4

We redo Example 3, but now for six variables named 'A1', 'A2', 'B1', 'B2', 'C1', 'C2', nesting two '!for...!do...!end' structures one within the other:

Model file language: !for...!do...!end

```
!for
  ?letter = A, B, C
!do
  !for
    ?number = 1, 2
  !do
    ?letter?number = rho?.letter?number*?letter?number{-1}
    + e?.letter?number;
  !end
!end
```

The preparser produces the following six equations:

```
A1 = rhoa1*A1{-1} + ea1;
A2 = rhoa2*A2{-1} + ea2;
B1 = rhob1*B1{-1} + eb1;
B2 = rhob2*B2{-1} + eb2;
C1 = rhoc1*C1{-1} + ec1;
C2 = rhoc2*C2{-1} + ec2;
```

### Example 5

We use a Matlab expression (the colon operator) to simplify the list of tokens. The following block of code

```
!for
  1, 2, 3, 4, 5, 6, 7
!do
  a? = a?{-1} + res_a?;
!end
```

can be simplified as follow:

```
!for
  [ 1 : 7 ]
!do
  a? = a?{-1} + res_a?;
!end
```

## ■ !if...!elseif...!else...!end

Choose block of code depending on a condition

**Syntax with else and elseif clauses**

```
!if Condition1
    Block1
!elseif Condition2
    Block2
!elseif Condition3
    ...
!else
    Block3
!end
```

**Syntax with an else clause only**

```
!if Condition1
    Block1
!else
    Block2
!end
```

**Syntax without an else clause**

```
!if Condition
    Block1
!end
```

### **Description**

The !if...!elseif...!else...!end command works the same way as its counterpart in the Matlab programming language.

## Model file language: !if...!elseif...!else...!end

Use the !if...!else...!end command to create branches or versions of the model code. Whether a block of code in a particular branch is used or discarded, depends on the condition after the opening !if command and the conditions after subsequent !elseif commands if present. The condition must be a Matlab expression that evaluates to true or false. The condition can refer to model parameters, or to other fields included in the database passed in through the option 'assign=' in the `model` [P119](#) function.

### Example 1

```
!if B < Inf
    % This is a linearised sticky-price Phillips curve.
    pi = A*pi{-1} + (1-A)*pi{1} + B*log(mu*rmc);
!else
    % This is a flexible-price mark-up rule.
    rmc = 1/mu;
!end
```

If you set the parameter B to Inf in the parameter database when reading in the model file, then the flexible-price equation,  $rmc = 0$ , is used and the Phillips curve equation discarded. To use the Phillips curve equation instead, you need to re-read the model file with B set to a number other than Inf. In this example, B needs to be, obviously, declared as a model parameter.

### Example 2

```
!if exogenous == true
    x = y;
!else
    x = rho*x{-1} + epsilon;
!end
```

When reading the model file in, create a parameter database, include at least a field named exogenous in it, and use the 'assign=' option to pass the database in. Note that you do not need to declare exogenous as a parameter in the model file.

```
P = struct();
P.exogenous = true;
...
m = model('my.model', 'assign=', P);
```

In this case, the model will contain the first equation,  $x = \rho \cdot x_{-1} + \epsilon$ ; will be used, and the other discarded. To use the other equation,  $x = y$ , you need to re-read the model file with `exogenous` set to `false`:

```
P = struct();
P.exogenous = false;
...
m = model('my.model', 'assign=', P);
```

You can also use an abbreviate syntax to assign control parameters when readin the model file; for instance

```
m = model('my.model', 'exogenous=', true);
```

---

## ■ !import

Include the content of another model file

### Syntax

```
!import(FILENAME)
```

### Description

The `!import` command loads the content of the specified file `FILENAME`. This allows you to split the model code into several parts (each saved in a separate file) and to reuse some bits of the model.

### Example

```
!import(measurement_equations.model)
```

---

## ■ !links

Define dynamic links

### Syntax

```
!links
  Parameter_Name := Expression;
  Variable_Name := Expression;
```

### Syntax with equation labels

```
!links
  'Equation label' Parameter_Name := Expression;
  'Equation label' Variable_Name := Expression;
```

### Description

The dynamic links relate a particular parameter (or steady-state value) on the LHS to a function of other parameters or steady-state values on the RHS. Expression can be any expression involving parameter names, variables names, Matlab functions and constants, or your own m-file functions on the path; it must not refer to any lags or leads. Expression must evaluate to a single number. It is the user's responsibility to properly handle the imaginary (i.e. growth) part of the steady-state values.

The links are automatically refreshed in [solve](#) [P134](#), [sstate](#) [P138](#), and [chksstate](#) [P76](#) functions, and also in each iteration within the [estimate](#) [P82](#) function. They can also be refreshed manually by calling [refresh](#) [P124](#).

The links must not involve parameters occurring in [!dtrends](#) [P30](#) equations that will be estimated using the 'outoflik=' option of the [estimate](#) [P82](#) function.

### Example

```
!links
  R := 1/beta;
  alphak := 1 - alphan - alpham;
```

## ■ !log\_variables

List of log-linearised variables

### Syntax

```
!log_variables  
    VARIABLE_NAME, VARIABLE_NAME,  
    VARIABLE_NAME, ...
```

### Inverted syntax

```
!log_variables  
    !allbut  
    VARIABLE_NAME, VARIABLE_NAME,  
    VARIABLE_NAME, ...
```

### Syntax with regular expression(s)

```
!log_variables  
    VARIABLE_NAME, VARIABLE_NAME,  
    VARIABLE_NAME, ...  
    <REGEXP>, <REGEXP>, ...
```

### Description

List all log-variables under this headings. Only measurement or transition variables can be declared as log-variables.

In non-linear models, all variables are linearised around the steady state or a balanced-growth path. If you wish to log-linearise some of them instead, put them on a !log\_variables list. You can also use the !allbut keyword to indicate an inverse list: all variables will be log-linearised except those listed.

To create the list of log-variables, you can also use regular expressions, each enclosed in a pair of angle brackets, < and >. All measurement and transition variables whose names match one of the regular expressions will be declared as log-variables. See also help on regular expressions in the Matlab documentation.

### Example 1

The following block of code will cause the variables Y, C, I, and K to be declared as log-variables, and hence log-linearised in the model solution, while r and pie will be linearised:

```
!transition_variables
  Y, C, I, K, r, pie

!log_variables
  Y, C, I, K
```

You can do the same job by writing

```
!transition_variables
  Y, C, I, K, r, pie

!log_variables
  !allbut
  r, pie
```

### Example 2

We again achieve the same result as above, but now using a regular expression.

```
!transition_variables
  Y, C, I, K, r, pie

!log_variables
  <[A-Z]\w*>
```

The regular expression `[A-Z]\w*` selects all variables whose names start with an upper-case letter. Hence, again the variables Y, C, I, and K will be declared as log-variables.

---

## ■ !measurement \_ equations

Block of measurement equations

## Syntax

```
!measurement_equations
    Equation1;
    Equation2;
    Equation3;
    ...
```

## Syntax with equation labels

```
!measurement_equations
    Equation1;
    'Equation label' Equation2;
    Equation3;
    ...
```

## Description

The `!measurement_equations` keyword starts a new block of measurement equations; the equations can stretch over multiple lines and must be separated by semi-colons. You can have as many equation blocks as you wish in any order in your model file: They all get combined together when you read the model file in.

You can add descriptive labels to the equations (in single or double quotes, preceding the equation); these will be stored in, and accessible from, the model object.

## Example

```
!measurement_equations
    'Inflation observations' Infl = 40*(P/P{-1} - 1);
```

---

## ■ !measurement\_shocks

List of measurement shocks

## Syntax

```
!measurement_shocks
  SHOCK_NAME, SHOCK_NAME, ...
  ...
```

## Syntax with descriptors

```
!measurement_shocks
  SHOCK_NAME, SHOCK_NAME, ...
  'Description of the shock...' SHOCK_NAME
```

## Description

The `!measurement_shocks` keyword starts a new declaration block for measurement shocks (i.e. shocks or errors to measurement equation); the names of the shocks must be separated by commas, semicolons, or line breaks. You can have as many declaration blocks as you wish in any order in your model file: They all get combined together when you read the model file in. Each shock must be declared (exactly once).

You can add descriptors to the shocks (enclosed in single or double quotes, preceding the name of the shock); these will be stored in, and accessible from, the model object.

## Example

```
!measurement_shocks
  u1, 'Output measurement error' u2
  u3
```

---

## ■ !measurement\_variables

List of measurement variables

## Syntax

```
!measurement_variables
```

Model file language: !measurement\_variables

```
Variable_Name, Variable_Name, ...  
...
```

### Syntax with descriptors

```
!measurement_variables  
  Variable_Name, Variable_Name, ...  
  'Description of the variable...' Variable_Name
```

### Syntax with steady-state values

```
!measurement_variables  
  Variable_Name, Variable_Name, ...  
  Variable_Name = Value
```

### Description

The `!measurement_variables` keyword starts a new declaration block for measurement variables (i.e. observables); the names of the variables must be separated by commas, semi-colons, or line breaks. You can have as many declaration blocks as you wish in any order in your model file: They all get combined together when you read the model file in. Each variable must be declared (exactly once).

You can add descriptors to the variables (enclosed in single or double quotes, preceding the name of the variable); these will be stored in, and accessible from, the model object. You can also assign steady-state values to the variables straight in the model file (following an equal sign after the name of the variable); this is, though, rather rare and unnecessary practice because you can assign and change steady-state values more conveniently in the model object.

For each individual variable in a non-linear model, you can also decide if it is to be linearised or log-linearised by listing its name in the `!log_variables` [P41](#) section.

### Example

```
!measurement_variables  
  pie, 'Real output' Y  
  'Real exchange rate' Z = 1 + 1.05i;
```

## ■ !parameters

List of parameters

### Syntax

```
!parameters
  parameter_name, parameter_name, ...
  ...
```

### Syntax with descriptors

```
!parameters
  parameter_name, parameter_name, ...
  'Description of the parameter...' parameter_name
```

### Syntax with steady-state values

```
!parameters
  parameter_name, parameter_name, ...
  parameter_name = value
```

### Description

The !parameters keyword starts a new declaration block for parameters; the names of the parameters must be separated by commas, semi-colons, or line breaks. You can have as many declaration blocks as you wish in any order in your model file: They all get combined together when you read the model file in. Each parameters must be declared (exactly once).

You can add descriptors to the parameters (enclosed in single or double quotes, preceding the name of the parameter); these will be stored in, and accessible from, the model object. You can also assign parameter values straight in the model file (following an equal sign after the name of the parameter); this is, though, rather rare and unnecessary practice because you can assign and change parameter values more conveniently in the model object.

## Example

```
!parameters
  alpha, 'Discount factor' beta
  'Labour share' gamma = 0.60
```

---

## ■ !substitutions

Define text substitutions

### Syntax

```
!substitutions
  SUBSTITUTION_NAME := TEXT_STRING;
  SUBSTITUTION_NAME := TEXT_STRING;
  ...
```

### Description

The `!substitutions` starts a block with substitution definitions. The definition of each substitution must begin with the name of the substitution, followed by a colon-equal sign, `:=`, and a text string ended with a semi-colon. The semi-colon is not part of the substitution.

The substitutions can be used in any of the model equations, i.e. in [transition equations](#) [P50](#), [measurement equations](#) [P42](#), [deterministic trend equations](#) [P30](#), and [dynamic links](#) [P40](#). Each occurrence of the name of a substitution enclosed in dollar signs, i.e. `$substitution_name$`, in model equations will be replaced with the text string from the substitution's definition.

Substitutions can also refer to other substitutions; make sure, though, that they are not recursive. Also, remember to parenthesise the definitions of the substitutions (or the references to them) in the equations properly so that the resulting mathematical expressions are evaluated properly.

### Example

```
!substitution
  a := ((omega1+omega2)/(omega1+omega2+omega3));
```

Model file language: !switch...!case...!otherwise...!end

```
!transition_equations
  X = $a$^2*Y + (1-$a$^2)*Z;
```

In this example, we assume that omega1, omega2, and omega3 are declared as parameters. The equation will expand to

$$X = ((\omega_1 + \omega_2) / (\omega_1 + \omega_2 + \omega_3))^2 * Y + \dots \\ (1 - ((\omega_1 + \omega_2) / (\omega_1 + \omega_2 + \omega_3))^2) * Z;$$

Note that if had not used the outermost parentheses in the definition of the substitution, the resulting expression would not have given us what we meant: The square operator would have only applied to the denominator.

---

## ■ !switch...!case...!otherwise...!end

Switch among several branches of the model code depending on the value of an expression

### Syntax with an otherwise clause

```
!switch Expression
  !case Value1
    Block1
  !case Value2
    Block2
  ...
  !otherwise
    Otherwise_Block
!end
```

### Syntax without an otherwise clause

```
!switch Expression
  !case Value1
    Block1
  !case Value2
```

Model file language: !switch...!case...!otherwise...!end

```
    Block2
    ...
!end
```

## Description

The !switch...!case...!otherwise...!end command works the same way as its counterpart in the Matlab programming language.

Use the !switch...!case...!end command to create a larger number of branches of the model code. Which block of code is actually read in and which blocks are discarded depends on which value in the !case clauses matches the value of the !switch expression. This works exactly as the switch...case...end command in Matlab. The expression after the !switch part of the command must be a valid Matlab expression, and can refer to the model parameters, or to other fields included in the parameter database passed in when you run the `model` [P119](#) function; see [the option 'assign='](#) [P119](#).

If the expression fails to be matched by any value in the !case clauses, the branch in the !otherwise clause is used. If it is a !switch command without the !otherwise clause, the whole command is discarded. The Matlab function `isequal` is used to match the !switch expression with the !case values.

## Example

```
!switch policy_regime

!case 'IT'
    r = rho*r{-1} + (1-rho)*kappa*pie{4} + epsilon;

!case 'Managed_exchange_rate'
    s = s{-1} + epsilon;

!case 'Constant_money_growth'
    m-m{-1} = m{-1}-m{-2} + epsilon;

!end
```

When reading the model file in, create a parameter database, include at least a field named `policy_regime` in it, and use the option `'assign='` to pass the database in. Note that you do not need to declare `policy_regime` as a parameter in the model file.

## Model file language: !transition\_equations

```
P = struct();
P.policy_regime = 'Managed_exchange_rate';
...
m = model('my.model', 'assign', P);
```

In this case, the managed exchange rate policy rule,  $s = s_{-1} + \text{epsilon}$ ; is read in and the rest of the !switch command is discarded. To use another branch of the !switch command you need to re-read the model file again with a different value assigned to the policy\_regime field of the input database.

---

## ■ !transition \_equations

Block of transition equations

### Syntax

```
!transition_equations
    Equation1;
    Equation2;
    Equation2;
    ...
```

### Short-cut syntax

```
!equations
    Equation1;
    Equation2;
    Equation3;
    ...
```

### Syntax with equation labels

```
!transition_equations
    Equation1;
    'Equation label' Equation2;
    Equation3;
```

...

### Description

The !transition\_equations keyword starts a new block of transition equations (i.e. endogenous equations); the equations can stretch over multiple lines and must be separated by semi-colons. You can have as many equation blocks as you wish in any order in your model file: They all get combined together when you read the model file in.

You can add descriptive labels to the equations (in single or double quotes, preceding the equation); these will be stored in, and accessible from, the model object.

### Example

```
!transition_equations
  'Euler equation' C{1}/C = R*beta;
```

---

## ■ !transition\_shocks

List of transition shocks

### Syntax

```
!transition_shocks
  shock_name, shock_name, ...
  ...
```

### Short-cut syntax

```
!shocks
  shock_name, shock_name, ...
  ...
```

## Syntax with descriptors

```
!transition_shocks
  shock_name, shock_name, ...
  'Description of the shock...' shock_name
```

## Description

The `!transition_shocks` keyword starts a new declaration block for transition shocks (i.e. shocks to transition equation); the names of the shocks must be separated by commas, semi-colons, or line breaks. You can have as many declaration blocks as you wish in any order in your model file: They all get combined together when you read the model file in. Each shock must be declared (exactly once).

You can add descriptors to the shocks (enclosed in single or double quotes, preceding the name of the shock); these will be stored in, and accessible from, the model object.

## Example

```
!transition_shocks
  e1, 'Aggregate supply shock' e2
  e3
```

---

## ■ !transition\_variables

List of transition variables

### Syntax

```
!transition_variables
  Variable_Name, Variable_Name, ...
  ...
```

### Short-cut syntax

```
!variables
```

## Model file language: !transition\_variables

```
Variable_Name, Variable_Name, ...  
...
```

### Syntax with descriptors

```
!transition_variables  
  Variable_Name, Variable_Name, ...  
  'Description of the variable...' Variable_Name
```

### Syntax with steady-state values

```
!transition_variables  
  Variable_Name, Variable_Name, ...  
  Variable_Name = Value
```

### Description

The `!transition_variables` keyword starts a new declaration block for transition variables (i.e. endogenous variables); the names of the variables must be separated by commas, semi-colons, or line breaks. You can have as many declaration blocks as you wish in any order in your model file: They all get combined together when you read the model file in. Each variable must be declared (exactly once).

You can add descriptors to the variables (enclosed in single or double quotes, preceding the name of the variable); these will be stored in, and accessible from, the model object. You can also assign steady-state values to the variables straight in the model file (following an equal sign after the name of the variable); this is, though, rather rare and unnecessary practice because you can assign and change steady-state values more conveniently in the model object.

For each individual variable in a non-linear model, you can also decide if it is to be linearised or log-linearised by listing its name in the `!log_variables` [P41](#) section.

### Example

```
!transition_variables  
  pie, 'Real output' Y  
  'Real exchange rate' Z = 1 + 1.05i;
```

## ■ !ttrend

Linear time trend in deterministic trend equations

### Syntax

```
!ttrend
```

### Description

### Example

```
!dtrends  
  log(Y) += a*!ttrend;
```

---

## ■ %

Line comments

### Syntax

```
% Anything between the percent sign and the line break is discarded.
```

### Description

### Example

---

## ■ %{...%}

Block comments

## Syntax

```
%{ Anything between  
the opening block comment sign  
and the closing block comment sign  
is discarded %}
```

## Description

Unlike in Matlab, the opening and closing block comment signs do not need to stand alone on otherwise blank lines. You can even have block comments contained within a single line.

## Example

```
!transition_equations  
  x = rho*x{-1} %{ this is a valid block comment %} + epsilon;
```

---

## ■ &

Reference to the steady-state level of a variable

## Syntax

```
&Variable_Name  
$Variable_Name
```

## Description

Use either a & or \$ sign in front of a variable name to create a reference to that variable's steady-state level in transition or measurement equations. The two signs, & and \$, are interchangeable.

The steady-state reference will be replaced

- with the variable itself at the time model's steady state is being calculated, i.e. when calling the function `sstate` [P138](#);

Model file language: =#

- with the actually assigned steady-state value at the time the model is being solved, i.e. when calling the function `'solve'` [P134](#)].

### Example

```
x = rho*x{-1} + (1-rho)*&x + epsilon_x !! x = 1;
```

---

### ■ <...>

Regular expression in log-variable list

#### Syntax

```
!log_variables  
  <REGEXP>, <REGEXP>, ...
```

#### Description

See help on `!log_variables` [P41](#)].

---

### ■ =#

Mark an equation for exact non-linear simulation

#### Syntax

```
LHS =# RHS;
```

#### Description

Equations that have the equal sign marked with an # can be simulated in an exact non-linear mode.

Why is it the channels sign, #, that is used to mark the equations for exact non-linear simulations? Because if you associate your model file extension with the Matlab editor, the channel signs are displayed red making it easier to spot them.

---

## ■ diff

First difference pseudofunction

### Syntax

```
diff(EXPR)
diff(EXPR,K)
```

### Description

If the input argument K is not specified, this pseudofunction expands to

$$((\text{EXPR})-(\text{EXPR}\{-1\}))$$

If the input argument K is specified, it expands to

$$((\text{EXPR})-(\text{EXPR}\{K\}))$$

The two derived expressions,  $\text{EXPR}\{-1\}$  and  $\text{EXPR}\{K\}$ , are based on  $\text{EXPR}$ , and have all its time subscripts shifted by  $-1$  or by  $K$  periods, respectively.

### Example

These two lines

```
diff(Z)
diff(log(X{1})-log(Y{-1}),-2)
```

will expand to

```
((Z)-(Z{-1}))  
((log(X{1})-log(Y{-1}))-(log(X{-1})-log(Y{-3})))
```

---

## ■ difflog

First log-difference pseudofunction

### Syntax

```
difflog(EXPR)  
difflog(EXPR,K)
```

### Description

If the input argument K is not specified, this pseudofunction expands to

```
(log(EXPR)-log(EXPR{-1}))
```

If the input argument K is specified, it expands to

```
(log(EXPR)-log(EXPR{K}))
```

The two derived expressions, `EXPR{-1}` and `EXPR{K}`, are based on `EXPR`, and have all its time subscripts shifted by `-1` or by `K` periods, respectively.

### Example

The following two lines of code

```
difflog(Z)  
difflog(X{1}/Y{-1},-2)
```

will expand to

```
(log(Z)-log(Z{-1}))  
(log(X{1}/Y{-1})-log(X{-1}/Y{-3}))
```

---

## ■ dot

Gross rate of growth pseudofunction

### Syntax

```
dot(EXPR)  
dot(EXPR,K)
```

### Description

If the input argument  $k$  is not specified, this pseudofunction expands to

```
((expression)/(expression{-1}))
```

If the input argument  $k$  is specified, it expands to

```
((expression)/(expression{k}))
```

The two derived expressions,  $\text{expression}\{-1\}$  and  $\text{expression}\{k\}$ , are based on  $\text{expression}$ , and have all its time subscripts shifted by  $-1$  or by  $k$  periods, respectively.

### Example

The following two lines

```
dot(Z)  
dot(X+Y,-2)
```

will expand to

```
((Z)/(Z{-1}))  
(X+Y)/(X{-2}+Y{-2}))
```

---

## ■ min

Define the loss function in a time-consistent optimal policy model

### Syntax

```
min(DISC) EXPRESSION;
```

### Syntax for exact non-linear simulations

```
min#(DISC) EXPRESSION;
```

### Description

The loss function must be types as one of the transition equations. The DISC is a parameter or an expression defining the discount factor (applied to future dates), the EXPRESSION defines the loss function proper.

If you use the min#(DISC) syntax, all equations created by differentiating the lagrangian w.r.t. individual variables will be earmarked for exact non-linear simulations provided the respective derivative is nonzero.

### Example

This is a simple model file with a Phillips curve and a quadratic loss function.

```
!transition_variables  
  x, pi  
  
!transition_shocks  
  u
```

```
!parameters
  alpha, beta, gamma

!transition_equations
  min(beta) pi^2 + lambda*x^2;
  pi = alpha*pi{-1} + (1-alpha)*pi{1} + gamma*y + u;
```

---

## ■ movavg

Moving average pseudofunction

### Syntax

```
movavg(EXPR)
movavg(EXPR,K)
```

### Description

If the second input argument, K, is negative, this function expands to the moving average of the last K periods (including the current period), i.e.

$$(((EXPR)+(EXPR\{-1\})+ \dots +(EXPR\{-(K-1)\}))/-K)$$

where  $EXPR\{-N\}$  derives from  $EXPR$  and has all its time subscripts shifted by  $-N$  (if specified).

If the second input argument, K, is positive, this function expands to the moving average of the next K periods ahead (including the current period), i.e.

$$(((EXPR)+(EXPR\{1\})+ \dots +(EXPR\{K-1\}))/K)$$

If the second input argument, K, is not specified, the default value -4 is used (based on the fact that most of the macroeconomic models are quarterly).

### Example

The following three lines

```
movavg(Z)
movavg(Z,-3)
movavg(X+Y{-1},2)
```

will expand to

```
((Z)+(Z{-1})+(Z{-2})+(Z{-3}))/4)
(((Z)+(Z{-1})+(Z{-2}))/3)
(((X+Y{-1})+(X{1}+Y))/2)
```

## ■ movsum

Moving sum pseudofunction

### Syntax

```
movsum(EXPR)
movsum(EXPR,K)
```

### Description

If the second input argument, K, is negative, this function expands to the moving sum of the last K periods (including the current period), i.e.

$$((\text{EXPR})+(\text{EXPR}\{-1\})+ \dots +(\text{EXPR}\{-(K-1)\}))$$

where  $\text{EXPR}\{-N\}$  derives from  $\text{EXPR}$  and has all its time subscripts shifted by  $-N$  (if specified).

If the second input argument, K, is positive, this function expands to the moving sum of the next K periods ahead (including the current period), i.e.

$((\text{EXPR})+(\text{EXPR}\{1\})+ \dots +(\text{EXPR}\{K-1\}))$

If the second input argument, K, is not specified, the default value -4 is used (based on the fact that most of the macroeconomic models are quarterly).

### Example

The following three lines

```
movsum(Z)
movsum(Z, -3)
movsum(X+Y{-1}, 2)
```

will expand to

```
((Z)+(Z{-1})+(Z{-2})+(Z{-3}))
((Z)+(Z{-1})+(Z{-2}))
((X+Y{-1})+(X{1}+Y))
```

---

## ■ movsum

Moving product pseudofunction

### Syntax

```
movprod(Expr)
movprod(Expr, K)
```

### Description

If the second input argument, K, is negative, this function expands to the moving product of the last K periods (including the current period), i.e.

Model file language: {...}

$$((\text{Expr}) * (\text{Expr}\{-1\}) * \dots * (\text{Expr}\{-(K-1)\}))$$

where  $\text{Expr}\{-N\}$  derives from  $\text{Expr}$  and has all its time subscripts shifted by  $-N$  (if specified).

If the second input argument,  $K$ , is positive, this function expands to the moving product of the next  $K$  periods ahead (including the current period), i.e.

$$((\text{Expr}) * (\text{Expr}\{1\}) * \dots * (\text{Expr}\{K-1\}))$$

If the second input argument,  $K$ , is not specified, the default value  $-4$  is used (based on the fact that most of the macroeconomic models are quarterly).

### Example

The following three lines

```
movprod(Z)
movprod(Z,-3)
movprod(X+Y{-1},2)
```

will expand to

$$\begin{aligned} & ((Z) * (Z\{-1\}) * (Z\{-2\}) * (Z\{-3\})) \\ & ((Z) * (Z\{-1\}) * (Z\{-2\})) \\ & ((X+Y\{-1\}) * (X\{1\}+Y)) \end{aligned}$$

---

## ■ {...}

Lag or lead

### Syntax

```
VARIABLE_NAME{-lag}
VARIABLE_NAME{lead}
VARIABLE_NAME{+lead}
```

Model file language: {...}

### Description

To create a lag or a lead of a variable, use a pair of curly brackets.

### Example

```
!transition_equations
  x = rho*x{-1} + epsilon_x;
  pi = 1/2*pie{-1} + 1/2*pie{1} + gamma*y + epsilon_pi;
```

## 5 Model objects and functions

Model objects are created by loading a [model file](#) [P23]. Once a model object exists, you can use model functions and standard Matlab functions to write your own m-files to perform the desired tasks, such as calibrate or estimate the model, find its steady state, solve and simulate it, produce forecasts, analyse its properties, and so on.

Model methods:

### Constructor

- [model](#) [P119] - Create new model object based on model file.

### Getting information about models

- [addparam](#) [P71] - Add model parameters to a database (struct).
- [\[autocaption\]](#) (model/autocaption) -
- [autoexogenise](#) [P75] - Get or set variable/shock pairs for use in autoexogenised simulation plans.
- [comment](#) [P77] - Get or set user comments in an IRIS object.
- [eig](#) [P81] - Eigenvalues of the model transition matrix.
- [findeqtn](#) [P96] - Find equations by the labels.
- [findname](#) [P97] - Find names of variables, shocks, or parameters by their descriptors.
- [get](#) [P100] - Query model object properties.
- [iscompatible](#) [P107] - True if two models can occur together on the LHS and RHS in an assignment.
- [islinear](#) [P108] - True for models declared as linear.
- [islog](#) [P109] - True for log-linearised variables.
- [isnan](#) [P110] - Check for NaNs in model object.
- [isname](#) [P110] - True for valid names of variables, parameters, or shocks in model object.
- [issolved](#) [P111] - True if a model solution exists.
- [isstationary](#) [P112] - True if model or specified combination of variables is stationary.
- [length](#) [P114] - Number of alternative parameterisations.

## Model objects and functions

- [omega](#) P123 - Get or set the covariance matrix of shocks.
- [sspace](#) P137 - State-space matrices describing the model solution.
- [system](#) P145 - System matrices before model is solved.
- [userdata](#) P147 - Get or set user data in an IRIS object.

### Referencing model objects

- [subsasgn](#) P143 - Subscripted assignment for model and systemfit objects.
- [subsref](#) P144 - Subscripted reference for model and systemfit objects.

### Changing model objects

- [alter](#) P72 - Expand or reduce number of alternative parameterisations.
- [assign](#) P73 - Assign parameters, steady states, std deviations or cross-correlations.
- [export](#) P90 - Save carry-around files on the disk.
- [horzcat](#) P105 - Combine two compatible model objects in one object with multiple parameterisations.
- [refresh](#) P124 - Refresh dynamic links.
- [stdscale](#) P142 - Re-scale all std deviations by the same factor.
- [set](#) P128 - Change modifiable model object property.
- [single](#) P134 - Convert solution matrices to single precision.

### Steady state

- [chksstate](#) P76 - Check if equations hold for currently assigned steady0state values.
- [sstate](#) P138 - Compute steady state or balance-growth path of the model.
- [sstatefile](#) P141 - Create a steady-state file based on the model object's steady-state equations.

### Solution, simulation and forecasting

- [diffsrf](#) [P80](#) - Differentiate shock response functions w.r.t. specified parameters.
- [expand](#) [P89](#) - Compute forward expansion of model solution for anticipated shocks.
- [jforecast](#) [P112](#) - Forecast with judgmental adjustments (conditional forecasts).
- [icrf](#) [P106](#) - Initial-condition response functions.
- [lhsmrhs](#) [P115](#) - Evaluate the discrepancy between the LHS and RHS for each model equation and given data.
- [resample](#) [P127](#) - Resample from the model implied distribution.
- [reporting](#) [P126](#) - Run reporting equations.
- [shockplot](#) [P130](#) - Short-cut for running and plotting plain shock simulation.
- [simulate](#) [P131](#) - Simulate model.
- [solve](#) [P134](#) - Calculate first-order accurate solution of the model.
- [srf](#) [P136](#) - Shock response functions.

### Model data

- [data4lhsmrhs](#) [P78](#) - Prepare data array for running lhsmrhs.
- [emptydb](#) [P82](#) - Create model-specific database with variables, shocks, and parameters.
- [sstatedb](#) [P140](#) - Create model-specific steady-state or balanced-growth-path database.
- [zerodb](#) [P150](#) - Create model-specific zero-deviation database.

### Stochastic properties

- [acf](#) [P69](#) - Autocovariance and autocorrelation functions for model variables.
- [ifrf](#) [P107](#) - Frequency response function to shocks.
- [fevd](#) [P90](#) - Forecast error variance decomposition for model variables.
- [ffrf](#) [P92](#) - Filter frequency response function of transition variables to measurement variables.
- [fmse](#) [P99](#) - Forecast mean square error matrices.
- [vma](#) [P148](#) - Vector moving average representation of the model.
- [xsf](#) [P149](#) - Power spectrum and spectral density of model variables.

### Identification, estimation and filtering

- [bn](#) P75 - Beveridge-Nelson trends.
- [diffloglik](#) P79 - Approximate gradient and hessian of log-likelihood function.
- [estimate](#) P82 - Estimate model parameters by optimising selected objective function.
- [evalsystempriors](#) P88 - Evaluate minus log of system prior density.
- [filter](#) P93 - Kalman smoother and estimator of out-of-likelihood parameters.
- [fisher](#) P97 - Approximate Fisher information matrix in frequency domain.
- [lognormal](#) P118 - Characteristics of log-normal distributions returned by filter of forecast.
- [loglik](#) P116 - Evaluate minus the log-likelihood function in time or frequency domain.
- [neighbourhood](#) P122 - Evaluate the local behaviour of the objective function around the estimated parameter values.
- [regress](#) P125 - Centred population regression for selected model variables.
- [VAR](#) P147 - Population VAR for selected model variables.

### Getting on-line help on model functions

```
help model  
help model/function_name
```

---

## ■ acf

Autocovariance and autocorrelation functions for model variables

### Syntax

```
[C,R,List] = acf(M,...)
```

### Input arguments

- `M [ model ]` - Solved model object for which the ACF will be computed.

### Output arguments

- C [ namedmat | numeric ] - Auto/cross-covariance matrices.
- R [ namedmat | numeric ] - Auto/cross-correlation matrices.
- List [ cellstr ] - List of variables in rows and columns of C and R.

### Options

- 'applyTo=' [ cellstr | char | Inf ] - List of variables to which the 'filter=' will be applied; Inf means all variables.
- 'contributions=' [ true | false ] - If true the contributions of individual shocks to ACFs will be computed and stored in the 5th dimension of the C and R matrices.
- 'filter=' [ char | empty ] - Linear filter that is applied to variables specified by 'applyto'.
- 'nFreq=' [ numeric | 256 ] - Number of equally spaced frequencies over which the filter in the option 'filter=' is numerically integrated.
- 'order=' [ numeric | 0 ] - Order up to which ACF will be computed.
- 'output=' [ 'namedmat' | 'numeric' ] - Output matrices C and R will be either namedmat objects or plain numeric arrays; if the option 'select=' is used, 'output=' is always a namedmat object.
- 'select=' [ cellstr | Inf ] - Return ACF for selected variables only; Inf means all variables.

### Description

C and R are both N-by-N-by-(P+1)-by-Alt matrices, where N is the number of measurement and transition variables (including auxiliary lags and leads in the state space vector), P is the order up to which the ACF is computed (controlled by the option 'order='), and Alt is the number of alternative parameterisations in the input model object, M. If 'contributions=' true, the size of the two matrices is N-by-N-by-(P+1)-by-E-Alt, where E is the number of measurement and transition shocks in the model.

#### —ACF with linear filters

You can use the option 'filter=' to get the ACF for variables as though they were filtered through a linear filter. You can specify the filter in both the time domain (such as first-difference filter, or Hodrick-Prescott) and the frequency domain (such as a band of certain frequencies or periodicities). The filter is a text string in which you can use the following references:

- 'L', the lag operator, which will be replaced with  $\exp(-1i*\text{freq})$ ;
- 'per', the periodicity;
- 'freq', the frequency.

### Example 1

A first-difference filter (i.e. computes the ACF for the first differences of the respective variables):

```
[C,R] = acf(m,'filter=', '1-L')
```

### Example 2

The cyclical component of the Hodrick-Prescott filter with the smoothing parameter, *lambda*, 1,600. The formula for the filter follows from the classical Wiener-Kolmogorov signal extraction theory,

$$w(L) = \frac{\lambda}{\lambda + \frac{1}{|(1-L)(1-L)|^2}}$$

```
[C,R] = acf(m,'filter', '1600/(1600 + 1/abs((1-L)^2)^2)')
```

### Example 3

A band-pass filter with user-specified lower and upper bands. The band-pass filters can be defined either in frequencies or periodicities; the latter is usually more convenient. The following is a filter which retains periodicities between 4 and 40 periods (this would be between 1 and 10 years in a quarterly model),

```
[C,R] = acf(m,'filter', 'per >= 4 & per <= 40')
```

---

## ■ addparam

Add model parameters to a database (struct)

### Syntax

```
D = addparam(M,D)
```

### Input arguments

- M [ model ] - Model object whose parameters will be added to database (struct) D.
- D [ struct ] - Database to which the model parameters will be added.

### Output arguments

- 'D [ struct ] - Database with the model parameters added.

### Description

If there are database entries in D whose names coincide with the model parameters, they will be overwritten.

### Example

```
D = struct();  
D = addparam(M,D);
```

---

## ■ alter

Expand or reduce number of alternative parameterisations

### Syntax

```
M = alter(M,N)
```

### Input arguments

- M [ model ] - Model object in which the number of parameterisations will be changed.
- N [ numeric ] - New number of parameterisations.

### Output arguments

- M [ model ] - Model object with the new number of parameterisations.

### Description

### Example

---

## ■ assign

Assign parameters, steady states, std deviations or cross-correlations

### Syntax

```
[M,Assigned] = assign(M,P)
[M,Assigned] = assign(M,Name,Value,Name,Value,...)
[M,Assigned] = assign(M,List,Values)
```

### Syntax for fast assign

```
% Initialise
assign(M,List);

% Fast assign
M = assign(M,Values);
...
M = assign(M,Values);
...
```

### Syntax for assigning only steady-state levels

```
M = assign(M, '-level', ...)
```

### Syntax for assignin only steady-state growth rates

```
M = assign(M, '-growth', ...)
```

### Input arguments

- M [ model ] - Model object.
- P [ struct | model ] - Database whose fields refer to parameter names, variable names, std deviations, or cross-correlations; or another model object.
- Name [ char ] - A parameter name, variable name, std deviation, cross-correlation, or a regular expression that will be matched against model names.
- Value [ numeric ] - A value (or a vector of values in case of multiple parameterisations) that will be assigned.
- List [ cellstr ] - A list of parameter names, variable names, std deviations, or cross-correlations.
- Values [ numeric ] - A vector of values.

### Output arguments

- M [ model ] - Model object with newly assigned parameters and/or steady states.
- Assigned [ cellstr | Inf ] - List of actually assigned parameter names, variables names (steady states), std deviations, and cross-correlations; Inf indicates that all values has been assigned from another model object.

### Description

### Example

---

## ■ autoexogenise

Get or set variable/shock pairs for use in autoexogenised simulation plans

Syntax fo getting autoexogenised variable/shock pairs

```
A = autoexogenise(M)
```

Syntax fo setting autoexogenised variable/shock pairs

```
M = autoexogenise(M,A)
```

### Input arugments

- M [ model ] - Model object.
- A [ struct | empty ] - Database with each field representing a variable/shock pair, A.Variable\_Name = 'Shock\_Name', that can be used in building [simulation plans](#) P152 by the plan function [autoexogenise](#) P153.

### Output arguments

- M [ model ] - Model object with updated definitions of autoexogenised variable/shock pairs.

### Description

Whenever you set the autoexogenised variable/shock pairs, the previously assigned pairs are removed, and replaced with the new ones in A. In other words, the new pairs are not added to the existing ones, the replace them.

### Example

---

## ■ bn

Beveridge-Nelson trends

## Syntax

Outp = bn(M,Inp,Range,...)

## Input arguments

- M [ model ] - Solved model object.
- Inp [ struct | cell ] - Input data on which the BN trends will be computed.
- Range [ numeric ] - Date range on which the BN trends will be computed.

## Output arguments

- Outp [ struct | cell ] - Output data with the BN trends.

## Options

- 'deviations=' [ true | false ] - Input and output data are deviations from balanced-growth paths.
- 'dtrends=' [ 'auto' | true | false ] - Measurement variables in input and output data include deterministic trends specified in [!dtrends](#) P30 equations.

## Description

## Example

---

## ■ chksstate

Check if equations hold for currently assigned steady0state values

## Syntax

```
[Flag,List] = chksstate(M,...)
[Flag,Discr,List] = chksstate(M,...)
```

### Input arguments

- M [ model ] - Model object.

### Output arguments

- Flag [ true | false ] - True if discrepancy between LHS and RHS is smaller than 'tolerance=' in each equation.
- Discr [ numeric ] - Discrepancy between LHS and RHS evaluated for each equation at two consecutive times.
- List [ cellstr ] - List of equations in which the discrepancy between LHS and RHS is greater than 'tolerance='.

### Options

- 'error=' [ true | false ] - Throw an error if one or more equations do not hold.
- 'refresh=' [ true | false ] - Refresh dynamic links before evaluating the equations.
- 'ssstateEqtn=' [ true | false ] - If false, the dynamic model equations will be checked; if true, the steady-state versions of the equations (wherever available) will be checked.
- 'tolerance=' [ numeric | getrealsmall() ] - Tolerance.
- 'warning=' [ true | false ] - Display warnings produced by this function.

### Description

### Example

---

## ■ comment

Get or set user comments in an IRIS object

### Syntax for getting user comments

```
Cmt = comment(Obj)
```

### Syntax for assigning user comments

```
Obj = comment(Obj,Cmt)
```

### Input arguments

- Obj [ model | tseries | VAR | SVAR | FAVAR | sstate ] - One of the IRIS objects.
- Cmt [ char ] - User comment that will be attached to the object.

### Output arguments

- Cmt [ char ] - User comment that are currently attached to the object.

### Description

### Example

---

## ■ data4lhsmrhs

Prepare data array for running 'lhsmrhs'

### Syntax

```
[YXE,List,XRange] = data4lhsmrhs(M,D,Range)
```

### Input arguments

- M [ model ] - Model object whose equations will be later evaluated by calling [lhsmrhs](#) P115.
- D [ struct ] - Input database with observations on measurement variables, transition variables, and shocks on which [lhsmrhs](#) P115 will be evaluated.
- Range [ numeric ] - Date range on which [lhsmrhs](#) P115 will be evaluated.

### Output arguments

- `YXE` [ numeric ] - Numeric array with the observations on measurement variables, transition variables, and shocks organised row-wise.
- `List` [ cellstr ] - List of measurement variables, transition variables and shocks in order of their appearance in the rows of `YXE`.
- `XRange` [ numeric ] - Extended range including pre-sample and post-sample observations needed to evaluate lags and leads of transition variables.

### Description

The resulting array, `YXE`, is `nVar` by `nXPer` by `nData`, where `nVar` is the total number of measurement variables, transition variables, and shocks, `nXPer` is the number of periods including the pre-sample and post-sample periods needed to evaluate lags and leads, and `nData` is the number of alternative data sets (i.e. the number of columns in each input time series) in the input database, `D`.

### Example

```
YXE = data4lmsrhs(M,d,range);  
D = lmsrhs(M,YXE);
```

---

## ■ `diffloglik`

Approximate gradient and hessian of log-likelihood function

### Syntax

```
[MinusLogLik,Grad,Hess,V] = diffloglik(M,D,Range,PList,...)
```

### Input arguments

- `M` [ model ] - Model object whose likelihood function will be differentiated.
- `D` [ cell | struct ] - Input data from which measurement variables will be taken.
- `Range` [ numeric ] - Date range on which the likelihood function will be evaluated.

- `List [ cellstr ]` - List of model parameters with respect to which the likelihood function will be differentiated.

### Output arguments

- `MinusLogLik [ numeric ]` - Value of minus the likelihood function at the input data.
- `Grad [ numeric ]` - Gradient (or score) vector.
- `Hess [ numeric ]` - Hessian (or information) matrix.
- `V [ numeric ]` - Estimated variance scale factor if the `'relative='` options is true; otherwise `v` is 1.

### Options

- `'chkSstate=' [ true | false | cell ]` - Check steady state in each iteration; works only in non-linear models.
- `'refresh=' [ true | false ]` - Refresh dynamic links for each change in a parameter.
- `'solve=' [ true | false ]` - Re-compute solution for each change in a parameter.
- `'sstate=' [ true | false | cell ]` - Re-compute steady state in each differentiation step; if the model is non-linear, you can pass in a cell array with options used in the `sstate` function.

See help on [model/filter](#) P93 for other options available.

### Description

### Example

---

## ■ `diffsrf`

Differentiate shock response functions w.r.t. specified parameters

### Syntax

```
S = diffsrf(M,RANGE,LIST,...)
S = diffsrf(M,NPER,LIST,...)
```

### Input arguments

- `M` [ model ] - Model object whose response functions will be simulated and differentiated.
- `RANGE` [ numeric ] - Simulation date range with the first date being the shock date.
- `NPER` [ numeric ] - Number of simulation periods.
- `LIST` [ char | cellstr ] - List of parameters w.r.t. which the shock response functions will be differentiated.

### Output arguments

- `S` [ struct ] - Database with shock response derivatives stored in multivariate time series.

### Options

See [model/srf](#) P136 for options available.

### Description

### Example

---

## ■ eig

Eigenvalues of the model transition matrix

### Syntax

```
e = eig(m)
```

### Input arguments

- `m` [ model ] - Model object whose eigenvalues will be returned.

### Output arguments

- `e [ numeric ]` - Array of all eigenvalues associated with the model, i.e. all stable, unit, and unstable roots are included.

### Description

### Example

---

## ■ `emptydb`

Create model-specific database with variables, shocks, and parameters

### Syntax

```
D = emptydb(M)
```

### Input arguments

- `M [ model | bkwmodel ]` - Model or bkwmodel object for which the empty database will be created.

### Output arguments

- `D [ struct ]` - Database with an empty tseries object for each variable and each shock, and an empty array for each parameter.

### Description

### Example

---

## ■ `estimate`

Estimate model parameters by optimising selected objective function

## Syntax

```
[PEst,Pos,Cov,Hess,M,V,Delta,PDelta] = estimate(M,D,Range,Est,...)
[PEst,Pos,Cov,Hess,M,V,Delta,PDelta] = estimate(M,D,Range,Est,SPr,...)
```

## Input arguments

- M [ struct ] - Model object.
- D [ struct | cell ] - Input database or datapack from which the measurement variables will be taken.
- Range [ struct ] - Date range.
- Est [ struct ] - Database with the list of parameters that will be estimated, and the parameter prior specifications (see below).
- SPr [ empty | systempriors ] - System priors object, [systempriors](#) P164.

## Output arguments

- PEst [ struct ] - Database with point estimates of requested parameters.
- Pos [ poster ] - Posterior, [poster](#) P169, object; this object also gives you access to the value of the objective function at optimum or at any point in the parameter space, see the [poster/eval](#) P171 function.
- Cov [ numeric ] - Approximate covariance matrix for the estimates of parameters with slack bounds based on the asymptotic Fisher information matrix (not on the Hessian returned from the optimisation routine).
- Hess [ cell ] - Hess{1} is the total hessian of the objective function; Hess{2} is the contributions of the priors to the hessian.
- M [ model ] - Model object solved with the estimated parameters (including out-of-likelihood parameters and common variance factor).

The remaining three output arguments, V, Delta, PDelta, are the same as the [model/loglik](#) P116 output arguments of the same names.

## Options

- 'chkSstate=' [ true | false | cell ] - Check steady state in each iteration; works only in non-linear models.
- 'evalFrFpriors=' [ true | false ] - In each iteration, evaluate frequency response function prior density, and include it to the overall objective function to be optimised.
- 'evalLik=' [ true | false ] - In each iteration, evaluate likelihood (or another data based criterion), and include it to the overall objective function to be optimised.
- 'evalPPriors=' [ true | false ] - In each iteration, evaluate parameter prior density, and include it to the overall objective function to be optimised.
- 'evalSPriors=' [ true | false ] - In each iteration, evaluate system prior density, and include it to the overall objective function to be optimised.
- 'filter=' [ cell | empty ] - Cell array of options that will be passed on to the Kalman filter including the type of objective function; see help on [model/filter](#) P93 for the options available.
- 'initVal=' [ model | struct | struct ] - If struct use the values in the input struct Est to start the iteration; if model use the currently assigned parameter values in the input model, M.
- 'maxIter=' [ numeric | 500 ] - Maximum number of iterations allowed.
- 'maxFunEvals=' [ numeric | 2000 ] - Maximum number of objective function calls allowed.
- 'noSolution=' [ 'error' | 'penalty' ] - Specifies what happens if solution or steady state fails to solve in an iteration: 'error=' stops the execution with an error message, 'penalty=' returns an extremely low value of the likelihood.
- 'optimSet=' [ cell | empty ] - Cell array used to create the Optimization Toolbox options structure; works only with the option 'optimiser=' 'default'.
- 'refresh=' [ true | false ] - Refresh dynamic links in each iteration.
- 'solve=' [ true | false ] - Re-compute solution in each iteration.
- 'optimiser=' [ 'default' | 'pso' | cell | function\_handle ] - Minimisation procedure.
  - 'default': The Optimization Toolbox function fminunc or fmincon will be called depending on the presence or absence of lower and/or upper bounds.
  - 'pso': The Particle Swarm Optimizer will be called; use the option 'pso=' to specify further options to control the optimizer (see Options for Particle Swarm Optimizer below).

- `function_handle` or `cell`: Enter a function handle to your own optimisation procedure, or a cell array with a function handle and additional input arguments (see below).
- `'sstate='` [ `true` | `false` | `cell` | `function_handle` ] - Re-compute steady state in each iteration. You can specify a cell array with options for the `sstate` function, or a function handle whose behaviour is described below.
- `'tolFun='` [ `numeric` | `1e-6` ] - Termination tolerance on the objective function.
- `'tolX='` [ `numeric` | `1e-6` ] - Termination tolerance on the estimated parameters.

### Options for Particle Swarm Optimizer

The following options can be specified through the main option `'optimset='` when `'optimiser=pso'`.

- `'cognitiveAttraction='` [ `numeric` | `0.5` ] - Scalar between 0 and 1 to control the relative attraction to the best location a particle can remember.
- `'constrBoundary='` [ `absorb` | `reflect` | `soft` ] - Controls the way imposed constraints are handled when violated.
  - `'soft'`: Particles are allowed to travel outside the bounds but get bad fitness function (likelihood) values when they do;
  - `'reflect'`: Particle velocity is changed such that when the particle encounters the bound its velocity is changed to effectively make it bounce off of the boundary;
  - `'absorb'`: Particles hit the bound and stay at the bound until attracted elsewhere because its velocity is set to zero.
- `'display='` [ `'off'` | `'final'` | `'iter'` ] - Level of display in order of increasing verbosity; `'iter'` will only produce output at most `'updateInterval='` seconds.
- `'fitnessLimit='` [ `numeric` | `-Inf` ] - Algorithm will terminate when a function value this low is encountered.
- `'generations='` [ `numeric` | `1000` ] - Positive integer describing the maximum length of swarm evolution.
- `'hybridFcn='` [ `true` | `false` | `'fmincon'` | `'fminunc'` | `cell` ] - Run a second stage optimization after PSO (only available with the Optimization Tbx installed):
  - `false`: No second stage optimization, run the particle swarm only.
  - `true`: After PSO, run either `fminunc` or `fmincon`, the Optimization Toolbox routines, depending on the presence or absence of lower and upper bounds on estimated parameters.

## Model objects and functions: estimate

- 'fminunc', 'fmincon': After PSO, run the specified Optimization Toolbox routine.
- cell: A cell array in which the first argument specifies the function as previously and the second argument contains the options structure for that function; for instance `{@fmincon,optimset('Display','iter')}`.
- 'includeInitialValue=' [ true | false ] - Include the initial vector of parameters in the initial population.
- 'initialPopulation=' [ numeric | empty ] - An NPar-by-NPop array containing the initial distribution of particles, where NPar is the number of estimated parameters, and NPop is the size of population. If empty, a population will be created containing the initial parameter vector and the rest of the particles will be randomly generated according to 'popInitRange='. Use the option 'includeInitialValue=' false to exclude the initial value from the initial population so that the entire population is randomly generated.
- 'socialAttraction=' [ numeric | 1.25 ] - Positive scalar to control the relative attraction of each particle to the best location they have heard about from other particles.
- 'plotFcns=' [ cell | empty ] - Cell array of function handles to functions which accept (options, state, flag) values as input arguments. The only built-in general-purpose plotting function is @optim.scoreDiversity.
- 'populationSize=' [ numeric | 40 ] - Positive integer which determines the number of particles in the swarm.
- 'popInitRange=' [ numeric | empty ] - A 2-by-NPar array which sets the range over which the initial population will be distributed, where NPar is the number of estimated parameters, or a 2-by-1 array with the range for all parameters. If empty and 'PopInitRange=' is not set, the upper and lower bounds will be used if both are finite. If either of the bounds are infinite, the range will be [0;1].
- 'stallGenLimit=' [ numeric | 100 ] - Maximum number of swarm iterations which result in no improvement in the fitness function (likelihood) value before the algorithm terminates.
- 'timeLimit=' [ numeric | Inf ] - Maximum running time in seconds.
- 'tolCon=' [ numeric | 1e-6 ] - Largest tolerated constraint violation.
- 'tolFun=' [ numeric | 1e-6 ] - Function tolerance; when the change in the best fitness function value (likelihood) improvement per generation falls below this value the algorithm will terminate.
- 'velocityLimit=' [ numeric | Inf ] - Positive scalar to bound particle inertia from above.
- 'updateInterval='\* [ numeric | 5 ] - Minimum length of time in seconds which must pass before new command window output will be produced.

- 'useParallel=' [ true | false ] - Use a parfor loop which requires you already have a matlabpool open. Overhead is slightly higher for constrained problems than unconstrained problems.

## Description

In the input parameter database, E, you can provide the following four specifications for each parameter:

```
E.parameter_name = {start,lower,upper,logprior}
```

where start is the value from which the numerical optimisation will start, lower is the lower bound, upper is the upper bound, and logprior is a function handle expected to return the log of the prior density. You can use the `logdist` [P176](#) package to create function handles for some of the basic prior distributions.

You can use NaN for start if you wish to use the value currently assigned in the model object. You can use -Inf and Inf for the bounds, or leave the bounds empty or not specify them at all. You can leave the prior distribution empty or not specify it at all.

### —User-supplied optimisation (minimisation) routine

You can supply a function handle to your own minimisation routine through the option 'optimiser='. This routine will be used instead of the Optim Tbx's `fminunc` or `fmincon` functions. The user-supplied function is expected to take at least five input arguments and return three output arguments:

```
[PEst,ObjEst,Hess] = yourminfunc(F,P0,PLow,PHigh,Opt)
```

with the following input arguments:

- F is a function handle to the function minimised;
- P0 is a 1-by-N vector of initial parameter values;
- PLow is a 1-by-N vector of lower bounds (with -Inf indicating no lower bound);
- PHigh is a 1-by-N vector of upper bounds (with Inf indicating no upper bounds);
- Opt is an Optim Tbx style struct with the optimisation settings (tolerance, number of iterations, etc); of course you may simply ignore this information and leave the input argument unused.

and the following output arguments:

- PEst is a 1-by-N vector of estimated parameters;
- ObjEst is the value of the objective function at optimum;
- Hess is a N-by-N approximate Hessian matrix at optimum.

If you need to use extra input arguments in your minimisation function, enter a cell array instead of a plain function handle:

```
{@yourminfunc,Arg1,Arg2,...}
```

In that case, the optimiser will be called the following way:

```
[PEst,ObjEst,Hess] = yourminfunc(F,P0,PLow,PHigh,Opt,Arg1,Arg2,...)
```

—*User-supplied steady-state solver*

You can supply a function handle to your own steady state solver (i.e. a function that finds the steady state for given parameters) through the 'sstate=' option.

The function is expected to take one input argument, the model object with newly assigned parameters, and return at least two output arguments, the model object with a new steady state (or balanced-growth path) and a success flag. The flag is true if the steady state has been successfully computed, and false if not:

```
[M,Success] = yoursstatesolver(M)
```

It is your responsibility to add the growth characteristics if some of the model variables drift over time. In other words, you need to take care of the imaginary parts of the steady state values in the model object returned by the solver.

**Example**

---

■ **evalsystempriors**

Evaluate minus log of system prior density

### Syntax

`[P,C,X] = evalsystempriors(M,S)`

### Input arguments

- `M [ model ]` - Model object on which current parameterisation the system priors will be evaluated.
- `S [ systempriors ]` - System priors objects.

### Output arguments

- `P [ numeric ]` - Minus log of system prior density.
- `C [ numeric ]` - Contributions of individual priors to the overall system prior density.
- `X [ numeric ]` - Value of each system property for which a prior has been defined in the system priors object, `S`.

### Description

### Example

---

## ■ expand

Compute forward expansion of model solution for anticipated shocks

### Syntax

`m = expand(m,k)`

### Input arguments

- `m [ model ]` - Model object whose solution will be expanded.
- `k [ numeric ]` - Number of periods ahead,  $t+k$ , up to which the solution for anticipated shocks will be expanded.

### Output arguments

- `m [ model ]` - Model object with the solution expanded.

### Description

### Example

---

## ■ export

Save carry-around files on the disk

### Syntax

```
export(M)
```

### Input arguments

- `M [ model ]` - Model object whose carry-around m-files (written in underlying the model file) will be saved on the disk.

### Description

See the IRIS model language keyword `!export` [P32](#) for help on how to write carry-around m-files in model files.

### Example

---

## ■ fevd

Forecast error variance decomposition for model variables

## Syntax

```
[X,Y,List,A,B] = fevd(M,Range,...)
[X,Y,List,A,B] = fevd(M,NPer,...)
```

## Input arguments

- M [ model ] - Model object for which the decomposition will be computed.
- Range [ numeric ] - Decomposition date range with the first date beign the first forecast period.
- NPer [ numeric ] - Number of periods for which the decomposition will be computed.

## Output arguments

- X [ namedmat | numeric ] - Array with the absolute contributions of individual shocks to total variance of each variables.
- Y [ namedmat | numeric ] - Array with the relative contributions of individual shocks to total variance of each variables.
- List [ cellstr ] - List of variables in rows of the X an Y arrays, and shocks in columns of the X and Y arrays.
- A [ struct ] - Database with the absolute contributions converted to time series.
- B [ struct ] - Database with the relative contributions converted to time series.

## Options

- 'output=' [ 'namedmat' | numeric ] - Output matrices X and Y will be either namedmat objects or plain numeric arrays; if the option 'select=' is used, 'output=' is always 'namedmat'.
- 'select=' [ char | cellstr ] - Return FEVD for selected variables and/or shocks only; Inf means all variables. This option does not apply to the output databases, A and B.

## Description

## Example

---

## ■ ffrf

Filter frequency response function of transition variables to measurement variables

### Syntax

```
[F,List] = ffrf(M,Freq,...)
```

### Input arguments

- M [ model ] - Model object for which the frequency response function will be computed.
- Freq [ numeric ] - Vector of frequencies for which the response function will be computed.

### Output arguments

- F [ numeric ] - Array with frequency responses of transition variables (in rows) to measurement variables (in columns).
- List [ cell ] - List of transition variables in rows of the F matrix, and list of measurement variables in columns of the F matrix.

### Options

- 'include=' [ char | cellstr | Inf ] - Include the effect of the listed measurement variables only; Inf means all measurement variables.
- 'exclude=' [ char | cellstr | empty ] - Remove the effect of the listed measurement variables.
- 'maxIter=' [ numeric | 500 ] - Maximum number of iteration when computing the steady-state Kalman filter.
- 'output=' [ 'namedmat' | numeric ] - Output matrix F will be either a namedmat object or a plain numeric array; if the option 'select=' is used, 'output=' is always 'namedmat'.
- 'select=' [ char | cellstr | Inf ] - Return the frequency response function for selected variables only; Inf means all variables.
- 'tolerance=' [ numeric | 1e-7 ] - Convergence tolerance when computing the steady-state Kalman filter.

## Description

## Example

---

## ■ filter

Kalman smoother and estimator of out-of-likelihood parameters

## Syntax

```
[M,Outp,V,Delta,PE,SCov] = filter(M,Inp,Range,...)
[M,Outp,V,Delta,PE,SCov] = filter(M,Inp,Range,J,...)
```

## Input arguments

- M [ model ] - Solved model object.
- Inp [ struct | cell ] - Input database or datapack from which the measurement variables will be taken.
- Range [ numeric ] - Filter date range.
- J [ struct ] - Database with tunes on the mean of shocks and/or time-varying std devs of shocks.

## Output arguments

- M [ model ] - Model object with updates of std devs (if 'relative=' is true) and/or updates of out-of-likelihood parameters (if 'outoflik=' is non-empty).
- Outp [ struct | cell ] - Output struct with smoother or prediction data.
- V [ numeric ] - Estimated variance scale factor if the 'relative=' options is true; otherwise V is 1.
- Delta [ struct ] - Database with estimates of out-of-likelihood parameters.
- PE [ struct ] - Database with prediction errors for measurement variables.
- SCov [ numeric ] - Sample covariance matrix of smoothed shocks; the covariance matrix is computed using shock estimates in periods that are included in the option 'objrange=' and, at the same time, contain at least one observation of measurement variables.

## Options

- 'ahead=' [ numeric | 1 ] - Predictions will be computed this number of period ahead.
- 'condition=' [ char | cellstr | empty ] - List of conditioning measurement variables. Condition time t|t-1 prediction errors (that enter the likelihood function) on time t observations of these measurement variables.
- 'deviation=' [ true | false ] - Treat input and output data as deviations from balanced-growth path.
- 'dtrends=' [ 'auto' | true | false ] - Measurement data contain deterministic trends.
- 'data=' [ 'predict' | 'smooth' | 'predict,smooth' ] - Return smoother data or prediction data or both.
- 'initCond=' [ 'fixed' | 'optimal' | 'stochastic' | struct ] - Method or data to initialise the Kalman filter; user-supplied initial condition must be a mean database or a mean-MSE struct.
- 'lastSmooth=' [ numeric | Inf ] - Last date up to which to smooth data backward from the end of the range; if Inf smoother will run on the entire range.
- 'meanOnly=' [ true | false ] - Return a plain database with mean data only; this option overrides the 'return\*=' options, i.e. 'returnCont=', 'returnMse=', 'returnStd='.
- 'outOfLik=' [ cellstr | empty ] - List of parameters in deterministic trends that will be estimated by concentrating them out of the likelihood function.
- 'objFunc=' [ '-loglik' | 'prederr' ] - Objective function computed; can be either minus the log likelihood function or weighted sum of prediction errors.
- 'objRange=' [ numeric | Inf ] - The objective function will be computed on this subrange only; Inf means the entire filter range.
- 'precision=' [ 'double' | 'single' ] - Numeric precision to which output data will be stored; all calculations themselves always run to double precision.
- 'rollback=' [ numeric | empty ] - Date up to which to roll back individual observations on measurement variables from the end of the sample.
- 'relative=' [ true | false ] - Std devs of shocks assigned in the model object will be treated as relative std devs, and a common variance scale factor will be estimated.
- 'returnCont=' [ true | false ] - Return contributions of measurement variables to the estimates of all variables and shocks.
- 'returnMse=' [ true | false ] - Return MSE matrices for predetermined state variables; these can be used for setting up initial condition in subsequent call to another filter or jforecast.

- 'returnStd=' [ true | false ] - Return database with std devs of model variables.
- 'tolMse=' [ numeric | 0 ] - Tolerance under which two MSE matrices in two consecutive periods will be treated as equal, and the Kalman gain system will be re-used, not re-computed.
- 'weighting=' [ numeric | empty ] - Weighting vector or matrix for prediction errors when 'objective=' 'prederr'; empty means prediction errors are weighted equally.

### Options for models with non-linearised equations

- 'nonlinearise=' [ numeric | 0 ] - If non-zero the prediction step in the Kalman filter will be run in an exact non-linear mode using the same technique as [model/simulate](#) P131.
- 'simulate=' [ cell | empty ] - Options passed in to simulate when invoking the non-linear simulation in the prediction step; only used when nonlinearise= is greater than 0.

### Description

The 'ahead=' and 'rollback=' options cannot be combined with one another, or with multiple data sets, or with multiple parameterisations.

—*Initial conditions in time domain*

By default (with 'initCond=' 'stochastic'), the Kalman filter starts from the model-implied asymptotic distribution. You can change this behaviour by setting the option 'initCond=' to one of the following four different values:

- 'fixed' – the filter starts from the model-implied asymptotic mean (steady state) but with no initial uncertainty. The initial condition is treated as a vector of fixed, non-stochastic, numbers.
- 'optimal' – the filter starts from a vector of fixed numbers that is estimated optimally (likelihood maximising).
- database (i.e. struct with fields for individual model variables) – a database through which you supply the mean for all the required initial conditions, see help on [model/get](#) P100 for how to view the list of required initial conditions.
- mean-mse struct (i.e. struct with fields .mean and .mse) – a struct through which you supplye the mean and MSE for all the required initial conditions.

—*Contributions of measurement variables to the estimates of all variables*

Use the option 'returnCont=' true to request the decomposition of measurement variables, transition variables, and shocks into the contributions of each individual measurement variable. The resulting output database will include one extra subdatabase called .cont. In the .cont subdatabase, each time series will have  $N_y$  columns where  $N_y$  is the number of measurement variables in the model. The  $k$ -th column will be the contribution of the observations on the  $k$ -th measurement variable.

The contributions are additive for linearised variables, and multiplicative for log-linearised variables (log-variables). The difference between the actual path for a particular variable and the sum of the contributions (or their product in the case of log-variables) is due to the effect of constant terms and deterministic trends.

### Example

---

## ■ findeqtn

Find equations by the labels

### Syntax

```
[Eqtn,Eqtn,...] = findeqtn(M,Label,Label,...)
[List,List,...] = findeqtn(M,'-rexp',Rexp,Rexp,...)
```

### Input arguments

- M [ model ] - Model object in which the equations will be searched for.
- Label [ char ] - Equation label that will be searched for.
- Rexp [ char ] - Regular expressions that will be matched against equation labels.

### Output arguments

- Eqtn [ char ] - First equation found with the label Label.
- List [ cellstr ] - List of equations whose labels match the regular expression Rexp.

## Description

## Example

---

### ■ findname

Find names of variables, shocks, or parameters by their descriptors

## Syntax

```
[Name,Name,...] = findname(M,Desc,Desc,...)
[List,List,...] = findname(M,'-rexp',Rexp,Rexp,...)
```

## Input arguments

- M [ model ] - Model object in which the names will be searched for.
- Desc [ char ] - Variable, shock, or parameter descriptors that will be searched for.
- Rexp [ char ] - Regular expressions that will be matched against variable, shock, and parameter descriptors.

## Output arguments

- Name [ char ] - First name found with the descriptor Desc.
- List [ cellstr ] - List of names whose descriptors match the regular expression Rexp.

## Description

## Example

---

### ■ fisher

Approximate Fisher information matrix in frequency domain

## Syntax

```
[F,FF,Delta,Freq] = fisher(M,NPer,List,...)
```

## Input arguments

- M [ model ] - Solved model object.
- NPer [ numeric ] - Length of the hypothetical range for which the Fisher information will be computed.
- List [ cellstr ] - List of parameters with respect to which the likelihood function will be differentiated.

## Output arguments

- F [ numeric ] - Approximation of the Fisher information matrix.
- FF [ numeric ] - Contributions of individual frequencies to the total Fisher information matrix.
- Delta [ numeric ] - Kronecker delta by which the contributions in Fi need to be multiplied to sum up to F.
- Freq [ numeric ] - Vector of frequencies at which the Fisher information matrix is evaluated.

## Options

- 'chkSstate=' [ true | false | cell ] - Check steady state in each iteration; works only in non-linear models.
- 'deviation=' [ true | false ] - Exclude the steady state effect at zero frequency.
- 'exclude=' [ char | cellstr | empty ] - List of measurement variables that will be excluded from the likelihood function.
- 'percent=' [ true | false ] - Report the overall Fisher matrix F as Hessian w.r.t. the log of variables; the interpretation for this is that the Fisher matrix describes the changes in the log-likelihood function in response to percent, not absolute, changes in parameters.
- 'progress=' [ true | false ] - Display progress bar in the command window.
- 'refresh=' [ true | false ] - Refresh dynamic links in each differentiation step.
- 'solve=' [ true | false ] - Re-solve model in each differentiation step.
- 'sstate=' [ true | false | cell ] - Re-compute steady state in each differentiation step; if the model is non-linear, you can pass in a cell array with opt used in the sstate function.

## Description

## Example

---

## ■ fmse

Forecast mean square error matrices

## Syntax

```
[F,List,D] = fmse(M,NPer,...)
[F,List,D] = fmse(M,Range,...)
```

## Input arguments

- M [ model ] - Model object for which the forecast MSE matrices will be computed.
- NPer [ numeric ] - Number of periods.
- Range [ numeric ] - Date range.

## Output arguments

- F [ numeric ] - Forecast MSE matrices.
- List [ cellstr ] - List of variables in rows and columns of M.
- D [ dbase ] - Database with the std deviations of individual variables, i.e. the square roots of the diagonal elements of F.

## Options

- 'output=' [ 'namedmat' | numeric ] - Output matrix M will be either a namedmat object or a plain numeric array; if the option 'select=' is used, 'output=' is always 'namedmat'.
- 'select=' [ cellstr | Inf ] - Return FMSE for selected variables only; Inf means all variables. The option does not apply to the output database D.

## Description

## Example

---

## ■ get

Query model object properties

## Syntax

```
Ans = get(M,Query)
[Ans,Ans,...] = get(M,Query,Query,...)
```

## Input arguments

- M [ model ] - Model object.
- Query [ char ] - Query to the model object.

## Output arguments

- Ans [ ... ] - Answer to the query.

## Valid queries to model objects

Below is the categorised list of model properties and attributes that can be queried/accessed by the get function. Note that letter 'y' is used in various contexts to denote measurement variables or equations, 'x' transition variables or equations, 'e' shocks, 'p' parameters, 'g' exogenous variables, 'd' deterministic trend equations, 'l' dynamic links, and 'r' reporting equations. The property names are case insensitive.

### —Steady state

- 'sstate' – Returns [ struct ] a database with the steady states for all model variables. The steady states are described by complex numbers in which the real part is the level and the imaginary part is the growth rate.
- 'sstateLevel' – Returns [ struct ] a database with the steady-state levels for all model variables.

## Model objects and functions: get

- 'sstateGrowth' – Returns [ struct ] a database with steady-state growth (first difference for linearised variables, gross rate of growth for log-linearised variables) for all model variables.
- 'dtrends' – Returns [ struct ] a database with the effect of the deterministic trends on the measurement variables. The effect is described by complex numbers the same way as the steady state.
- 'dtrendsLevel' – Returns [ struct ] a database with the effect of the deterministic trends on the steady-state levels of the measurement variables.
- 'dtrendsGrowth' – Returns [ struct ] a database with the effect of deterministic trends on steady-state growth of the measurement variables.
- 'sstate+dtrends' – Returns [ struct ] the same as 'sstate' except that the measurement variables are corrected for the effect of the deterministic trends.
- 'sstateLevel+dtrendsLevel' – Returns [ struct ] the same as 'sstateLevel' except that the measurement variables are corrected for the effect of the deterministic trends.
- 'sstateGrowth+dtrendsGrowth' – Returns [ struct ] the same as 'sstateGrowth' except that the measurement variables are corrected for the effect of the deterministic trends.

### —Variables, shocks, and parameters

- 'yList', 'xList', 'eList', 'pList', 'gList' – Return [ cellstr ] the lists of, respectively, measurement variables (y), transition variables (x), shocks (e), parameters (p), and exogenous variables (g), each in order of appearance of the names in declaration sections of the original model file. Note that the list of parameters, 'pList', does not include the names of std deviations or cross-correlations.
- 'eyList' – Returns [ cellstr ] the list of measurement shocks in order of their appearance in the model code declarations; only those shocks that actually occur in at least one measurement equation are returned.
- 'exList' – Returns [ cellstr ] the list of transition shocks in order of their appearance in the model code declarations; only those shocks that actually occur in at least one transition equation are returned.
- 'stdList' – Returns [ cellstr ] the list of the names of the standard deviations for the shocks in order of the appearance of the corresponding shocks in the model code.
- 'corrList' – Returns [ cellstr ] the list of the names of cross-correlation coefficients for the shocks in order of the appearance of the corresponding shocks in the model code.
- 'stdCorrList' – Returns [ cellstr ] the list of the names of std deviations and cross-correlation coefficients for the shocks in order of the appearance of the corresponding shocks in the model code.

—*Equations*

- 'yEqtn', 'xEqtn', 'dEqtn', 'lEqtn', 'rEqtn' - Return [ cellstr ] the lists of, respectively, to measurement equations (y), transition equations (x), deterministic trends (d), dynamic links (l), and reporting equations (r), each in order of appearance in the original model file.
- 'links' - Returns [ struct ] a database with the dynamic links with fields names after the LHS name.

—*First-order Taylor expansion of equations*

- 'derivatives' - Returns [ cellstr ] the symbolic/automatic derivatives for each model equation; in each equation, the derivatives w.r.t. all variables present in that equation are evaluated at once and returned as a vector of numbers; see also 'wrt'.
- 'wrt' - Returns [ cellstr ] the list of the variables (and their auxiliary lags or leads) with respect to which the corresponding equation in 'derivatives' is differentiated.

—*Descriptions and aliases of variables, parameters, and shocks*

- 'descript' - Returns [ struct ] a database with user descriptions of model variables, shocks, and parameters.
- 'yDescript', 'xDescript', 'eDescript', 'pDescript', 'gDescript' - Return [ cellstr ] user descriptions of, respectively, measurement variables (y), transition variables (x), shocks (e), parameters (p), and exogenous variables (g).
- 'alias' - Returns [ struct ] a database with all aliases of model variables, shocks, and parameters.
- 'yAlias', 'xAlias', 'eAlias', 'pAlias', 'gAlias' - Return [ cellstr ] the aliases of, respectively, measurement variables (y), transition variables (x), shocks (e), parameters (p), and exogenous variables (g).

—*Equation labels and aliases*

- 'labels' - Returns [ cellstr ] the list of all user labels added to equations.
- 'yLabels', 'xLabels', 'dLabels', 'lLabels', 'rLabels' - Return [ cellstr ] user labels added, respectively, to measurement equations (y), transition equations (x), deterministic trends (d), dynamic links (l), and reporting equations (r).
- 'eqtnAlias' - Returns [ cellstr ] the list of all aliases added to equations.
- 'yEqtnAlias', 'xEqtnAlias', 'dEqtnAlias', 'lEqtnAlias', 'rEqtnAlias' - Return [ cellstr ] the aliases of, respectively, measurement equations (y), transition equations (x), deterministic trends (d), dynamic links (l), and reporting equations (r).

—*Parameter values*

- 'corr' – Returns [ struct ] a database with current cross-correlation coefficients of shocks.
- 'nonzeroCorr' – Returns [ struct ] a database with current nonzero cross-correlation coefficients of shocks.
- 'parameters' – Returns [ struct ] a database with current parameter values, including the std devs and non-zero corr coefficients.
- 'std' – Returns [ struct ] a database with current std deviations of shocks.

—*Eigenvalues*

- 'stableRoots' – Returns [ cell of numeric ] a vector of the model eigenvalues that are smaller than one in magnitude (allowing for rounding errors around one).
- 'unitRoots' – Returns [ cell of numeric ] a vector of the model eigenvalues that equal one in magnitude (allowing for rounding errors around one).
- 'unstableRoots' [ cell of numeric ] A vector of the model eigenvalues that are greater than one in magnitude (allowing for rounding errors around one).

—*Model structure, solution, build*

- 'build' – Returns [ numeric ] IRIS version number under which the model object has been built.
- 'log' – Returns [ struct ] a database with true for each log-linearised variables, and false for each linearised variable.
- 'maxLag' – Returns [ numeric ] the maximum lag in the model.
- 'maxLead' – Returns [ numeric ] the maximum lead in the model.
- 'stationary' – Returns [ struct ] a database with true for each stationary variables, and false for each unit-root (non-stationary) variables (under current solution).
- 'nonStationary' – Returns [ struct ] a database with true for each unit-root (non-stationary) variable, and false for each stationary variable (under current solution).
- 'stationaryList' – Returns [ cellstr ] the list of stationary variables (under current solution).
- 'nonStationaryList' – Returns [ cellstr ] cell with the list of unit-root (non-stationary) variables (under current solution).
- 'initCond' – Returns [ cellstr ] the list of the lagged transition variables that need to be supplied as initial conditions in simulations and forecasts. The list of the initial conditions is solution-specific as the state-spece coefficients at some of the lags may evaluate to zero depending on the current parameters.

- 'yVector' – Returns [ cellstr ] the list of measurement variables in order of their appearance in the rows and columns of state-space matrices (effectively identical to 'yList') from the [model/sspace](#) P137 function.
- 'xVector' – Returns [ cellstr ] the list of transition variables, and their auxiliary lags and leads, in order of their appearance in the rows and columns of state-space matrices from the [model/sspace](#) P137 function.
- 'xfVector' – Returns [ cellstr ] the list of forward-looking (i.e. non-predetermined) transition variables, and their auxiliary lags and leads, in order of their appearance in the rows and columns of state-space matrices from the [model/sspace](#) P137 function.
- 'xbVector' – Returns [ cellstr ] the list of backward-looking (i.e. predetermined) transition variables, and their auxiliary lags and leads, in order of their appearance in the rows and columns of state-space matrices from the [model/sspace](#) P137 function.
- 'eVector' – Returns [ cellstr ] the list of the shocks in order of their appearance in the rows and columns of state-space matrices (effectively identical to 'eList') from the [model/sspace](#) P137 function.

## Description

—*First-order Taylor expansion of equations*

The expressions for symbolic/automatic derivatives of individual model equations returned by 'derivatives' are expressions that evaluate the derivatives with respect to all variables present in that equation at once. The list of variables with respect to which each equation is differentiated is returned by 'wrt'.

The expressions returned by the query 'derivatives' can refer to

- the names of model parameters, such as alpha;
- the names of transition or measurement variables, such as X;
- the lags or leads of variables, such as X{-1} or X{2}.

Note that the lags and leads of variables must be, in general, preserved in the derivatives for non-stationary (unit-root) models. For stationary models, the lags and leads can be removed and each simply replaced with the current date of the respective variable.

## Example

```
d = get(m,'derivatives');
```

```
w = get(m, 'wrt');
```

The 1-by-N cell array `d` (where `N` is the total number of equations in the model) will contain expressions that evaluate to the vector of derivatives of the individual equations w.r.t. to the variables present in that equation:

```
d{k}
```

is an expression that returns, in general, a vector of `M` numbers. These `M` numbers are the derivatives of the `k`-th equation w.r.t to `M` variables whose list is in

```
w{k}
```

---

## ■ horzcat

Combine two compatible model objects in one object with multiple parameterisations

### Syntax

```
M = [M1,M2,...]
```

### Input arguments

- `M1, M2 [ model ]` - Compatible model objects that will be combined; the input models must be based on the same model file.

### Output arguments

- `M [ model ]` - Output model object that combines the input model objects as multiple parameterisations.

## Description

## Example

---

### ■ icrf

## Initial-condition response functions

### Syntax

```
S = icrf(M,NPer,...)
S = icrf(M,Range,...)
```

### Input arguments

- M [ model ] - Model object for which the initial condition responses will be simulated.
- Range [ numeric ] - Date range with the first date being the shock date.
- NPer [ numeric ] - Number of periods.

### Output arguments

- S [ struct ] - Database with initial condition response series.

### Options

- 'delog=' [ true | false ] - Delogarithmise the responses for variables declared as !variables:log.
- 'size=' [ numeric | 1 for linear models | log(1.01) for non-linear models ] - Size of the deviation in initial conditions.

## Description

## Example

---

## ■ `ifrf`

Frequency response function to shocks

### Syntax

```
[W,List] = ifrf(M,Freq,...)
```

### Input arguments

- `M` [ `model` ] - Model object for which the frequency response function will be computed.
- `Freq` [ `numeric` ] - Vector of frequencies for which the response function will be computed.

### Output arguments

- `W` [ `numeric` ] - Array with frequency responses of transition variables (in rows) to shocks (in columns).
- `List` [ `cell` ] - List of transition variables in rows of the `W` matrix, and list of shocks in columns of the `W` matrix.

### Options

- `'output='` [ `'namedmat'` | `numeric` ] - Output matrix `W` will be either a `namedmat` object or a plain numeric array; if the option `'select='` is used, `'output='` is always `'namedmat'`.
- `'select='` [ `char` | `cellstr` | `Inf` ] - Return the frequency response function only for selected variables and/or selected shocks.

### Description

### Example

---

## ■ `iscompatible`

True if two models can occur together on the LHS and RHS in an assignment

### Syntax

```
Flag = iscompatible(M1,M2)
```

### Input arguments

- M1, M2 [ model ] - Two model objects that will be tested for compatibility.

### Output arguments

- Flag [ true | false ] - True if M1 and M1 can occur in an assignment,  $M1(\dots) = M2(\dots)$  or horizontal concatenation, [M1,M2].

### Description

The function compares the names of all variables, shocks, and parameters, and the composition of the state-space vectors.

### Example

---

## ■ islinear

True for models declared as linear

### Syntax

```
Flag = islinear(M)
```

### Input arguments

- m [ model ] - Queried model object.

### Output arguments

- Flag [ true | false ] - True if the model has been declared linear.

## Description

The value returned depends on whether the model has been declared as linear by the user when constructing the model object by calling the `model/model` [P119](#) function. In other words, no check is performed whether or not the model is actually linear.

## Example

```
m = model('mymodel.file','linear=',true);
islinear(m)
ans =
     1
```

---

## ■ islog

True for log-linearised variables

## Syntax

```
flag = islog(m,name)
```

## Input arguments

- `m` [ model ] - Model object.
- `name` [ char | cellstr ] - Name or names of model variable(s).

## Output arguments

- `flag` [ true | false ] - True for variables declared as log-linear in a non-linear model.

## Description

## Example

---

## ■ isname

True for valid names of variables, parameters, or shocks in model object

### Syntax

```
Flag = isname(M,Name)
[Flag,Flag,...] = isname(M,Name,Name,...)
```

### Input arguments

- M [ model ] - Model object.
- Name [ char ] - A text string that will be matched against the names of variables, parameters and shocks in the model object M.

### Output arguments

- Flag [ true | false ] - True for input strings that are valid names in the model object M.

### Description

### Example

---

## ■ isnan

Check for NaNs in model object

### Syntax

```
[Flag,List] = isnan(M,'parameters')
[Flag,List] = isnan(M,'sstate')
[Flag,List] = isnan(M,'derivatives')
```

### Input arguments

- `M [ model ]` - Model object.

### Output arguments

- `Flag [ true | false ]` - True if at least one NaN value exists in the queried category.
- `List [ cellstr ]` - List of parameters (if called with 'parameters') or variables (if called with 'variables') that are assigned NaN in at least one parameterisation, or equations (if called with 'derivatives') that produce an NaN derivative in at least one parameterisation.

### Description

### Example

---

## ■ issolved

True if a model solution exists

### Syntax

```
flag = issolved(m)
```

### Input arguments

- `m [ model ]` - Model object.

### Output arguments

- `flag [ true | false ]` - True for each parameterisation for which a stable unique solution has been found and exists currently in the model object.

## Description

## Example

---

### ■ **isstationary**

True if model or specified combination of variables is stationary

## Syntax

```
Flag = isstationary(M)  
Flag = isstationary(M,Expn)
```

## Input arguments

- M [ model ] - Model object.
- Expn [ char ] - Text string with an expression describing a combination of transition variables to be tested.

## Output arguments

- 'flag=' [ true | false ] - True if the model (if called without a second input argument) or the specified combination of variables (if called with a second input argument) is stationary.

## Description

## Example

---

### ■ **jforecast**

Forecast with judgmental adjustments (conditional forecasts)

## Syntax

```
F = jforecast(M,D,Range,...)
```

## Input arguments

- M [ model ] - Solved model object.
- D [ struct ] - Input data from which the initial condition is taken.
- Range [ numeric ] - Forecast range.

## Output arguments

- F [ struct ] - Output struct with the judgmentally adjusted forecast.

## Options

- 'anticipate=' [ true | false ] - If true, real future shocks are anticipated, imaginary are unanticipated; vice versa if false.
- 'currentOnly=' [ true | false ] - If true, MSE matrices will be computed only for current-dated variables, not for their lags or leads.
- 'deviation=' [ true | false ] - Treat input and output data as deviations from balanced-growth path.
- 'dtrends=' [ 'auto' | true | false ] - Measurement data contain deterministic trends.
- 'initCond=' [ 'data' | 'fixed' ] - Use the MSE for the initial conditions if found in the input data or treat the initial conditions as fixed.
- 'meanOnly=' [ true | false ] - Return only mean data, i.e. point estimates.
- 'plan=' [ plan ] - Simulation plan specifying the exogenised variables and endogenised shocks.
- 'vary=' [ struct | empty ] - Database with time-varying std deviations or cross-correlations of shocks.

### Description

When adjusting the mean and/or std devs of shocks, you can use real and imaginary numbers to distinguish between anticipated and unanticipated shocks:

- any shock entered as an imaginary number is treated as an anticipated change in the mean of the shock distribution;
- any std dev of a shock entered as an imaginary number indicates that the shock will be treated as anticipated when conditioning the forecast on the reduced-form tunes.
- the same shock or its std dev can have both the real and the imaginary part.

### Description

### Example

---

## ■ length

Number of alternative parameterisations

### Syntax

`N = length(M)`

### Input arguments

- `M [ model | esteq ]` - Model or esteq object.

### Output arguments

- `N [ numeric ]` - Number of alternative parameterisations.

### Description

### Example

---

## ■ lhsmrhs

Evaluate the discrepancy between the LHS and RHS for each model equation and given data

### Syntax for casual evaluation

```
Q = lhsmrhs(M,D,Range)
```

### Syntax for fast evaluation

```
Q = lhsmrhs(M, YXE)
```

### Input arguments

M [ model ] - Model object whose equations and currently assigned parameters will be evaluated.

YXE [ numeric ] - Numeric array created from an input database by calling the function [data4lhsmrhs](#) [P78](#); YXE contains the observations on the measurement variables, transition variables, and shocks organised row-wise.

- D [ struct ] - Input database with observations on measurement variables, transition variables, and shocks on which the discrepancies will be evaluated.
- Range [ numeric ] - Date range on which the discrepancies will be evaluated.

### Output arguments

Q [ numeric ] - Numeric array with discrepancies between the LHS and RHS for each model equation.

### Description

The function lhsmrhs evaluates the discrepancy between the LHS and the RHS in each model equation; each lead is replaced with the actual observation supplied in the input data. The function lhsmrhs does not work for models with [references to steady state values](#) [P55](#).

The first syntax, with the array YXE pre-built in a call to [data4lhsmrhs](#) [P78](#) is computationally much more efficient if you need to evaluate the LHS-RHS discrepancies repeatedly for different parameterisations.

The output argument D is an nEqtn by nPer by nAlt array, where nEqtn is the number of measurement and transition equations, nPer is the number of periods used to create X in a prior call to `data4lhsrhs` [P78](#), and nAlt is the greater of the number of alternative parameterisations in M, and the number of alternative datasets in the input data.

### Example

```
YXE = data4lhsrhs(M,d,range);  
Q = lhsrhs(M,YXE);
```

---

## ■ loglik

Evaluate minus the log-likelihood function in time or frequency domain

### Full syntax

```
[Obj,V,F,PE,Delta,PDelta] = loglik(M,D,Range,...)
```

### Syntax for fast one-off likelihood evaluation

```
Obj = loglik(M,D,Range,...)
```

### Syntax for repeated fast likelihood evaluations

```
% Step #1: Initialise.  
loglik(M,D,Range,...,'persist=',true);  
  
% Step #2: Assign/change parameters.  
M... = ...; % Change parameters.  
  
% Step #3: Re-compute steady state and solution if necessary.  
M = ...;  
M = ...;  
  
% Step #4: Evaluate likelihood.
```

## Model objects and functions: loglik

```
L = loglik(M);  
  
% Repeat steps #2, #3, #4 for different values of parameters.  
% ...
```

### Input arguments

- M [ model ] - Model object on which the likelihood of the input data will be evaluated.
- D [ struct | cell ] - Input database or datapack from which the measurement variables will be taken.
- Range [ numeric ] - Date range.

### Output arguments

—*Test title*

- Obj [ numeric ] - Value of minus the log-likelihood function (or other objective function if specified in options).
- V [ numeric ] - Estimated variance scale factor if the 'relative=' options is true; otherwise V is 1.
- F [ numeric ] - Sequence of forecast MSE matrices for measurement variables.
- PE [ struct ] - Database with prediction errors for measurement variables; exp of prediction errors for measurement variables declared as log-variables.
- Delta [ struct ] - Database with point estimates of the deterministic trend parameters specified in the 'outoflik=' option.
- PDelta [ numeric ] - MSE matrix of the estimates of the 'outoflik=' parameters.

### Options

- 'persist=' [ true | false ] - Pre-process and store the overhead (data and options) for subsequent fast calls.

See help on [model/filter](#) P93 for other options available.

## Description

The number of output arguments you request when calling `loglik` affects computational efficiency. Running the function with only the first output argument, i.e. the value of the likelihood function (minus the log of it, in fact), results in the fastest performance.

The `loglik` function runs an identical Kalman filter as `model/filter` [P93](#), the only difference is the types and order of output arguments returned.

—*Fast evaluation of likelihood*

Every time you change the parameters, you need to update the steady state and solution of the model if necessary by yourself, before calling `loglik`. Follow these rules:

- If you only change std deviations and no other parameters, you don't have to re-calculate steady state or solution.
- If the model is linear, you only need to call `solve` [P134](#).
- The only exception to rules #2 and #3 is when the model has `dynamic links` [P40](#) with references to some steady state values. In that case, you must also run `sstate` [P138](#) after `solve` [P134](#) in linear models to update the steady state.
- If the model is non-linear, and you only change parameters that affect transitory dynamics and not the steady state, you only need to call `solve` [P134](#).
- If the model is non-linear, and you change parameters that affect both transitory dynamics and steady state, you must run first `sstate` [P138](#) and then `solve` [P134](#).

## Example

---

### ■ lognormal

Characteristics of log-normal distributions returned by filter of forecast

#### Syntax

```
D = lognormal(M,D,...)
```

### Input arguments

- M [ model ] - Model on which the filter or forecast function has been run.
- D [ struct ] - Struct or database returned from the filter or forecast function.

### Output arguments

- D [ struct ] - Struct including new sub-databases with requested log-normal statistics.

### Options

- 'fresh=' [ true | false ] - Output structure will include only the newly computed databases.
- 'mean=' [ true | false ] - Compute the mean of the log-normal distributions.
- 'median=' [ true | false ] - Compute the median of the log-normal distributions.
- 'mode=' [ true | false ] - Compute the mode of the log-normal distributions.
- 'prctile=' [ numeric | [5,95] ] - Compute the selected percentiles of the log-normal distributions.
- 'prefix=' [ char | 'lognormal' ] - Prefix used in the names of the newly created databases.
- 'std=' [ true | false ] - Compute the std deviations of the log-normal distributions.

### Description

---

## ■ model

Create new model object based on model file

### Syntax

```
m = model(fname,...)
m = model(m,...)
```

### Input arguments

- `fname` [ char | cellstr ] - Name(s) of the model file(s) that will be loaded and converted to a new model object.
- `m` [ model ] - Existing model object that will be rebuilt as if from a model file.

### Output arguments

- `m` [ model ] - New model object based on the input model code file or files.

### Options

- `'multiple='` [ true | false ] - Allow each variable, shock, or parameter name to be declared (and assigned) more than once in the model file.
- `'assign='` [ struct | empty ] - Assign model parameters and/or steady states from this database at the time the model objects is being created.
- `'baseYear='` [ numeric | 2000 ] - Base year for constructing deterministic time trends.
- `'comment='` [ char | empty ] - Text comment attached to the model object.
- `'declareParameters='` [ true | false ] - If false, skip parameter declaration in the model file, and determine the list of parameters automatically as names found in equations but not declared.
- `'epsilon='` [ numeric |  $\text{eps}^{(1/4)}$  ] - The minimum relative step size for numerical differentiation.
- `'linear='` [ true | false ] - Indicate linear models.
- `'removeLeads='` [ true | false ] - Remove all leads from the state-space vector, keep included only current dates and lags.
- `'sstateOnly='` [ true | false ] - Read in only the steady-state versions of equations (if available).
- `'std='` [ numeric | 1 for linear models | 0.01 for non-linear models ] - Default standard deviation for model shocks.
- `'userdata='` [ ... | empty ] - Attach user data to the model object.

**Description***—Loading a model file*

The model function can be used to read in a [model file](#) [P23](#) named `fname`, and create a model object `m` based on the model file. You can then work with the model object in your own `m`-files, using using the IRIS [model functions](#) [P66](#) and standard Matlab functions.

If `fname` is a cell array of more than one filenames then all files are combined together (in order of appearance).

*—Re-building an existing model object*

The only instance where you may need to call a model function on an existing model object is to change the `'removeLeads='` option. Of course, you can always achieve the same by loading the original model file.

**Example 1**

Read in a model code file named `my.model`, and declare the model as linear:

```
m = model('my.model','linear',true);
```

**Example 2**

Read in a model code file named `my.model`, declare the model as linear, and assign some of the model parameters:

```
m = model('my.model','linear=',true,'assign=',P);
```

Note that this is equivalent to

```
m = model('my.model','linear=',true);
m = assign(m,P);
```

unless some of the parameters passed in to the model function are needed to evaluate [if](#) [P37](#) or [!switch](#) [P48](#) expressions.

## ■ neighbourhood

Evaluate the local behaviour of the objective function around the estimated parameter values

### Syntax

```
[D, FigH, AxH, ObjH, LikH, EstH, BH] = neighbourhood(M, PS, Neigh, ...)
```

### Input arguments

- M [ model | bkwmodel ] - Model or bkwmodel object.
- PS [ poster ] - Posterior simulator (poster) object returned by the [model/estimate](#) P82 function.
- Neigh [ numeric ] - The neighbourhood in which the objective function will be evaluated defined as multiples of the parameter estimates.

### Output arguments

- D [ struct ] - Struct describing the local behaviour of the objective function and the data likelihood (minus log likelihood) within the specified range around the optimum for each parameter.

The following output arguments are non-empty only if you choose 'plot=' true:

- FigH [ numeric ] - Handles to the figures created.
- AxH [ numeric ] - Handles to the axes objects created.
- ObjH [ numeric ] - Handles to the objective function curves plotted.
- LikH [ numeric ] - Handles to the data likelihood curves plotted.
- EstH [ numeric ] - Handles to the actual estimate marks plotted.
- BH [ numeric ] - Handles to the bounds plotted.

## Options

- 'plot=' [ true | false ] - Call the [grfun.plotneigh](#) P433 function from within neighbourhood to visualise the results.
- 'neighbourhood=' [ struct | empty ] - Struct specifying the neighbourhood points for some of the parameters; these points will be used instead of those based on Neigh.

## Plotting options

See help on [grfun.plotneigh](#) P433 for options available when you choose 'plot=' true.

## Description

In the output database, D, each parameter is a 1-by-3 cell array. The first cell is a vector of parameter values at which the local behaviour was investigated. The second cell is a matrix with two column vectors: the values of the overall minimised objective function (as set up in the [estimate](#) P82 function), and the values of the data likelihood component. The third cell is a vector of four numbers: the parameter estimate, the value of the objective function at optimum, the lower bound and the upper bound.

## Example

---

## ■ omega

Get or set the covariance matrix of shocks

### Syntax for getting covariance matrix

```
OMG = omega(M)
```

### Syntax for setting covariance matrix

```
M = omega(M,OMG)
```

### Input arguments

- M [ model | bkwmodel ] - Model or bkwmodel object.
- OMG [ numeric ] - Covariance matrix that will be converted to new values for std deviations and cross-corr coefficients.

### Output arguments

- OMG [ numeric ] - Covariance matrix of shocks or residuals based on the currently assigned std deviations and cross-correlation coefficients.
- M [ model | bkwmodel ] - Model or bkwmodel object with new values for std deviations and cross-corr coefficients based on the input covariance matrix.

### Description

### Example

---

## ■ refresh

Refresh dynamic links

### Syntax

```
M = refresh(M)
```

### Input arguments

- M [ model ] - Model object whose dynamic links will be refreshed.

### Output arguments

- M [ model ] - Model object with dynamic links refreshed.

## Description

## Example

```
m = refresh(m);
```

---

## ■ regress

Centred population regression for selected model variables

## Syntax

```
[B,CovRes,R2] = regress(M,Lhs,Rhs,...)
```

## Input arguments

- M [ model ] - Model on whose covariance matrices the population regression will be based.
- Lhs [ char | cellstr ] - Lhs variables in the regression; each of the variables must be part of the state-space vector.
- Rhs [ char | cellstr ] - Rhs variables in the regression; each of the variables must be part of the state-space vector, or must refer to a larger lag of a transition variable present in the state-space vector.

## Output arguments

- B [ namedmat | numeric ] - Population regression coefficients.
- CovRes [ namedmat | numeric ] - Covariance matrix of residuals from the population regression.
- R2 [ numeric ] - Coefficient of determination (R-squared).

## Options

- 'output=' [ 'namedmat' | 'numeric' ] - Output matrices will be either namedmat objects or plain numeric arrays.

## Description

Population regressions calculated by this function are always centred. This means the regressions are always calculated as if estimated on observations with their unconditional means (the steady-state levels) removed from them.

The Lhs and Rhs variables that are log-variables must include `log(...)` explicitly in their names. For instance, if `X` is declared to be a log variable, then you must refer to `log(X)` or `log(X{-1})`.

## Example

```
[B,C] = regress('log(R)', {'log(R{-1})', 'log(dP)'});
```

---

## ■ reporting

Run reporting equations

### Syntax

```
D = reporting(M,D,Range,...)
```

### Input arguments

- `M [ model ]` - Model object with reporting equations.
- `D [ struct ]` - Input database that will be used to evaluate the reporting equations.
- `Range [ numeric ]` - Date range on which the reporting equations will be evaluated.

### Output arguments

- `D [ struct ]` - Output database with reporting variables.

### Options

- `'dynamic=' [ true | false ]` - If true, equations will be evaluated period by period allowing for own lags; if false, equations will be evaluated en bloc for all periods.

- 'merge=' [ true | false ] - Merge output database with input datase.

## Description

---

### ■ resample

Resample from the model implied distribution

#### Syntax

```
Outp = resample(M,Inp,Range,NDraw,...)
Oupt = resample(M,Inp,Range,NDraw,J,...)
```

#### Input arguments

- M [ model ] - Solved model object.
- Inp [ struct | empty ] - Input data (if needed) for the distributions of initial condition and/or empirical shocks; if not bootstrap is invovled
- Range [ numeric ] - Resampling date range.
- NDraw [ numeric ] - Number of draws.
- J [ struct | empty ] - Database with user-supplied (time-varying) tunes on std devs, corr coeffs, and/or means of shocks.

#### Output arguments

- Outp [ struct ] - Output database with resampled data.

#### Options

- 'deviation=' [ true | false ] - Treat input and output data as deviations from balanced-growth path.
- 'dtrends=' [ 'auto' | true | false ] - Add deterministic trends to measurement variables.

- 'method=' [ 'bootstrap' | 'montecarlo' ] - Method of randomising shocks and initial condition.
- 'progress=' [ true | false ] - Display progress bar in the command window.
- 'randomInitCond=' [ true | false | numeric ] - Randomise initial condition; a number means the initial condition will be simulated using the specified number of extra pre-sample periods.
- 'stateVector=' [ 'alpha' | 'x' ] - When resampling initial condition, use the transformed state vector, alpha, or the vector of original variables, x; this option is meant to guarantee replicability of results.
- 'svdOnly=' [ true | false ] - Do not attempt Cholesky and only use SVD to factorize the covariance matrix when resampling initial condition; only applies when 'randomInitCond=' true.
- 'wild=' [ true | false ] - Use wild bootstrap instead of Efron bootstrap; only applies when 'method=' 'bootstrap'.

### Description

When you use wild bootstrap for resampling the initial condition, the results are based on an assumption that the mean of the initial condition is the asymptotic mean implied by the model (i.e. the steady state).

### Example

---

## ■ set

Change modifiable model object property

### Syntax

```
M = set(M,Request,Value)
```

```
M = set(M,Request,Value,Request,Value,...)
```

### Input arguments

- M [ model ] - Model object.

## Model objects and functions: set

- Request [ char ] - Name of a modifiable model object property that will be changed.
- Value [ ... ] - Value to which the property will be set.

### Output arguments

- M [ model ] - Model object with the requested property or properties modified.

### Valid requests to model objects

#### —*Equation labels and aliases*

- 'yLabels=', 'xLabels=', 'dLabels=', 'lLabels=' [ cellstr ] - Change the labels attached to, respectively, measurement equations (y), transition equations (x), deterministic trends (d), and dynamic links (d).
- 'labels=' [ cell ] - Change the labels attached to all equations; needs to be a cellstr matching the size of get(M, 'labels').
- 'yeqtnAlias=', 'xeqtnAlias=', 'deqtnAlias=', 'leqtnAlias=' [ cellstr ] - Change the aliases of, respectively, measurement equations (y), transition equations (x), deterministic trends (d), and dynamic links (d).
- 'eqtnAlias=' [ cell ] - Change the aliases of all equations; needs to be a cellstr matching the size of get(M, 'eqtnAlias').

#### —*Descriptions and aliases of variables, shocks, and parameters*

- 'yDescript=', 'xDescript=', 'eDescript=', 'pDescript=' [ cellstr ] - Change the descriptions of, respectively, measurement variables (y), transition variables (x), shocks (e), and exogenous variables (g).
- 'descript=' [ struct ] - Change the descriptions of all variables, parameters, and shocks; needs to be a struct (database) with fields corresponding to model names.
- 'yAlias=', 'xAlias=', 'eAlias=', 'pAlias=' [ cellstr ] - Change the aliases of, respectively, measurement variables (y), transition variables (x), shocks (e), and exogenous variables (g).
- 'alias=' [ struct ] - Change the aliases of all variables, parameters, and shocks; needs to be a struct (database) with fields corresponding to model names.

—*Other requests*

- 'nAlt=' [ numeric ] - Change the number of alternative parameterisations.
  - 'stdVec=' [ numeric ] - Change the whole vector of std deviations.
  - 'tOrigin=' [ numeric ] - Change the base year for computing deterministic time trends in measurement variables.
  - 'epsilon=' [ numeric ] - Change the relative differentiation step when computing Taylor expansion.
- 

## ■ shockplot

Short-cut for running and plotting plain shock simulation

### Syntax

```
[S,FF,AA] = shockplot(M,ShockName,SimRange,PlotList,...)
```

### Input arguments

- M [ model ] - Model object that will be simulated.
- ShockName [ char ] - Name of the shock that will be simulated.
- SimRange [ numeric ] - Date range on which the shock will be simulated.
- PlotList [ cellstr ] - List of variables that will be reported; you can use the syntax of [dbase/dbplot](#) P365.

### Output arguments

- S [ struct ] - Database with simulation results.
- FF [ numeric ] - Handles of figure windows created.
- AA [ numeric ] - Handles of axes objects created.

### Options affecting the simulation

- 'deviation=' [ true | false ] - See the option 'deviation=' in [model/simulate](#) P131.
- 'dtrends=' [ true | false ] - See the option 'dtrends=' option in [model/simulate](#) P131.
- 'shockSize=' [ 'std' | numeric ] - Size of the shock that will be simulated; 'std' means that one std dev of the shock will be simulated.

### Options affecting the graphs

See help on [dbase/dbplot](#) P365 for other options available.

### Description

The simulated shock always occurs at time  $t=1$ . Starting the simulation range, `SimRange`, before  $t=1$  allows you to simulate anticipated shocks.

The graphs automatically include one pre-sample period, i.e. one period prior to the start of the simulation.

### Example

---

## ■ simulate

Simulate model

### Syntax

```
S = simulate(M,D,Range,...)
[S,Flag,AddF,Discrep] = simulate(M,D,Range,...)
```

### Input arguments

- M [ model ] - Solved model object.
- D [ struct | cell ] - Input database or datapack from which the initial conditions and shocks from within the simulation range will be read.

## Model objects and functions: simulate

- Range [ numeric ] - Simulation range.

### Output arguments

- S [ struct | cell ] - Database with simulation results.

### Output arguments in non-linear simulations

- Flag [ cell | empty ] - Cell array with exit flags for non-linearised simulations.
- AddF [ cell | empty ] - Cell array of tseries with final add-factors added to first-order approximate equations to make non-linear equations hold.
- Discrep [ cell | empty ] - Cell array of tseries with final discrepancies between LHS and RHS in equations earmarked for non-linear simulations by a double-equal sign.

### Options

- 'anticipate=' [ true | false ] - If true, real future shocks are anticipated, imaginary are unanticipated; vice versa if false.
- 'contributions=' [ true | false ] - Decompose the simulated paths into contributions of individual shocks.
- 'deviation=' [ true | false ] - Treat input and output data as deviations from balanced-growth path.
- 'dbOverlay=' [ true | false | struct ] - Use the function doverlay to combine the simulated output data with the input database, or with another database, at the end.
- 'dTrends=' [ 'auto' | true | false ] - Add deterministic trends to measurement variables.
- 'ignoreShocks=' [ true | false ] - Read only initial conditions from input data, and ignore any shocks within the simulation range.
- 'plan=' [ plan ] - Specify a simulation plan to swap endogeneity and exogeneity of some variables and shocks temporarily, and/or to simulate some of the non-linear equations accurately.
- 'progress=' [ true | false ] - Display progress bar in the command window.

### Options for models with non-linearised equations

- 'addSstate=' [ true | false ] - Add steady state levels to simulated paths before evaluating non-linear equations; this option is used only if 'deviation=' true.
- 'display=' [ true | false | numeric | Inf ] - Report iterations on the screen; if 'display=' N, report every N iterations; if 'display=' Inf, report only final iteration.
- 'error=' [ true | false ] - Throw an error whenever a non-linear simulation fails converge; if false, only an warning will display.
- 'lambda=' [ numeric | 1 ] - Step size (between 0 and 1) for add factors added to non-linearised equations in every iteration.
- 'reduceLambda=' [ numeric | 0.5 ] - Factor (between 0 and 1) by which lambda will be multiplied if the non-linear simulation gets on an divergence path.
- 'maxIter=' [ numeric | 100 ] - Maximum number of iterations.
- 'tolerance=' [ numeric | 1e-5 ] - Convergence tolerance.

### Description

#### —*Output range*

Time series in the output database, S, are defined on the simulation range, RANGE, plus include all necessary initial conditions, i.e. lags of variables that occur in the model code. You can use the option 'doverlay=' to combine the output database with the input database (i.e. to include a longer history of data in the simulated series).

#### —*Simulations with multiple parameterisations and/or multiple data sets*

If you simulate a model with N parameterisations and the input database contains K data sets (i.e. each variable is a time series with K columns), then the following happens:

- The model will be simulated a total of  $P = \max(N,K)$  number of times. This means that each variables in the output database will have P columns.
- The 1st parameterisation will be simulated using the 1st data set, the 2nd parameterisation will be simulated using the 2nd data set, etc. until you reach either the last parameterisation or the last data set, i.e.  $\min(N,K)$ . From that point on, the last parameterisation or the last data set will be simply repeated (re-used) in the remaining simulations.
- Put formally, the I-th column in the output database, where  $I = 1, \dots, P$ , is a simulation of the  $\min(I,N)$ -th model parameterisation using the  $\min(I,K)$ -th input data set number.

## Example

---

### ■ single

Convert solution matrices to single precision

#### Syntax

```
m = single(m)
```

#### Input arguments

- m [ model ] - Model objects whose solution matrices will be converted to single precision.

#### Output arguments

- m [ model ] - Model objects single-precision solution matrices.

#### Description

---

### ■ solve

Calculate first-order accurate solution of the model

#### Syntax

```
M = solve(M,...)
```

#### Input arguments

- M [ model ] - Paramterised model object. Non-linear models must also have a steady state values assigned.

## Output arguments

- `M [ model ]` - Model with newly computed solution.

## Options

- `'expand=' [ numeric | 0 | NaN ]` - Number of periods ahead up to which the model solution will be expanded; if NaN the matrices needed to support solution expansion are not calculated and stored at all and the model cannot be used later in simulations or forecasts with anticipated shocks or plans.
- `'error=' [ true | false ]` - Throw an error if no unique stable solution exists; if false, a warning message only will be displayed.
- `'linear=' [ 'auto' | true | false ]` - Solve the model using a linear approach, i.e. differentiating around zero and not the currently assigned steady state.
- `'progress=' [ true | false ]` - Display progress bar in the command window.
- `'refresh=' [ true | false ]` - Refresh dynamic links before computing the solution.
- `'select=' [ true | false ]` - Automatically detect which equations need to be re-differentiated based on parameter changes from the last time the system matrices were calculated.
- `'warning=' [ true | false ]` - Display warnings produced by this function.

## Description

The IRIS solver uses an ordered QZ (or generalised Schur) decomposition to integrate out future expectations. The QZ may (very rarely) fail for numerical reasons. IRIS includes two patches to handle the some of the QZ failures: a SEVN2 patch (Sum-of-EigenValues-Near-Two), and an E2C2S patch (Eigenvalues-Too-Close-To-Swap).

- The SEVN2 patch: The model contains two or more unit roots, and the QZ algorithm interprets some of them incorrectly as pairs of eigenvalues that sum up accurately to 2, but with one of them significantly below 1 and the other significantly above 1. IRIS replaces the entries on the diagonal of one of the QZ factor matrices with numbers that evaluate to two unit roots.
- The E2C2S patch: The re-ordering of the QZ matrices fails with a warning 'Reordering failed because some eigenvalues are too close to swap.' IRIS attempts to re-order the equations until QZ works. The number of attempts is limited to N-1 at most where N is the total number of equations.

## Example

---

### ■ srf

#### Shock response functions

#### Syntax

```
S = srf(M,NPer,...)
S = srf(M,Range,...)
```

#### Input arguments

- M [ model ] - Model object whose shock responses will be simulated.
- Range [ numeric ] - Simulation date range with the first date being the shock date.
- NPer [ numeric ] - Number of simulation periods.

#### Output arguments

- S [ struct ] - Database with shock response time series.

#### Options

- 'delog=' [ true | false ] - Delogarithmise the responses for variables declared as !variables:log.
- 'select=' [ cellstr | Inf ] - Run the shock response function for a selection of shocks only; Inf means all shocks are simulated.
- 'size=' [ 'std' | numeric ] - Size of the shocks that will be simulated; 'std' means that each shock will be set to its std dev currently assigned in the model object m.

#### Description

#### Example

---

## ■ sspace

State-space matrices describing the model solution

### Syntax

```
[T,R,K,Z,H,D,U,Omg] = sspace(m,...)
```

### Input arguments

- `m [ model ]` - Solved model object.

### Output arguments

- `T [ numeric ]` - Transition matrix.
- `R [ numeric ]` - Matrix at the shock vector in transition equations.
- `K [ numeric ]` - Constant vector in transition equations.
- `Z [ numeric ]` - Matrix mapping transition variables to measurement variables.
- `H [ numeric ]` - Matrix at the shock vector in measurement equations.
- `D [ numeric ]` - Constant vector in measurement equations.
- `U [ numeric ]` - Transformation matrix for predetermined variables.
- `Omg [ numeric ]` - Covariance matrix of shocks.

### Options

- `'triangular=' [ true | false ]` - If true, the state-space form returned has the transition matrix `T` quasi triangular and the vector of predetermined variables transformed accordingly. This is the form used in IRIS calculations.

### Description

The state-space representation has the following form:

$$[xf; \alpha] = T * \alpha(-1) + K + R * e$$

$$y = Z * \alpha + D + H * e$$

$$xb = U * \alpha$$

$$\text{Cov}[e] = \text{Omg}$$

where  $xb$  is an  $nb$ -by-1 vector of predetermined (backward-looking) transition variables and their auxiliary lags,  $xf$  is an  $nf$ -by-1 vector of non-predetermined (forward-looking) variables and their auxiliary leads,  $\alpha$  is a transformation of  $xb$ ,  $e$  is an  $ne$ -by-1 vector of shocks, and  $y$  is an  $ny$ -by-1 vector of measurement variables. Furthermore, we denote the total number of transition variables, and their auxiliary lags and leads,  $nx = nb + nf$ .

The transition matrix,  $T$ , is, in general, rectangular  $nx$ -by- $nb$ . Furthermore, the transformed state vector  $\alpha$  is chosen so that the lower  $nb$ -by- $nb$  part of  $T$  is quasi upper triangular.

You can use the `get(m, 'xVector')` function to learn about the order of appearance of transition variables and their auxiliary lags and leads in the vectors  $xb$  and  $xf$ . The first  $nf$  names are the vector  $xf$ , the remaining  $nb$  names are the vector  $xb$ .

## ■ sstate

Compute steady state or balance-growth path of the model

### Syntax

```
M = sstate(M, ...)
```

### Input arguments

- `M [ model ]` - Parameterised model object.

### Output arguments

- `M [ model ]` - Model object with newly computed steady state assigned.

## Options

- 'linear=' [ 'auto' | true | false ] - Solve for steady state using a linear approach, i.e. based on the first-order solution matrices and the vector of constants.
- 'warning=' [ true | false ] - Display IRIS warning produced by this function.

### —Options for non-linear models

- 'blocks=' [ true | false ] - Re-arrange steady-state equations in recursive blocks before computing steady state.
- 'display=' [ 'iter' | 'final' | 'notify' | 'off' ] - Level of screen output, see Optim Tbx.
- 'endogenise=' [ cellstr | char | empty ] - List of parameters that will be endogenised when computing the steady state; the number of endogenised parameters must match the number of transition variables exogenised in the 'exogenise=' option.
- 'exogenise=' [ cellstr | char | empty ] - List of transition variables that will be exogenised when computing the steady state; the number of exogenised variables must match the number of parameters exogenised in the 'exogenise=' option.
- 'fix=' [ cellstr | empty ] - List of variables whose steady state will not be computed and kept fixed to the currently assigned values.
- 'fixAllBut=' [ cellstr | empty ] - Inverse list of variables whose steady state will not be computed and kept fixed to the currently assigned values.
- 'fixGrowth=' [ cellstr | empty ] - List of variables whose steady-state growth will not be computed and kept fixed to the currently assigned values.
- 'fixGrowthAllBut=' [ cellstr | empty ] - Inverse list of variables whose steady-state growth will not be computed and kept fixed to the currently assigned values.
- 'fixLevel=' [ cellstr | empty ] - List of variables whose steady-state levels will not be computed and kept fixed to the currently assigned values.
- 'fixLevelAllBut=' [ cellstr | empty ] - Inverse list of variables whose steady-state levels will not be computed and kept fixed to the currently assigned values.
- 'growth=' [ true | false ] - If true, both the steady-state levels and growth rates will be computed; if false, only the levels will be computed assuming that the model is either stationary or that the correct steady-state growth rates are already assigned in the model object.
- 'optimSet=' [ cell | empty ] - Name-value pairs with Optim Tbx settings; see help optimset for details on these settings.

- 'refresh=' [ true | false ] - Refresh dynamic links after steady state is computed.
- 'reuse=' [ true | false ] - Reuse the steady-state values calculated for a parameterisation to initialise the next parameterisation.
- 'solver=' [ 'fsolve' | 'lsqnonlin' ] - Solver function used to solve for the steady state of non-linear models; it can be either of the two Optimization Tbx functions, or a user-supplied solver.
- 'sstate=' [ true | false | cell ] - If true or a cell array, the steady state is re-computed in each iteration; the cell array can be used to modify the default options with which the sstate function is called.

—*Options for linear models*

- 'refresh=' [ true | false ] - Refresh dynamic links before steady state is computed.
- 'solve=' [ true | false ] - Solve model before computing steady state.

## Description

Note that for backward compatibility, the option 'growth=' is set to false by default so that either the model is assumed stationary or the steady-state growth rates have been already pre-assigned to the model object. To use the sstate function for computing both the steady-state levels and steady-state growth rates in a balanced-growth model, you need to set the option 'growth=' true.

## Example

---

## ■ sstatedb

Create model-specific steady-state or balanced-growth-path database

### Syntax

```
[D,IsDev] = sstatedb(M,Range)
[D,IsDev] = sstatedb(M,Range,NCol)
```

### Input arguments

- `M` [ model ] - Model object for which the sstate database will be created.
- `Range` [ numeric ] - Intended simulation range; the steady-state or balanced-growth-path database will be created on a range that also automatically includes all the necessary lags.
- `NCol` [ numeric ] - Number of columns for each variable; the input argument `NCol` can be only used with single-parameterisation models.

### Output arguments

- `D` [ struct ] - Database with a steady-state or balanced-growth path `tseries` object for each model variable, and a scalar or vector of the currently assigned values for each model parameter.
- `IsDev` [ false ] - The second output argument is always false, and can be used to set the option 'deviation=' in [model/simulate](#) P131.

### Description

### Example

---

## ■ sstatefile

Create a steady-state file based on the model object's steady-state equations

### Syntax

```
sstatefile(m,filename,...)
```

### Input arguments

- `m` [ model ] - Model object.
- `file` [ char ] - Filename under which the steady-state file will be saved.

## Options

- 'endogenise=' [ cellstr | char | empty ] - List of parameters that will be endogenised when computing the steady state; the number of endogenised parameters must match the number of transtion variables exogenised in the 'exogenised=' option.
- 'endogenise=' [ cellstr | char | empty ] - List of transition variables that will be exogenised when computing the steady state; the number of exogenised variables must match the number of parameters exogenised in the 'exogenise=' option.
- 'growthNames=' [ char | 'd?' ] - Template for growth names used in evaluating lags and leads.
- 'time=' [ true | false ] - Keep or remove time subscripts (curly braces) in the steady-state file.

## Description

## Example

---

## ■ stdscale

Re-scale all std deviations by the same factor

## Syntax

```
m = stdscale(m, factor)
```

## Input arguments

- m [ model ] - Model object whose std deviations will be re-scaled.
- factor [ numeric ] - Factor by which all the model std deviations will be re-scaled.

## Output arguments

- m [ model ] - Model object with all of its std deviations re-scaled.

## Description

## Example

---

### ■ subsasgn

Subscripted assignment for model and systemfit objects

Syntax for assigning parameterisations from other object

```
M(Inx) = N
```

Syntax for deleting specified parameterisations

```
M(Inx) = []
```

Syntax for assigning parameter values or steady-state values

```
M.Name = X  
M(Inx).Name = X  
M.Name(Inx) = X
```

Syntax for assigning std deviations or cross-correlations of shocks

```
M.std_Name = X  
M.corr_Name1__Name2 = X
```

Note that a double underscore is used to separate the Names of shocks in correlation coefficients.

## Input arguments

- M [ model | systemfit ] - Model or systemfit object that will be assigned new parameterisations or new parameter values or new steady-state values.

- `N [ model | systemfit ]` - Model or systemfit object compatible with `M` whose parameterisations will be assigned (copied) into `M`.
- `Inx [ numeric ]` - `Inx` of parameterisations that will be assigned or deleted.
- `Name, Name1, Name2 [ char ]` - Name of a variable, shock, or parameter.
- `X [ numeric ]` - A value (or a vector of values) that will be assigned to a parameter or variable Named `Name`.

### Output arguments

- `M [ model | systemfit ]` - Model or systemfit object with newly assigned or deleted parameterisations, or with newly assigned parameters, or steady-state values.

### Description

#### Example

Expand the number of parameterisations in a model or systemfit object that has initially just one parameterisation:

```
m(1:10) = m;
```

The parameterisation is simply copied ten times within the model or systemfit object.

---

## ■ subsref

Subscripted reference for model and systemfit objects

### Syntax for retrieving object with subset of parameterisations

```
M(Inx)
```

### Syntax for retrieving parameters or steady-state values

```
M.Name
```

### Syntax to retrieve a std deviation or a cross-correlation of shocks

```
M.std_ShockName  
M.corr_ShockName1__ShockName2
```

Note that a double underscore is used to separate the names of shocks in correlation coefficients.

### Input arguments

- M [ model | systemfit ] - Model or systemfit object.
- Inx [ numeric | logical ] - Inx of requested parameterisations.
- Name - Name of a variable, shock, or parameter.
- ShockName1, ShockName2 - Name of a shock.

### Description

### Example

---

## ■ system

System matrices before model is solved

### Syntax

```
[A,B,C,D,F,G,H,J,List,NF] = system(M)
```

### Input arguments

- M [ model ] - Model object whose system matrices will be returned.

### Output arguments

- A [ numeric ] - Matrix at the vector of expectations in the transition equation.

- B [ numeric ] - Matrix at current vector in the transition equations.
- C [ numeric ] - Constant vector in the transition equations.
- D [ numeric ] - Matrix at transition shocks in the transition equations.
- F [ numeric ] - Matrix at measurement variables in the measurement equations.
- G [ numeric ] - Matrix at predetermined transition variables in the measurement variables.
- H [ numeric ] - Constant vector in the measurement equations.
- J [ numeric ] - Matrix at measurement shocks in the measurement equations.
- List [ cell ] - Lists of measurement variables, transition variables including their auxiliary lags and leads, and shocks as they appear in the rows and columns of the system matrices.
- NF [ numeric ] - Number of non-predetermined (forward-looking) transition variables.

### Options

- 'linear=' [ 'auto' | true | false ] - Compute the model using a linear approach, i.e. differentiating around zero and not the currently assigned steady state.
- 'select=' [ true | false ] - Automatically detect which equations need to be re-differentiated based on parameter changes from the last time the system matrices were calculated.

### Description

The system before the model is solved has the following form:

$$A E[x_f; x_b] + B [x_f(-1); x_b(-1)] + C + D e = 0$$

$$F y + G x_b + H + J e = 0$$

where  $E$  is a conditional expectations operator,  $x_f$  is a vector of non-predetermined (forward-looking) transition variables,  $x_b$  is a vector of predetermined (backward-looking) transition variables,  $y$  is a vector of measurement variables, and  $e$  is a vector of transition and measurement shocks.

### Example

---

## ■ userdata

Get or set user data in an IRIS object

### Syntax for getting user data

```
X = userdata(OBJ)
```

### Syntax for assigning user data

```
OBJ = userdata(OBJ,X)
```

### Input arguments

- OBJ [ model | tseries | VAR | SVAR | FAVAR | sstate ] - One of the IRIS objects with access to user data functions.
- X [ ... ] - Any kind of data that will be attached to, and stored within, the object OBJ.

### Output arguments

- X [ ... ] - User data that are currently attached to the object.
- OBJ [ model | tseries | VAR | SVAR | FAVAR | sstate ] - The object with its user data updated.

### Description

### Example

---

## ■ VAR

Population VAR for selected model variables

### Syntax

```
V = VAR(M,Select,Range,...)
```

### Input arguments

- M [ model ] - Solved model object.
- Select [ cellstr | char ] - List of variables selected for the VAR.
- Range [ numeric ] - Hypothetical range, including pre-sample initial condition, on which the VAR would be estimated.

### Output arguments

- V [ VAR ] - Asymptotic reduced-form VAR for selected model variables.

### Options

- 'order=' [ numeric | 1 ] - Order of the VAR.
- 'constant=' [ true | false ] - Include in the VAR a constant vector derived from the steady state of the selected variables.

### Description

### Example

---

## ■ vma

Vector moving average representation of the model

### Syntax

```
[Phi,List] = vma(M,P,...)
```

### Input arguments

- M [ model ] - Model object for which the VMA representation will be computed.
- P [ numeric ] - Order up to which the VMA will be evaluated.

### Output arguments

- Phi [ namedmat | numeric ] - VMA matrices.
- List [ cell ] - List of measurement and transition variables in the rows of the Phi matrix, and list of shocks in the columns of the Phi matrix.

### Option

- 'output=' [ 'namedmat' | numeric ] - Output matrix Phi will be either a namedmat object or a plain numeric array; if the option 'select=' is used, 'output=' is always 'namedmat'.
- 'select=' [ cellstr | Inf ] - Return the VMA matrices for selected variables and/or shocks only; Inf means all variables.

### Description

### Example

---

## ■ xsf

Power spectrum and spectral density of model variables

### Syntax

```
[S,D,List] = xsf(M,Freq,...)  
[S,D,List,Freq] = xsf(M,NFreq,...)
```

### Input arguments

- M [ model ] - Model object.
- Freq [ numeric ] - Vector of frequencies at which the XSFs will be evaluated.
- NFreq [ numeric ] - Total number of requested frequencies; the frequencies will be evenly spread between 0 and pi.

### Output arguments

- S [ namedmat | numeric ] - Power spectrum matrices.
- D [ namedmat | numeric ] - Spectral density matrices.
- List [ cellstr ] - List of variable in order of appearance in rows and columns of S and D.
- Freq [ numeric ] - Vector of frequencies at which the XSFs has been evaluated.

### Options

- 'applyTo=' [ cellstr | char | Inf ] - List of variables to which the option 'filter=' will be applied; Inf means all variables.
- 'filter=' [ char | empty ] - Linear filter that is applied to variables specified by 'applyto'.
- 'nFreq=' [ numeric | 256 ] - Number of equally spaced frequencies over which the 'filter' is numerically integrated.
- 'output=' [ 'namedmat' | 'numeric' ] - Output matrices S and F will be either namedmat objects or plain numeric arrays; if the option 'select=' is used, 'output=' is always a namedmat object.
- 'progress=' [ true | false ] - Display progress bar on in the command window.
- 'select=' [ cellstr | Inf ] - Return XSF for selected variables only; Inf means all variables.

### Description

### Example

---

## ■ zerodb

Create model-specific zero-deviation database

### Syntax

```
[D,IsDev] = zerodb(M,Range)
[D,IsDev] = zerodb(M,Range,NCol)
```

### Input arguments

- `M [ model ]` - Model object for which the zero database will be created.
- `Range [ numeric ]` - Intended simulation range; the zero database will be created on a range that also automatically includes all the necessary lags.
- `NCol [ numeric ]` - Number of columns for each variable; the input argument `NCol` can be only used on models with one parameterisation.

### Output arguments

- `D [ struct ]` - Database with a `tseries` object filled with zeros for each linearised variable, a `tseries` object filled with ones for each log-linearised variables, and a scalar or vector of the currently assigned values for each model parameter.
- `IsDev [ true ]` - The second output argument is always true, and can be used to set the option 'deviation=' in `model/simulate` [P131](#).

### Description

### Example

## 6 Simulation plans

Simulation plans complement the use of the `model/simulate` [P131](#) or `model/jforecast` [P112](#) functions.

You need to use a simulation plan object to set up the following types of more complex simulations or forecasts (or a combination of these):

**simulations or forecasts with some of the model variables temporarily**

exogenised;

**simulations with some of the non-linear equations solved in an exact**

non-linear mode;

**forecasts conditioned upon some variables;**

The plan object is passed to the `model/simulate` [P131](#) or `model/jforecast` [P112](#) functions through the 'plan=' option.

Plan methods:

### Constructor

- `plan` [P161](#) - Create new simulation plan.

### Getting information about simulation plans

- `detail` [P154](#) - Display details of a simulation plan.
- `get` [P157](#) - Query to plan object.
- `nnzcond` [P158](#) - Number of conditioning data points.
- `nnzendog` [P158](#) - Number of endogenised data points.
- `nnzexog` [P159](#) - Number of exogenised data points.
- `nnznonlin` [P160](#) - Number of non-linearised data points.

### Setting up simulation plans

- [autoexogenise](#) P153 - Exogenise variables and automatically endogenise corresponding shocks.
- [condition](#) P154 - Condition forecast upon the specified variables at the specified dates.
- [endogenise](#) P155 - Endogenise shocks or re-endogenise variables at the specified dates.
- [exogenise](#) P156 - Exogenise variables or re-exogenise shocks at the specified dates.
- [nonlinearise](#) P160 - Select equations for simulation in an exact non-linear mode.

### Referencing plan objects

- [subsref](#) P162 - Subscripted reference for plan objects.

### Getting on-line help on simulation plans

```
help plan  
help plan/function_name
```

---

## ■ autoexogenise

Exogenise variables and automatically endogenise corresponding shocks

### Syntax

```
P = autoexogenise(P,List,Dates)  
P = autoexogenise(P,List,Dates,Flag)
```

### Input arguments

- P [ plan ] - Simulation plan.
- List [ cellstr | char ] - List of variables that will be exogenised; these variables must have their corresponding shocks assigned, see [!autoexogenise](#) P29.
- Dates [ numeric ] - Dates at which the variables will be exogenised.
- Flag [ 1 | li ] - Select the shock anticipation mode; if not specified, Flag = 1.

### Output arguments

- P [ plan ] - Simulation plan with new information on exogenised variables and endogenised shocks included.

### Description

### Example

---

## ■ condition

Condition forecast upon the specified variables at the specified dates

### Syntax

```
P = condition(P,List,Dates)
```

### Input arguments

- P [ plan ] - Simulation plan.
- List [ cellstr | char ] - List of variables upon which a forecast will be conditioned.
- Dates [ numeric ] - Dates at which the forecast will be conditioned upon the specified variables.

### Output arguments

- P [ plan ] - Simulation plan with new conditioning information included.

### Description

### Example

---

## ■ detail

Display details of a simulation plan

### Syntax

```
detail(P)
detail(P,Data)
```

### Input arguments

- P [ plan ] - Simulation plan.
- Data [ struct ] - Input database.

### Description

If you supply also the second input argument, the input database D, both the dates and the respective values will be reported for exogenised and conditioning data points, and the values will be checked for the presence of NaNs (with a warning should there be found any).

### Example

---

## ■ endogenise

Endogenise shocks or re-endogenise variables at the specified dates

### Syntax

```
P = endogenise(P,List,Dates)
P = endogenise(P,Dates,List)
P = endogenise(P,List,Dates,Sigma)
P = endogenise(P,Dates,List,Sigma)
```

### Input arguments

- P [ plan ] - Simulation plan.
- List [ cellstr | char ] - List of shocks that will be endogenised, or list of variables that will be re-endogenise.

## Simulation plans: exogenise

- Dates [ numeric ] - Dates at which the shocks or variables will be endogenised.
- Sigma [ numeric ] - Select the anticipation mode, and assign a weight to the shock in the case of underdetermined simulation plans; if omitted, Sigma = 1.

### Output arguments

- P [ plan ] - Simulation plan with new information on endogenised shocks included.

### Description

### Example

---

## ■ exogenise

Exogenise variables or re-exogenise shocks at the specified dates

### Syntax

```
P = exogenise(P,List,Dates)
P = exogenise(P,Dates,List)
P = exogenise(P,List,Dates,Mode)
P = exogenise(P,Dates,List,Mode)
```

### Input arguments

- P [ plan ] - Simulation plan.
- List [ cellstr | char ] - List of variables that will be exogenised, or list of shocks that will be re-exogenised.
- Dates [ numeric ] - Dates at which the variables will be exogenised.
- Flag [ 1 | 1i ] - Only when re-exogenising shocks: Select the anticipation mode in which the shock will be re-exogenised; if omitted, Flag = 1.

### Output arguments

- P [ plan ] - Simulation plan with new information on exogenised variables included.

## Description

## Example

---

## ■ get

Query to plan object

## Syntax

```
Ans = get(P,Query)
[Ans,Ans,...] = get(P,Query,Query,...)
```

## Input arguments

- P [ plan ] - Simulation plan object.
- Query [ char ] - Name of the queried property.

## Output arguments

- Ans [ ... ] - Answer.

## Valid queries to plan objects

- 'endogenised=' – Returns [ struct ] a database with time series for each shock with 1 in each period where the variable is endogenised, and 0 in each period where the variable is not endogenised.
- 'exogenised=' – Returns [ struct ] a database with time series for each measurement and transition variable with 1 in each period where the variable is exogenised, and 0 in each period where the variable is not exogenised.
- 'onlyEndogenised=' – Returns [ struct ] the same database as 'endogenised=' but including only those shocks that are endogenised at least in one period.
- 'onlyExogenised=' – Returns [ struct ] the same database as 'exogenised=' but including only those measurement and transition variables that are endogenised at least in one period.
- 'range=' – Returns [ numeric ] the simulation plan range.

## Description

## Example

---

### ■ nnzcond

Number of conditioning data points

## Syntax

$N = \text{nnzcond}(P)$

## Input arguments

- $P$  [ plan ] - Simulation plan.

## Output arguments

- $N$  [ numeric ] - Number of conditioning data points; each variable at each date counts as one data point.

## Description

## Example

---

### ■ nnzendog

Number of endogenised data points

## Syntax

$[N, NREAL, NIMAG] = \text{nnzendog}(P)$

### Input arguments

- P [ plan ] - Simulation plan.

### Output arguments

- N [ numeric ] - Total number of endogenised data points; each shock at each time counts as one data point.
- NREAL [ numeric ] - Number of endogenised data points with anticipation mode 1.
- NIMAG [ numeric ] - Number of endogenised data points with anticipation mode 1i.

### Description

### Example

---

## ■ nnzexog

Number of exogenised data points

### Syntax

$N = \text{nnzexog}(P)$

### Input arguments

- P [ plan ] - Simulation plan.

### Output arguments

- N [ numeric ] - Number of exogenised data points; each variable at each date counts as one data point.

**Description**

**Example**

---

■ **nnznonlin**

Number of non-linearised data points

**Syntax**

`N = nnznonlin(P)`

**Input arguments**

- `P [ plan ]` - Simulation plan.

**Output arguments**

- `N [ numeric ]` - Number of non-linearised equations.

**Description**

**Example**

---

■ **nonlinearise**

Select equations for simulation in an exact non-linear mode

**Syntax**

`P = nonlinearise(P)`  
`P = nonlinearise(P,Range)`  
`P = nonlinearise(P,List,Range)`

### Input arguments

- P [ plan ] - Simulation plan object.
- List [ cellstr ] - List of labels for equations that will be simulated in an exact non-linear mode; all selected equations must be marked by an `=#` P56 mark in the model file. If List is not specified, all equations marked in the model file will be simulated in a non-linear mode.
- Range [ numeric ] - Date range on which the equations will be simulated in an exact non-linear mode; currently, the range must start at the start of the plan range. If Range is not specified, the equations are non-linearised over the whole simulation range.

### Output arguments

- P [ plan ] - Simulation plan with information on exact non-linear simulation included.

### Description

### Example

---

## ■ plan

Create new simulation plan

### Syntax

P = plan(M,Range)

### Input arguments

- M [ model ] - Model object that will be simulated subject to this simulation plan.
- Range [ numeric ] - Simulation range; this range must exactly correspond to the range on which the model will be simulated.

### Output arguments

- P [ plan ] - New, empty simulation plan.

## Description

You need to use a simulation plan object to set up the following types of more complex simulations or forecasts:

**simulations or forecasts with some of the model variables temporarily exogenised;**

**simulations with some of the non-linear equations solved exactly.**

**forecasts conditioned upon some variables;**

The plan object is passed to the `simulate` [P131](#) or `jforecast` [P112](#) functions through the option `'plan='`.

## Example

---

## ■ subsref

Subscripted reference for plan objects

### Syntax

`P = P(StartDate:EndDate)`

`P = P{Shift}`

### Input arguments

- `P [ plan ]` - Simulation plan.

### Output arguments

- `P [ plan ]` - Simulation plan reduced, expanded, or shifted to the new range,
- `StartDate [ numeric ]` - New start date for the simulation plan.
- `EndDate [ numeric ]` - New end date for the simulation plan.
- `Shift [ numeric ]` - Lag or lead by which the simulation plan range will be shifted.

Simulation plans: subsref

**Description**

**Example**

## 7 System priors

System priors are priors imposed on the system properties of the model as whole, such as shock response functions, frequency response functions, correlations, or spectral densities; moreover, `systempriors` objects also allow for priors on combinations of parameters. The system priors can be combined with priors on individual parameters.

Systempriors methods:

### Constructor

- `systempriors` P168 - Create new system priors.

### Setting up priors

- `prior` P166 - Create prior for a system property.

### Getting information about system priors

- `detail` P164 - Display details of system priors.
- `isempty` P165 - True if the system priors object is empty.
- `length` P165 - Number of priors imposed in system priors object.

---

## ■ detail

Display details of system priors

### Syntax

```
detail(S)
```

### Input arguments

- S [ `systempriors` ] - System priors, `systempriors` P164 object.

## Description

## Example

---

### ■ isempty

True if the system priors object is empty

## Syntax

```
Flag = isempty(S)
```

## Input arguments

- S [ systempriors ] - System priors, [systempriors](#) P164, object.

## Output arguments

- Flag [ true | false ] - True if the system priors object, S, is empty, false otherwise.

## Description

## Example

---

### ■ length

Number of priors imposed in system priors object

## Syntax

```
N = length(S)
```

### Input arguments

- S [ systempriors ] - System priors, [systempriors](#) P164 object.

### Output arguments

- N [ numeric ] - Number of priors imposed in the system priors object, S.

### Description

### Example

---

## ■ prior

Create prior for a system property

### Syntax

```
S = prior(S,Expr,PriorFunc,...)
S = prior(S,Expr,[],...)
```

### Input arguments

- S [ systempriors ] - System priors object.
- Expr [ char ] - Expression that defines a value for which a prior density will be defined; see Description for system properties that can be referred to in the expression.
- PriorFunc [ function\_handle | empty ] - Function handle returning the log of prior density; empty, [], means a uniform prior.

### Output arguments

- S [ systempriors ] - The system priors object with the new prior added.

## Options

- 'lowerBound=' [ numeric | -Inf ] - Lower bound for the prior.
- 'upperBound=' [ numeric | Inf ] - Upper bound for the prior.

## Description

—*System properties that can be used in Expr*

- srf[VarName,ShockName,T] - Plain shock response function of variables VarName to shock ShockName in period T. Mind the square brackets.
- ffrf[VarName,MVarName,Freq] - Filter frequency response function of transition variables TVarName to measurement variable MVarName at frequency Freq. Mind the square brackets.
- corr[VarName1,VarName2,Lag] - Correlation between variable VarName1 and variables VarName2 lagged by Lag periods.
- spd[VarName1,VarName2,Freq] - Spectral density between variables VarName1 and VarName2 at frequency Freq.

If a variable is declared as a [log-variable](#) P41, it must be referred to as `log(VarName)` in the above expressions, and the log of that variables is returned, e.g. `srf[log(VarName),ShockName,T]`. or `ffrf[log(TVarName),MVarName,T]`.

—*Expressions involving combinations or functions of parameters*

Model parameter names can be referred to in Expr preceded by a dot (period), e.g. `.alpha^2 + .beta^2` defines a prior on the sum of squares of the two parameters (alpha and beta).

## Example

Create a new, empty `systempriors` object based on an existing model.

```
s = systempriors(m);
```

Add a prior on minus the shock response function of variable `ygap` to shock `eps_pie` in period 4. The prior density is lognormal with mean 0.3 and std deviation 0.05;

```
s = prior(s, '-srf[ygap,eps_pie,4]', logdist.lognormal(0.3,0.05));
```

## System priors: systempriors

Add a prior on the gain of the frequency response function of transition variable `ygap` to measurement variable 'y' at frequency  $2\pi/40$ . The prior density is normal with mean 0.5 and std deviation 0.01. This prior says that we wish to keep the cut-off periodicity for trend-cycle decomposition close to 40 periods.

```
s = prior(s,'abs(ffrf[ygap,y,2*pi/40])',logdist.normal(0.5,0.01));
```

Add a prior on the sum of parameters `alpha1` and `alpha2`. The prior is normal with mean 0.9 and std deviation 0.1, but the sum is forced to be between 0 and 1 by imposing lower and upper bounds.

```
s = prior('s','alpha1+alpha2',logdist.normal(0.9,0.1), ...  
         'lowerBound=',0,'upperBound=',1);
```

---

## ■ systempriors

Create new system priors

### Syntax

```
S = systempriors(M)
```

### Input arguments

- `M [ model ]` - Model object on whose system properties the priors will be imposed.

### Output arguments

- `S [ systempriors ]` - New, empty system priors object.

### Description

### Example

## 8 Posterior objects and functions

Posterior objects, `poster`, are used to evaluate the behaviour of the posterior distribution, and to draw model parameters from the posterior distribution.

Posterior objects are set up within the `model/estimate` [P82](#) function and returned as the second output argument - the set up and initialisation of the posterior object is fully automated in this case. Alternatively, you can set up a posterior object manually, by setting all its properties appropriately.

Poster methods:

### Constructor

- `poster` [P172](#) - Posterior objects and functions.

### Evaluating posterior density

- `arwm` [P169](#) - Adaptive random-walk Metropolis posterior simulator.
- `eval` [P171](#) - Evaluate posterior density at specified points.

### Chain statistics

- `stats` [P173](#) - Evaluate selected statistics of ARWM chain.

### Getting on-line help on model functions

```
help poster
help poster/function_name
```

## ■ arwm

Adaptive random-walk Metropolis posterior simulator

### Syntax

```
[Theta,LogPost,AR,Scale,FinalCov] = arwm(Pos,NDraw,...)
```

### Input arguments

- Pos [ poster ] - Initialised posterior simulator object.
- NDraw [ numeric ] - Length of the chain not including burn-in.

### Output arguments

- Theta [ numeric ] - MCMC chain with individual parameters in rows.
- LogPost [ numeric ] - Vector of log posterior density (up to a constant) in each draw.
- AR [ numeric ] - Vector of cumulative acceptance ratios in each draw.
- Scale [ numeric ] - Vector of proposal scale factors in each draw.
- FinalCov [ numeric ] - Final proposal covariance matrix; the final covariance matrix of the random walk step is  $\text{Scale}(\text{end})^2 * \text{FinalCov}$ .

### Options

- 'adaptProposalCov=' [ numeric | 0.5 ] - Speed of adaptation of the Cholesky factor of the proposal covariance matrix towards the target acceptance ratio, targetAR; zero means no adaptation.
- 'adaptScale=' [ numeric | 1 ] - Speed of adaptation of the scale factor to deviations of acceptance ratios from the target ratio, targetAR.
- 'burnin=' [ numeric | 0.10 ] - Number of burn-in draws entered either as a percentage of total draws (between 0 and 1) or directly as a number (integer greater than one). Burn-in draws will be added to the requested number of draws ndraw and discarded after the posterior simulation.
- 'estTime=' [ true | false ] - Display and update the estimated time to go in the command window.
- 'firstPrefetch=' [ numeric | Inf ] - First draw where parallelised pre-fetching will be used; Inf means no pre-fetching.
- 'gamma=' [ numeric | 0.8 ] - The rate of decay at which the scale and/or the proposal covariance will be adapted with each new draw.
- 'initScale=' [ numeric | 1/3 ] - Initial scale factor by which the initial proposal covariance will be multiplied; the initial value will be adapted to achieve the target acceptance ratio.
- 'lastAdapt=' [ numeric | Inf ] - Last draw in which proposal covariance will be adapted; Inf means adaptation will continue until the last draw.

- 'nStep=' [ numeric | \*1 ] - Number of pre-fetched steps computed in parallel; only works with firstPrefetch= smaller than NDraw.
- 'progress=' [ true | false ] - Display progress bar in the command window.
- 'saveAs=' [ char | empty ] - File name where results will be saved when the option 'saveEvery=' is used.
- 'saveEvery=' [ numeric | Inf ] - Every N draws will be saved to an HDF5 file, and removed from workspace immediately; no values will be returned in the output arguments Theta, LogPost, AR, Scale; the option 'saveAs=' must be used to specify the file name; Inf means a normal run with no saving.
- 'targetAR=' [ numeric | 0.234 ] - Target acceptance ratio.

## Description

Use the [poster/stats](#) P173 function to process the simulated chain of parameters, and calculate selected statistics.

### —Parallelised ARWM

Set 'nStep=' greater than 1, and 'firstPrefetch=' smaller than NDraw to start a pre-fetching parallelised algorithm (pre-fetched will be all draws starting from 'firstPrefetch='); to that end, a pool of parallel workers (using e.g. matlabpool from the Parallel Computing Toolbox) must be opened before calling arwm.

With pre-fetching, all possible paths 'nStep=' steps ahead (i.e. all possible combinations of reject/accept) are pre-evaluated in parallel, and then the resulting path is selected. Adaptation then occurs only every 'nStep=' steps, and hence the results will always somewhat differ from a serial run. Identical results can be obtained by turning down adaptation before pre-fetching starts, i.e. by setting 'lastAdapt=' smaller than 'firstPrefetch=' (and, obviously, by re-setting the random number generator).

## Example

---

### ■ eval

Evaluate posterior density at specified points

## Syntax

```
[X,L,PP,SrfP,FrFP] = eval(Pos)
[X,L,PP,SrfP,FrFP] = eval(Pos,P)
```

## Input arguments

- Pos [ poster ] - Posterior object returned by the [model/estimate](#) P82 function.
- P [ struct ] - Struct with parameter values at which the posterior density will be evaluated; if P is not specified, the posterior density at the point of the estimated mode is returned.

## Output arguments

- X [ numeric ] - The value of log posterior density evaluated at P; N.B. the returned value is log posterior, and not minus log posterior.
- L [ numeric ] - Contribution of data likelihood to log posterior.
- PP [ numeric ] - Contribution of parameter priors to log posterior.
- SrfP [ numeric ] - Contribution of shock response function priors to log posterior.
- FrFP [ numeric ] - Contribution of frequency response function priors to log posterior.

## Description

The total log posterior consists, in general, of the four contributions listed above:

$$X = L + PP + SrfP + FrFP.$$

## Example

---

## ■ poster

### Posterior objects and functions

Posterior objects, poster, are used to evaluate the behaviour of the posterior distribution, and to draw model parameters from the posterior distribution.

Posterior objects are set up within the `model/estimate` [P82](#) function and returned as the second output argument - the set up and initialisation of the posterior object is fully automated in this case. Alternatively, you can set up a posterior object manually, by setting all its properties appropriately.

Poster methods:

### Constructor

- `poster` [P172](#) - Posterior objects and functions.

### Evaluating posterior density

- `arwm` [P169](#) - Adaptive random-walk Metropolis posterior simulator.
- `eval` [P171](#) - Evaluate posterior density at specified points.

### Chain statistics

- `stats` [P173](#) - Evaluate selected statistics of ARWM chain.

### Getting on-line help on model functions

```
help poster
help poster/function_name
```

---

## ■ stats

Evaluate selected statistics of ARWM chain

### Syntax

```
S = stats(Pos,Theta,...)
S = stats(Pos,Theta,LogPost,...)
S = stats(Pos,FName,...)
```

### Input arguments

- Pos [ poster ] - Posterior simulator object that has generated the Theta chain.
- Theta [ numeric ] - MCMC chain generated by the `poster/arwm` [P169](#) function.
- LogPost [ numeric ] - Vector of log posterior densities generated by the `arwm` function; LogPost is not necessary if you do not request 'mdd', the marginal data density.
- FName [ char ] - File name under which the simulated chain was saved when `poster/arwm` [P169](#) was run with options `saveEvery=` and `saveAs=`.

### Output arguments

- S [ struct ] - Struct with the statistics requested by the user.

### Options

- 'estTime=' [ true | false ] - Display and update the estimated time to go in the command window.
- 'mddGrid=' [ numeric | 0.1:0.1:0.9 ] - Points between 0 and 1 over which the marginal data density estimates will be averaged, see Geweke (1999).
- 'progress=' [ true | false ] - Display progress bar in the command window.

### Options to include/exclude output statistics

- 'bounds=' [ true | false ] - Include in S the lower and upper parameter bounds set up by the user.
- 'chain=' [ true | false ] - Include in S the entire simulated chains of parameter values.
- 'cov=' [ true | false ] - Include in S the sample covariance matrix.
- 'hist=' [ numeric | empty ] - Include in S histogram bins and counts with the specified number of bins.
- 'hpdi=' [ false | numeric ] - Include in S the highest probability density intervals with the specified coverage.
- 'ksdensity=' [ true | false | numeric ] - Include in S the x- and y-axis points for kernel-smoothed posterior density; use a numeric value to control the number of points over which the density is computed.
- 'mdd=' [ true | false ] - Include in S minus the log marginal data density.

## Posterior objects and functions: stats

- 'mean=' [ true | false ] - Include in S the sample averages.
- 'median=' [ true | false ] - Include in S the sample medians.
- 'mode=' [ true | false ] - Include in S the sample modes based on histograms.
- 'prctile=' [ numeric | empty ] - Include in S the specified percentiles.
- 'std=' [ true | false ] - Include in S the sample std deviations.

### Description

### Example

## 9 Probability distribution package

This package gives quick access to basic univariate distributions. Its primary use is setting up priors in the `model/estimate` [P82](#) and `poster/arwm` [P169](#) functions.

The `logdist` package is called to create function handles that have several different modes of use. The primary use is to compute values that are proportional to the log of the respective density. In addition, the function handles also give you access to extra information (such as the the proper p.d.f., the name, mean, std dev, mode, and structural parameters of the distribution), and to a random number generator from the respective distribution.

Logdist methods:

### Getting function handles for univariate distributions

- `normal` [P180](#) - Create function proportional to log of normal distribution.
- `lognormal` [P179](#) - Create function proportional to log of log-normal distribution.
- `beta` [P177](#) - Create function proportional to log of beta distribution.
- `gamma` [P178](#) - Create function proportional to log of gamma distribution.
- `invgamma` [P178](#) - Create function proportional to log of inv-gamma distribution.
- `uniform` [P180](#) - Create function proportional to log of uniform distribution.

### Calling the logdist function handles

The function handles `F` created by the `logdist` package functions can be called the following ways:

- Get a value proportional to the log-density of the respective distribution at a particular point; this call is used within the `posterior simulator` [P169](#):  
 $y = F(x)$
- Get the density of the respective distribution at a particular point:  
 $y = F(x, 'pdf')$
- Get the characteristics of the distribution – mean, std deviation, mode, and information (the inverse of the second derivative of the log density):  
 $m = F([], 'mean')$   $s = F([], 'std')$   $o = F([], 'mode')$   $i = F([], 'info')$
- Get the underlying “structural” parameters of the respective distribution:  
 $a = F([], 'a')$   $b = F([], 'b')$

- Get the name of the distribution (the names correspond to the function names, i.e. can be either of 'normal', 'lognormal', 'beta', 'gamma', 'invgamma', 'uniform'):

```
name = F([], 'name')
```

- Draw a vector or matrix of random numbers from the distribution; drawing from beta, gamma, and inverse gamma requires the Statistics Toolbox:

```
a = F([], 'draw', 1, 1000);
```

```
size(a) ans = 1 10000
```

### Getting on-line help on logdist functions

```
help logdist
```

```
help logdist/function_name
```

---

## ■ beta

Create function proportional to log of beta distribution

### Syntax

```
F = logdist.beta(Mean, Std)
```

### Input arguments

- Mean [ numeric ] - Mean of the beta distribution.
- Std [ numeric ] - Std dev of the beta distribution.

### Output arguments

- F [ function\_handle ] - Function handle returning a value proportional to the log of the beta density.

### Description

See [help on the logdisk package](#) P176 for details on using the function handle F.

## Example

---

### ■ gamma

Create function proportional to log of gamma distribution

#### Syntax

```
F = logdist.gamma(Mean, Std)
```

#### Input arguments

- Mean [ numeric ] - Mean of the gamma distribution.
- Std [ numeric ] - Std dev of the gamma distribution.

#### Output arguments

- F [ function\_handle ] - Function handle returning a value proportional to the log of the gamma density.

#### Description

See [help on the logdisk package](#) P176 for details on using the function handle F.

## Example

---

### ■ invgamma

Create function proportional to log of inv-gamma distribution

#### Syntax

```
F = logdist.invgamma(MEAN,STD)
```

### Input arguments

- MEAN [ numeric ] - Mean of the inv-gamma distribution.
- STD [ numeric ] - Std dev of the inv-gamma distribution.

### Output arguments

- F [ function\_handle ] - Function handle returning a value proportional to the log of the inv-gamma density.

### Description

See [help on the logdisk package](#) P176 for details on using the function handle F.

### Example

---

## ■ lognormal

Create function proportional to log of log-normal distribution

### Syntax

```
F = logdist.lognormal(Mean,Std)
```

### Input arguments

- Mean [ numeric ] - Mean of the log-normal distribution.
- Std [ numeric ] - Std dev of the log-normal distribution.

### Output arguments

- F [ function\_handle ] - Function handle returning a value proportional to the log of the log-normal density.

### Description

See [help on the logdisk package](#) P176 for details on using the function handle F.

### Example

---

## ■ normal

Create function proportional to log of normal distribution

### Syntax

```
F = logdist.normal(Mean,Std)
```

### Input arguments

- Mean [ numeric ] - Mean of the normal distribution.
- Std [ numeric ] - Std dev of the normal distribution.

### Output arguments

- F [ function\_handle ] - Function handle returning a value proportional to the log of the normal density.

### Description

See [help on the logdisk package](#) P176 for details on using the function handle F.

### Example

---

## ■ uniform

Create function proportional to log of uniform distribution

### Syntax

```
F = logdist.uniform(Lo,Hi)
```

### Input arguments

- Lo [ numeric ] - Lower bound of the uniform distribution.
- Hi [ numeric ] - Upper bound of the uniform distribution.

### Output arguments

- F [ function\_handle ] - Handle to a function returning a value that is proportional to the log of the uniform density.

### Description

See [help on the logdisk package](#) P176 for details on using the function handle F.

### Example

## 10 Steady-state file language

Steady-state (sstate) files are a complementary tool to solve and analyse the steady states of more complex models. They allow you to create steady-state files independent of the original model files, and write the steady-state equations in different ways, manipulate their structure or order, split the problem into subblocks, and combine numerical and symbolic solutions. Using then the [sstate objects](#) [P182](#), you can compile and run stand-alone steady-state m-file functions based on your steady-state files.

### Input parameters

- [!input](#) [P184](#) - List of input parameters or variables.
- [!growthnames](#) [P184](#) - Pattern for creating growth names.

### Equations and assignments

- [!equations](#) [P183](#) - Block of equations or assignments.
- [!growthnames2imag](#) [P184](#) - Pattern for creating growth names.
- [!solvefor](#) [P185](#) - List of variables for which the current equations block will be solved.
- [!symbolic](#) [P186](#) - Attempt to solve the current equations block symbolically using the Symbolic Maths Toolbox.

### Variables with steady state restricted to be positive

- [!log\\_variables](#) [P185](#) - Restrict the steady state of some of the variables to be positive.
- [!allbut](#) [P182](#) - Inverse list of variables with positive steady states.

### Getting on-line help on sstate file language

```
help sstatelang
help sstatelang/keyword
```

---

## ■ !allbut

Inverse list of variables with positive steady states

## Syntax

```
!log_variables  
  !allbut  
  LIST_OF_VARIABLES
```

## Description

See help on [!log\\_variables](#) P41.

---

## ■ !equations

Block of equations or assignments

### Syntax for a system of equations to be solved numerically

```
!equations  
  EQUATION;  
  EQUATION;  
  EQUATION;  
  ...  
  
  !solvefor  
  LIST_OF_VARIABLES
```

### Syntax for a system of equations to be solved symbolically

```
!equations  
  EQUATION;  
  EQUATION;  
  EQUATION;  
  ...  
  
  !symbolic  
  !solvefor  
  LIST_OF_VARIABLES
```

### Syntax for block of assignments

```
!equations
  VARIABLE_NAME = EXPRESSION;
  VARIABLE_NAME = EXPRESSION;
  VARIABLE_NAME = EXPRESSION;
  ...
```

### Description

### Example

---

## ■ !growthnames

Pattern for creating growth names

### Syntax

```
!growthname := string_pattern;
!growthname := [function_pattern];
```

### Description

-Example

---

## ■ !input

List of input parameters or variables

### Syntax

```
!input
  parameter_or_variable_name, parameter_or_variable_name,
  parameter_or_variable_name, ...
```

**Description**

**Example**

---

## ■ !log\_variables

Restrict the steady state of some of the variables to be positive

**Syntax**

```
!log_variables  
  list_of_variables
```

**Inverted syntax**

```
!log_variables  
  !allbut  
  list_of_variables
```

**Description**

**Example**

---

## ■ !solvefor

List of variables for which the current equations block will be solved

**Syntax**

```
!equations  
  EQUATION;
```

Steady-state file language: !symbolic

```
EQUATION;  
EQUATION;  
...  
  
!solvefor  
  LIST_OF_VARIABLES
```

### Description

### Example

---

## ■ !symbolic

Attempt to solve the current equations block symbolically using the Symbolic Maths Toolbox

### Syntax

```
!equations  
  EQUATION;  
  EQUATION;  
  EQUATION;  
  ...  
  
!symbolic  
!solvefor  
  LIST_OF_VARIABLES
```

### Description

### Example

## 11 Steady-state objects and functions

You can create a steady-state (sstate) object by loading a steady-state (sstate) file. The sstate object can be then saved as a stand-alone m-file function and repeatedly solved for different parameterisations.

Sstate methods:

### Constructor

- `sstate` [P188](#) - Create new model object based on sstate file.

### Compiling stand-alone m-file functions

- `compile` [P187](#) - Compile an m-file function based on a steady-state file.

### Running stand-alone sstate m-file functions

- `standalonemfile` [P189](#) - Run a compiled stand-alone sstate m-file function.

### Getting on-line help on sstate functions

```
help sstate  
help sstate/function_name
```

---

## ■ `compile`

Compile an m-file function based on a steady-state file

### Syntax

```
compile(S)  
compile(S,Fname,...)
```

### Input arguments

- S [ sstate ] - Sstate object built on a steady-state file.
- Fname [ char | empty ] - Filename of the compiled m-file function; if not specified or empty the original steady-state filename will be used with an '.m' extension.

### Options

- 'excludeZero=' [ true | false ] - Automatically detect and exclude zero solutions in blocks that result in multiple solutions.
- 'deleteSymbolicMfiles=' [ true | false ] - Delete auxiliary m-files created to call the Symbolic Math toolbox.
- 'end=' [ numeric | char | Inf ] - Compile the steady-state m-file function only up to this block.
- 'simplify=' [ numeric | Inf ] - The minimum length for a symbolic expression to be simplified using the simplify function; Inf means no expressions will undergo simplification.
- 'start=' [ numeric | char | 1 ] - Compile the steady-state m-file function starting from this block.
- 'symbolic=' [ true | false ] - Call the Symbolic Math toolbox to solve blocks marked with a **!symbolic** [P186](#) keyword; otherwise, all blocks will be solved numerically regardless of their specification.

### Description

### Example

---

## ■ sstate

Create new model object based on sstate file

### Syntax

```
S = sstate(FNAME,...)
```

### Input arguments

- `FNAME [ char ]` - Name of the steady-state file that will be loaded and converted to a new `sstate` object.

### Output arguments

- `S [ sstate ]` - New `sstate` object based on the input steady-state file.

### Options

- `'assign=' [ struct | empty ]` - Database that will be used by the parser to evaluate conditions and expressions in the `!if` and `!switch` structures.

### Description

### Example

---

## ■ `standalonemfile`

Run a compiled stand-alone `sstate` m-file function

After you [`sstate/compile`](#) P187 the stand-alone `sstate` m-file function, type `help FNAME` to get help on running the file, where `FNAME` is the name of the file created.

## 12 Matrices with named rows and columns

Matrices with named rows and columns are returned by several IRIS functions, such as [model/acf](#) [P69], [model/xsf](#) [P149], or [model/fmse](#) [P99], to facilitate easy selection of submatrices by referring to variable names in rows and columns.

Namedmat methods:

### Constructor

- [namedmat](#) [P191] - Create a new matrix with named rows and columns.

### Manipulating named matrices

- [select](#) [P193] - Select submatrix by referring to row names and column names.
- [transpose](#) [P193] - Transpose each page of matrix with names rows and columns.

### Getting row and column names

- [rownames](#) [P192] - Names of rows in namedmat object.
- [colnames](#) [P190] - Names of columns in namedmat object.

### Sample characteristics

- `[cutoff](namedmat/cutoff)` -

All operators and functions available for standard Matlab matrices and arrays (i.e. double objects) are also available for namedmat objects.

---

## ■ colnames

Names of columns in namedmat object

### Syntax

```
NAMES = colnames(X)
```

### Input arguments

- `X [ namedmat ]` - A `namedmat` object (an numeric array with named rows and columns) returned by some of the model functions.

### Output arguments

- `NAMES [ cellstr ]` - Names of columns in `X`.

### Description

### Example

---

## ■ namedmat

Create a new matrix with named rows and columns

### Syntax

```
X = namedmat(X,ROWNAMES,COLNAMES)
```

### Input arguments

- `X [ numeric ]` - Matrix or multidimensional array.
- `ROWNAMES [ cellstr ]` - Names for individual rows of `X`.
- `COLNAMES [ cellstr ]` - Names for individual columns of `X`.

### Output arguments

- `X [ namedmat ]` - Matrix with named rows and columns.

### Description

Namedmat objects are used by some of the IRIS functions to preserve the names of variables that relate to individual rows and columns, such as in

## Matrices with named rows and columns: select

- acf, the autocovariance and autocorrelation functions,
- xsf, the power spectrum and spectral density functions,
- fmse, the forecast mean square error functions,
- etc.

You can use the function `select` [P193](#) to extract submatrices by referring to a selection of names.

Namedmat matrices derives from the built-in double class of objects, and hence you can use any operators and functions on them that are available for double objects.

### Example

---

## ■ rownames

Names of rows in namedmat object

### Syntax

```
NAMES = rownames(X)
```

### Input arguments

- X [ namedmat ] - A namedmat object (an numeric array with named rows and columns) returned by some of the model functions.

### Output arguments

- NAMES [ cellstr ] - Names of rows in X.

### Description

### Example

---

## ■ select

Select submatrix by referring to row names and column names

### Syntax

```
[X,Pos] = select(This,RowSelect,ColSelect)
[X,Pos] = select(X,Select)
```

### Input arguments

- X [ namedmat ] - Matrix or array with named rows and columns.
- RowSelect [ char | cellstr ] - Selection of row names.
- ColSelect [ char | cellstr ] - Selection of column names.
- Select [ char | cellstr ] - Selection of names that will be applied to both rows and columns.

### Output arguments

- X [ namedmat ] - Submatrix with named rows and columns.
- Pos [ cell ] - Pos{1} is the vector of rows included in the submatrix X, Pos{2} is the vector of columns included in the submatrix X.

### Description

### Example

---

## ■ transpose

Transpose each page of matrix with names rows and columns

### Syntax

```
X = transpose(X)
X = X.'
```

## Matrices with named rows and columns: transpose

### Input arguments

- $X$  [ namedmat ] - Input matrix or array with named rows and columns.

### Output arguments

- $X$  [ namedmat ] - Transpose of the input matrix; if it is more than 2-dimensional, each page of the matrix is transposed.

### Description

### Example

Part III —

## Multivariate time series analysis

## 13 Vector autoregressions: VAR objects and functions

VAR objects can be constructed as plain VARs or simple panel VARs (with fixed effect), and estimated without or with prior dummy observations (Bayesian VARs). The VAR objects are also the point of departure for identifying structural VARs (SVAR [P231](#) objects).

VAR methods:

### Constructor

- [VAR](#) [P228](#) - Create new reduced-form VAR object.

### Getting information about VAR objects

- [addparam](#) [P199](#) - Add VAR parameters to a database (struct).
- [comment](#) [P201](#) - Get or set user comments in an IRIS object.
- [companion](#) [P202](#) - Matrices of first-order companion VAR.
- [eig](#) [P203](#) - Eigenvalues of a VAR process.
- [get](#) [P210](#) - Query VAR object properties.
- [iscompatible](#) [P215](#) - True if two VAR objects can occur together on the LHS and RHS in an assignment.
- [isexplosive](#) [P216](#) - True if any eigenvalue is outside unit circle.
- [ispanel](#) [P216](#) - True for panel VAR based objects.
- [isstationary](#) [P217](#) - True if all eigenvalues are within unit circle.
- [length](#) [P218](#) - Number of alternative parameterisations in VAR object.
- [mean](#) [P219](#) - Mean of VAR process.
- [nfitted](#) [P219](#) - Number of data points fitted in VAR estimation.
- [rngcmp](#) [P222](#) - True if two VAR objects have been estimated using the same dates.
- [sspace](#) [P225](#) - Quasi-triangular state-space representation of VAR.
- [userdata](#) [P227](#) - Get or set user data in an IRIS object.

### Referencing VAR objects

- `group` [P211](#) - Retrieve VAR object from panel VAR for specified group of data.
- `subsasgn` [P225](#) - Subscripted assignment for VAR objects.
- `subsref` [P226](#) - Subscripted reference for VAR objects.

### Simulation, forecasting and filtering

- `ferf` [P207](#) - Forecast error response function.
- `filter` [P207](#) - Filter data using a VAR model.
- `forecast` [P209](#) - Unconditional or conditional VAR forecasts.
- `instrument` [P213](#) - Define conditioning instruments in VAR models.
- `resample` [P221](#) - Resample from a VAR object.
- `simulate` [P223](#) - Simulate VAR model.

### Manipulating VARs

- `alter` [P200](#) - Expand or reduce the number of alternative parameterisations within a VAR object.
- `backward` [P201](#) - Backward VAR process.
- `demean` [P203](#) - Remove constant from VAR object.
- `horzcat` [P212](#) - Combine two compatible VAR objects in one object with multiple parameterisations.
- `integrate` [P214](#) - Integrate VAR process and data associated with it.

### Stochastic properties

- `acf` [P198](#) - Autocovariance and autocorrelation functions for VAR variables.
- `fmse` [P208](#) - Forecast mean square error matrices.
- `vma` [P229](#) - Matrices describing the VMA representation of a VAR process.
- `ksf` [P229](#) - Power spectrum and spectral density functions for VAR variables.

### Estimation, identification, and statistical tests

- `estimate` [P204](#) - Estimate a reduced-form VAR or BVAR.
- `infocrit` [P213](#) - Populate information criteria for a parameterised VAR.
- `lrtest` [P218](#) - Likelihood ratio test for VAR models.
- `portest` [P220](#) - Portmanteau test for autocorrelation in VAR residuals.
- `schur` [P223](#) - Compute and store triangular representation of VAR.

### Getting on-line help on VAR functions

```
help VAR
help VAR/function_name
```

---

## ■ acf

Autocovariance and autocorrelation functions for VAR variables

### Syntax

```
[C,R] = acf(V,...)
```

### Input arguments

- `V` [ VAR ] - VAR object for which the ACF will be computed.

### Output arguments

- `C` [ numeric ] - Auto/cross-covariance matrices.
- `R` [ numeric ] - Auto/cross-correlation matrices.

## Options

- 'applyTo=' [ logical | Inf ] - Logical index of variables to which the 'filter=' will be applied; the default Inf means all variables.
- 'filter=' [ char | empty ] - Linear filter that is applied to variables specified by 'applyto'.
- 'nfreq=' [ numeric | 256 ] - Number of equally spaced frequencies over which the 'filter' is numerically integrated.
- 'order=' [ numeric | 0 ] - Order up to which ACF will be computed.
- 'progress=' [ true | false ] - Display progress bar in the command window.

## Description

## Example

---

## ■ addparam

Add VAR parameters to a database (struct)

## Syntax

```
D = addparam(V,D)
```

## Input arguments

- V [ SVAR ] - SVAR object whose parameter matrices will be added to database (struct) D.
- D [ struct ] - Database to which the model parameters will be added.

## Output arguments

- 'D [ struct ] - Database with the VAR parameter matrices added.

## Description

The newly created database entries are named A (transition matrix), K (constant terms), and Omg (covariance matrix of shocks). Be aware that if there are database entries in D whose names coincide with these names, they will be overwritten.

## Example

```
D = struct();  
D = addparam(V,D);
```

---

## ■ alter

Expand or reduce the number of alternative parameterisations within a VAR object

### Syntax

```
V = alter(V,N)
```

### Input arguments

- V [ VAR ] - VAR object in which the number of parameterisations will be changed.
- N [ numeric ] - New number of parameterisations.

### Output arguments

- V [ VAR ] - VAR object with the new number of parameterisations.

## Description

## Example

---

## ■ backward

Backward VAR process

### Syntax

```
B = backward(V)
```

### Input arguments

- V [ VAR ] - VAR object.

### Output arguments

- B [ VAR ] - VAR object with the VAR process reversed in time.

### Description

### Example

---

## ■ comment

Get or set user comments in an IRIS object

### Syntax for getting user comments

```
Cmt = comment(Obj)
```

### Syntax for assigning user comments

```
Obj = comment(Obj,Cmt)
```

### Input arguments

- Obj [ model | tseries | VAR | SVAR | FAVAR | sstate ] - One of the IRIS objects.
- Cmt [ char ] - User comment that will be attached to the object.

### Output arguments

- Cmt [ char ] - User comment that are currently attached to the object.

### Description

### Example

---

## ■ companion

Matrices of first-order companion VAR

### Syntax

[A,B,K] = companion(V)

### Input arguments

- V [ VAR ] - VAR object for which the companion matrices will be returned.

### Output arguments

- A [ numeric ] - First-order companion transition matrix.
- B [ numeric ] - First-order companion coefficient matrix at reduced-form residuals.
- K [ numeric ] - First-order compnaion constant vector.

## Description

## Example

---

### ■ demean

Remove constant from VAR object

## Syntax

$V = \text{demean}(V)$

## Input arguments

- $V$  [ VAR ] - VAR object in which the constant vector will be reset to zero.

## Output arguments

- $V$  [ VAR ] - VAR object with the constant vector reset to zero.

## Description

## Example

---

### ■ eig

Eigenvalues of a VAR process

## Syntax

$E = \text{eig}(V)$

### Input arguments

- `v` [ VAR ] - VAR object whose eigenvalues will be returned.

### Output arguments

- `E` [ numeric ] - VAR eigenvalues.

### Description

This function is equivalent to calling

```
e = get(v, 'eig')
```

### Example

---

## ■ estimate

Estimate a reduced-form VAR or BVAR

### Syntax

```
[V,VData,Fitted] = estimate(V,Inp,Range,...)
```

### Input arguments

- `V` [ VAR ] - Empty VAR object.
- `Inp` [ struct ] - Input database.
- `Range` [ numeric ] - Estimation range, including `P` pre-sample periods, where `P` is the order of the VAR.

### Output arguments

- `V` [ VAR ] - Estimated reduced-form VAR object.
- `VData` [ struct ] - Output database with the endogenous variables and the estimated residuals.
- `Fitted` [ numeric ] - Periods in which fitted values have been calculated.

### Options

- `'A='` [ numeric | empty ] - Restrictions on the individual values in the transition matrix, A.
- `'BVAR='` [ numeric ] - Prior dummy observations for estimating a BVAR; construct the dummy observations using the one of the BVAR functions.
- `'C='` [ numeric | empty ] - Restrictions on the individual values in the constant vector, C.
- `'diff='` [ true | false ] - Difference the series before estimating the VAR; integrate the series back afterwards.
- `'G='` [ numeric | empty ] - Restrictions on the individual values in the matrix at the co-integrating vector, G.
- `'cointeg='` [ numeric | empty ] - Co-integrating vectors (in rows) that will be imposed on the estimated VAR.
- `'comment='` [ char | Inf ] - Assign comment to the estimated VAR object; Inf means the existing comment will be preserved.
- `'constraints='` [ char ] - General linear constraints on the VAR parameters.
- `'constant='` [ true | false ] - Include a constant vector in the VAR.
- `'covParameters='` [ true | false ] - Calculate the covariance matrix of estimated parameters.
- `'eqtnByEqtn='` [ true | false ] - Estimate the VAR equation by equation.
- `'maxIter='` [ numeric | 1 ] - Maximum number of iterations when generalised least squares algorithm is involved.
- `'mean='` [ numeric | empty ] - Impose a particular asymptotic mean on the VAR process.
- `'order='` [ numeric | 1 ] - Order of the VAR.
- `'progress='` [ true | false ] - Display progress bar in the command window.
- `'schur='` [ true | false ] - Calculate triangular (Schur) representation of the estimated VAR straight away.

- 'stdize=' [ true | false ] - Adjust the prior dummy observations by the std dev of the observations.
- 'timeWeights=' [ tseries | empty ] - Time series of weights applied to individual periods in the estimation range.
- 'tolerance=' [ numeric | 1e-5 ] - Convergence tolerance when generalised least squares algorithm is involved.
- 'yNames=' [ cellstr | function\_handle | @(n) sprintf('y%g',n) ] - Use these names for the VAR variables.
- 'eNames=' [ cellstr | function\_handle | @(yname,n) ['res\_',yname] ] - Use these names for the VAR residuals.
- 'warning=' [ true | false ] - Display warnings produced by this function.

### Options for panel VAR

- 'fixedEffect=' [ true | false ] - Include constant dummies for fixed effect in panel estimation; applies only if 'constant=' true.
- 'groupWeights=' [ numeric | empty ] - A 1-by-NGrp vector of weights applied to groups in panel estimation, where NGrp is the number of groups; the weights will be rescaled so as to sum up to 1.

### Description

—*Estimating a panel VAR*

Panel VAR objects are created by calling the function `VAR` [\[P228\]](#) with two input arguments: the list of variables, and the list of group names. To estimate a panel VAR, the input data, `Inp`, must be organised a super-database with sub-databases for each group, and time series for each variables within each group:

```
d.Group1_Name.Var1_Name
d.Group1_Name.Var2_Name
...
d.Group2_Name.Var1_Name
d.Group2_Name.Var2_Name
...
```

## Example

---

### ■ ferf

Forecast error response function

#### Syntax

```
[Phi,Psi,s,c] = ferf(V,NPer)
[Phi,Psi,s,c] = ferf(V,Range)
```

#### Input arguments

- V [ VAR ] - VAR object for which the forecast error response function will be computed.
- NPer [ numeric ] - Number of periods.
- Range [ numeric ] - Date range.

#### Output arguments

- Phi [ numeric ] - Response function matrices.
- Psi [ numeric ] - Cumulative response function matrices.
- S [ tseries ] - Response function time series.
- C [ tseries ] - Cumulative response function time series.

#### Description

#### Example

---

### ■ filter

Filter data using a VAR model

## Syntax

```
[V,Outp] = filter(V,Inp,Range,...)
```

## Input arguments

- V [ VAR ] - Input VAR object.
- Inp [ struct ] - Input database from which initial condition will be read.
- Range [ numeric ] - Forecast range.

## Output arguments

- V [ VAR ] - Output VAR object.
- Outp [ struct ] - Output database with prediction and/or smoothed data.

## Options

- 'cross=' [ numeric | 1 ] - Multiply the off-diagonal elements of the covariance matrix (cross-covariances) by this factor; 'cross=' must be equal to or smaller than 1.
- 'deviation=' [ true | false ] - Both input and output data are deviations from the unconditional mean.
- 'meanOnly=' [ true | false ] - Return a plain database with mean forecasts only.
- 'omega=' [ numeric | empty ] - Modify the covariance matrix of residuals for this run of the filter.

## Description

## Example

---

### ■ fmse

Forecast mean square error matrices

## Syntax

[M,X] = fmse(V,NPer)  
[M,X] = fmse(V,Range)

## Input arguments

- C [ VAR ] - VAR object for which the forecast MSE matrices will be computed.
- NPer [ numeric ] - Number of periods.
- Range [ numeric ] - Date range.

## Output arguments

- M [ numeric ] - Forecast MSE matrices.
- X [ dbase | tseries ] - Database or tseries with the std deviations of individual variables, i.e. the square roots of the diagonal elements of M.

## Options

- 'output=' [ 'dbase' | 'tseries' ] - Format of output data.

## Description

## Example

}

---

## ■ forecast

Unconditional or conditional VAR forecasts

## Syntax

Outp = forecast(V,Inp,Range,...)  
Outp = forecast(V,Inp,Range,Cond,...)

### Input arguments

- `V [ VAR ]` - VAR object.
- `Inp [ struct ]` - Input database from which initial condition will be read.
- `Range [ numeric ]` - Forecast range; must not refer to `Inf`.
- `Cond [ struct | tseries ]` - Conditioning database with the mean values of residuals, reduced-form conditions on endogenous variables, and conditioning instruments.

### Output arguments

- `Outp [ struct ]` - Output database with forecasts of endogenous variables, residuals, and conditioning instruments.

### Options

- `'cross=' [ numeric | 1 ]` - Multiply the off-diagonal elements of the covariance matrix (cross-covariances) by this factor; `'cross='` must be equal to or smaller than 1.
- `'dbOverlay=' [ true | false ]` - Combine the output data with the input data; works only if the input data is a database.
- `'deviation=' [ true | false ]` - Both input and output data are deviations from the unconditional mean.
- `'meanOnly=' [ true | false ]` - Return a plain database with mean forecasts only.
- `'omega=' [ numeric | empty ]` - Modify the covariance matrix of residuals for this forecast.

### Description

### Example

---

## ■ get

Query VAR object properties

### Syntax

```
Ans = get(V,Query)
[Ans,Ans,...] = get(V,Query,Query,...)
```

### Input arguments

- V [ VAR ] - VAR object.
- Query [ char ] - Query to the VAR object.

### Output arguments

- Ans [ ... ] - Answer to the query.

### Valid queries to VAR objects

### Description

### Example

---

## ■ group

Retrieve VAR object from panel VAR for specified group of data

### Syntax

```
V = group(V,Grp)
```

### Input arguments

- V [ VAR ] - Panel VAR object estimated on multiple groups of data.
- Grp [ char ] - Requested group name; must be one of the names specified when the panel VAR object was constructed using the function [VAR](#) P228.

### Output arguments

- `v [ VAR ]` - VAR object for the K-th group of data.

### Description

#### Example

Create and estimate a panel VAR for three variables, x, y, z, and three countries, US, EU, JA. Then, retrieve a plain VAR for an individual country.

```
v = VAR({'x','y','z'},{'US','EU','JA'});  
v = estimate(v,d,range,'fixedEffect=',true);  
vi_us = group(v,'US');
```

---

## ■ horzcat

Combine two compatible VAR objects in one object with multiple parameterisations

### Syntax

```
v = [v1,v2,...]
```

### Input arguments

- `v1, v2 [ VAR ]` - Compatible VAR objects that will be combined.

### Output arguments

- `v [ VAR ]` - Output VAR object that combines the input VAR objects as multiple parameterisations.

## Description

## Example

---

### ■ infocrit

Populate information criteria for a parameterised VAR

## Syntax

```
V = infocrit(V)
```

## Input arguments

- V [ VAR ] - VAR object.

## Output arguments

- V [ VAR ] - VAR object with the AIC and SBC information criteria re-calculated.

## Description

In most cases, you don't have to run the function `infocrit` as it is called from within `estimate` immediately after a new parameterisation is created.

## Example

---

### ■ instrument

Define conditioning instruments in VAR models

### Syntax to add forecast instruments

```
V = instrument(V,Def)
V = instrument(V,Name,Exprn)
V = instrument(V,Name,Vec)
```

### Syntax to remove all forecast instruments

```
V = instrument(V)
```

### Input arguments

- V [ VAR ] - VAR object to which forecast instruments will be added.
- Def [ char | cellstr ] - Definition string for the new conditioning instruments.
- Name [ char ] - Name of the new conditioning instrument.
- Exprn [ char ] - Expression defining the new conditioning instrument.
- Vec [ numeric ] - Vector of coefficients to combine the VAR variables to create the new conditioning instrument.

### Output arguments

---

## ■ integrate

Integrate VAR process and data associated with it

### Syntax

```
V = integrate(V,...)
```

### Input arguments

- V [ VAR ] - VAR object whose variables will be integrated by one order.

### Output arguments

- `v` [ VAR ] - VAR object with the specified variables integrated by one order.

### Options

- `'applyTo='` [ logical | numeric | `Inf` ] - Index of variables to integrate; `Inf` means all variables will be integrated.

### Description

### Example

---

## ■ `iscompatible`

True if two VAR objects can occur together on the LHS and RHS in an assignment

### Syntax

```
Flag = iscompatible(V1,V2)
```

### Input arguments

- `V1, V2` [ model ] - Two VAR objects that will be tested for compatibility.

### Output arguments

- `Flag` [ true | false ] - True if `V1` and `V2` can occur in an assignment, `V1(...)` = `V2(...)`, or horizonatl concatenation, `[V1,V2]`.

### Description

The function compares the names of all variables, shocks, and parameters, and the composition of the state-space vectors.

## Example

---

### ■ isexplosive

True if any eigenvalue is outside unit circle

#### Syntax

```
Flag = isexplosive(V)
```

#### Input arguments

- V [ VAR ] - VAR object whose eigenvalues will be tested for explosiveness.

#### Output arguments

- Flag [ true | false ] - True if at least one eigenvalue is outside unit circle.

#### Options

- 'tolerance=' [ numeric | getrealsmall() ] - Tolerance for the eigenvalue test.

#### Description

#### Example

---

### ■ ispanel

True for panel VAR based objects

#### Syntax

```
Flag = ispanel(X)
```

### Input arguments

- `x` [ VAR | SVAR | FAVAR ] - VAR based object.

### Output arguments

- Flag [ true | false ] - True if the VAR based object, `x`, is based on a panel of data.

### Description

Plain, i.e. non-panel, VAR based objects are created by calling the constructor with one input argument: the list of variables. Panel VAR based objects are created by calling the constructor with two input arguments: the list of variables, and the names of groups of data.

### Example

---

## ■ `isstationary`

True if all eigenvalues are within unit circle

### Syntax

```
Flag = isstationary(V)
```

### Input arguments

- `V` [ VAR ] - VAR object whose eigenvalues will be tested for stationarity.

### Output arguments

- Flag [ true | false ] - True if all eigenvalues are within unit circle.

### Options

- `'tolerance='` [ numeric | `getrealsmall()` ] - Tolerance for the eigenvalue test.
-

## ■ length

Number of alternative parameterisations in VAR object

### Syntax

```
N = length(V)
```

### Input arguments

- V [ VAR ] - VAR object.

### Output arguments

- N [ numeric ] - Number of alternative parameterisations.

### Description

### Example

---

## ■ lrtest

Likelihood ratio test for VAR models

### Syntax

```
[Stat,Crit] = lrtest(V1,V2,Level)
```

### Input arguments

- V1 [ VAR ] - Unrestricted VAR model.
- V2 [ VAR ] - Restricted VAR model.
- Level [ numeric ] - Significance level; if not specified, 0.05 is used.

### Output arguments

- Stat [ numeric ] - LR test stastic.
- Crit [ numeric ] - LR test critical value based on chi-square distribution.

### Description

### Example

---

## ■ mean

Mean of VAR process

### Syntax

`X = mean(V)`

### Input arguments

- V [ VAR ] - VAR object.

### Output arguments

- X [ numeric ] - Mean vector.

### Description

### Example

---

## ■ nfitted

Number of data points fitted in VAR estimation

### Syntax

```
N = nfitted(V)
```

### Input arguments

- `V [ VAR ]` - Estimated VAR object.

### Output arguments

- `N [ numeric ]` - Number of data points (periods) fitted when estimating the VAR object.

### Description

### Example

---

## ■ portest

Portmanteau test for autocorrelation in VAR residuals

### Syntax

```
[Stat,Crit] = portest(V,Data,H)
```

### Input arguments

- `V [ VAR | swar ]` - Estimated VAR from which the tested residuals were obtained.
- `Data [ tseries ]` - VAR residuals, or VAR output data including residuals, to be tested for autocorrelation.
- `H [ numeric ]` - Test horizon; must be greater than the order of the tested VAR.

### Output arguments

- Stat [ numeric ] - Portmanteau test statistic.
- Crit [ numeric ] - Portmanteau test critical value based on chi-square distribution.

### Options

- 'level=' [ numeric | 0.05 ] - Requested significance level for computing the criterion Crit.

### Description

### Example

---

## ■ resample

Resample from a VAR object

### Syntax

```
Outp = resample(V,Inp,Range,NDraw,...)
Outp = resample(V,[],Range,NDraw,...)
```

### Input arguments

- V [ VAR ] - VAR object to resample from.
- Inp [ struct | tseries ] - Input database or tseries used in bootstrap; not needed when 'method=' 'montecarlo'.
- Range [ numeric ] - Range for which data will be returned.

### Output arguments

- Outp [ struct | tseries ] - Resampled output database or tseries.

## Options

- 'deviation=' [ true | false ] - Do not include the constant term in simulations.
- 'group=' [ numeric | NaN ] - Choose group whose parameters will be used in resampling; required in VAR objects with multiple groups when 'deviation=' false.
- 'method=' [ 'bootstrap' | 'montecarlo' | function\_handle ] - Bootstrap from estimated residuals, resample from normal distribution, or use user-supplied sampler.
- 'progress=' [ true | false ] - Display progress bar in the command window.
- 'randomise=' [ true | false ] - Randomise or fix pre-sample initial condition.
- 'wild=' [ true | false ] - Use wild bootstrap instead of standard Efron bootstrap when 'method=' 'bootstrap'.

## Description

## Example

---

## ■ rngcmp

True if two VAR objects have been estimated using the same dates

—*Syntax*

```
Flag = rngcmp(V1,V2)
```

## Input arguments

- V1, V2 [ VAR ] - Two estimated VAR objects.

## Output arguments

- Flag [ true | false ] - True if the two VAR objects, V1 and V2, have been estimated using observations at the same dates.

## Description

## Example

---

### ■ schur

Compute and store triangular representation of VAR

## Syntax

```
V = schur(V)
```

## Input arguments

- V [ VAR ] - VAR object.

## Output arguments

- V [ VAR ] - VAR object with the triangular representation matrices re-calculated.

## Description

In most cases, you don't have to run the function `schur` as it is called from within `estimate` immediately after a new parameterisation is created.

## Example

---

### ■ simulate

Simulate VAR model

## Syntax

```
Outp = simulate(V,Inp,Range,...)
```

## Input arguments

- `V` [ VAR ] - VAR object that will be simulated.
- `Inp` [ tseries | struct ] - Input data from which the initial conditions and residuals will be taken.
- `Range` [ numeric ] - Simulation range; must not refer to `Inf`.

## Output arguments

- `Outp` [ tseries ] - Simulated output data.

## Options

- `'contributions='` [ true | false ] - Decompose the simulated paths into contributions of individual residuals.
- `'deviation='` [ true | false ] - Treat input and output data as deviations from unconditional mean.
- `'output='` [ 'auto' | 'dbase' | 'tseries' ] - Format of output data.

## Description

—*Backward simulation (backcast)*

If the `Range` is a vector of decreasing dates, the simulation is performed backward. The VAR object is first converted to its backward representation using the function `backward` [\[P201\]](#), and then the data are simulated from the latest date to the earliest date.

## Example

---

## ■ **sspace**

Quasi-triangular state-space representation of VAR

### Syntax

```
[T,R,K,Z,H,D,Omg] = sspace(V,...)
```

### Input arguments

- V [ VAR ] - VAR object.

### Output arguments

- T [ numeric ] - Transition matrix.
- R [ numeric ] - Matrix at the shock vector in transition equations.
- K [ numeric ] - Constant vector in transition equations.
- Z [ numeric ] - Matrix mapping transition variables to measurement variables.
- H [ numeric ] - Matrix at the shock vector in measurement equations.
- D [ numeric ] - Constant vector in measurement equations.
- U [ numeric ] - Transformation matrix for predetermined variables.
- Omega [ numeric ] - Covariance matrix of shocks.

### Description

### Example

---

## ■ **subsasgn**

Subscripted assignment for VAR objects

### Syntax to assign parameterisations from other VAR object

```
V(inx) = W
```

### Syntax to delete specified parameterisations

```
V(Inx) = []
```

### Input arguments

- V [ VAR ] - VAR object.
- inx [ numeric ] - Index of parameterisations that will be assigned or deleted.
- W [ VAR ] - VAR object compatible with V whose parameterisations will be assigned (copied) into V.

### Output arguments

- V [ model ] - VAR object with newly assigned or deleted parameterisations,

### Description

### Example

Expand the number of parameterisations in a VAR object that has initially just one parameterisation:

```
V(1:10) = V;
```

The parameterisation is simply copied ten times within the VAR object.

---

## ■ subsref

Subscripted reference for VAR objects

### Syntax to retrieve VAR object with subset of parameterisations

V(Inx)

#### Input arguments

- V [ VAR ] - VAR object.
- Inx [ numeric | logical ] - Index of requested parameterisations.

#### Description

#### Example

---

## ■ userdata

Get or set user data in an IRIS object

#### Syntax for getting user data

X = userdata(OBJ)

#### Syntax for assigning user data

OBJ = userdata(OBJ,X)

#### Input arguments

- OBJ [ model | tseries | VAR | SVAR | FAVAR | sstate ] - One of the IRIS objects with access to user data functions.
- X [ ... ] - Any kind of data that will be attached to, and stored within, the object OBJ.

### Output arguments

- `X [ ... ]` - User data that are currently attached to the object.
- `OBJ [ model | tseries | VAR | SVAR | FAVAR | sstate ]` - The object with its user data updated.

### Description

### Example

---

## ■ VAR

Create new reduced-form VAR object

### Syntax for plain VAR

```
V = VAR(YNames)
```

### Syntax for panel VAR

```
V = VAR(YNames, GroupNames)
```

### Output arguments

- `V [ VAR ]` - New empty VAR object.
- `YNames [ cellstr | char | function_handle ]` - Names of VAR variables.
- `GroupNames [ cellstr | char | function_handle ]` - Names of groups of data for panel estimation.

### Description

This function creates a new empty VAR object. It is usually followed by the [estimate](#) P204 function to estimate the VAR parameters on data.

### Example

To estimate a VAR, you first need to create an empty VAR object specifying the variable names, and then run the [VAR/estimate](#) P204 function on it, e.g.

```
v = VAR({'x', 'y', 'z'});  
[v,d] = estimate(v,d,range);
```

where the input database d ought to contain time series d.x, d.y, d.z.

---

## ■ vma

Matrices describing the VMA representation of a VAR process

### Syntax

```
Phi = vma(V,N)
```

### Input arguments

- V [ VAR ] - VAR object for which the VMA matrices will be computed.
- N [ numeric ] - Order up to which the VMA matrices will be computed.

### Output arguments

- Phi [ numeric ] - VMA matrices.

### Description

### Example

---

## ■ xsf

Power spectrum and spectral density functions for VAR variables

## Syntax

`[S,D] = xsf(V,Freq,...)`

## Input arguments

- `V` [ VAR ] - VAR object.
- `Freq` [ numeric ] - Vector of Frequencies at which the XSFs will be evaluated.

## Output arguments

- `S` [ numeric ] - Power spectrum matrices.
- `D` [ numeric ] - Spectral density matrices.

## Options

- `'applyTo='` [ cellstr | char | `':'` ] - List of variables to which the `'filter='` will be applied; `':'` means all variables.
- `'filter='` [ char | empty ] - Linear filter that is applied to variables specified by `'applyto'`.
- `'nFreq='` [ numeric | 256 ] - Number of equally spaced frequencies over which the `'filter'` is numerically integrated.
- `'progress='` [ true | false ] - Display progress bar in the command window.

## Description

The output matrices, `S` and `D`, are `N`-by-`N`-by-`K`, where `N` is the number of VAR variables and `K` is the number of frequencies (i.e. the length of the vector `freq`).

The `k`-th page is the `S` matrix, i.e. `S(:, :, k)`, is the cross-spectrum matrix for the VAR variables at the `k`-th frequency. Similarly, the `k`-th page in `D`, i.e. `D(:, :, k)`, is the cross-density matrix.

## Example

## 14 Structural vector autoregressions: SVAR objects and functions

SVAR methods:

### Constructor

- [SVAR](#) P238 - Convert reduced-form VAR to structural VAR.

SVAR objects can call any of the [VAR](#) P196 functions. In addition, the following functions are available for SVAR objects.

### Getting information about SVAR objects

- [fprintf](#) P233 - Format SVAR as a model code and write to text file.
- [get](#) P233 - Query SVAR object properties.
- [sprintf](#) P236 - Format SVAR as a model code and write to text string.

### Simulation

- [srf](#) P237 - Shock (impulse) response function.

### Stochastic properties

- [fevd](#) P232 - Forecast error variance decomposition for SVAR variables.

### Manipulating SVAR objects

- [sort](#) P234 - Sort SVAR parameterisations by squared distance of shock responses to median.

See help on [VAR](#) P196 objects for other functions available.

### Getting on-line help on SVAR functions

```
help SVAR
help SVAR/function_name
```

## Getting on-line help on SVAR functions that are inherited from VARs

```
help VAR  
help VAR/function_name
```

---

### ■ fevd

Forecast error variance decomposition for SVAR variables

#### Syntax

```
[X, Y, XX, YY] = fevd(V, NPer)  
[X, Y, XX, YY] = fevd(V, Range)
```

#### Input arguments

- V [ VAR ] - Structural VAR model.
- NPer [ numeric ] - Number of periods.
- Range [ numeric ] - Date range.

#### Output arguments

- X [ numeric ] - Forecast error variance decomposition into absolute contributions of residuals; absolute contributions sum up to the total variance.
- Y [ numeric ] - Forecast error variance decomposition into relative contributions of residuals; relative contributions sum up to 1.
- XX [ tseries ] - X converted to a tseries object.
- YY [ tseries ] - Y converted to a tseries object.

#### Description

#### Example

---

## ■ fprintf

Format SVAR as a model code and write to text file

### Syntax

```
[C,D] = fprintf(S,FName,...)
```

### Input arguments

- S [ SVAR ] - SVAR object that will be printed to a model file.
- FName [ char | cellstr ] - Filename, or filename format string, under which the model code will be saved.
- Output arguments
- C [ cellstr ] - Text string with the model code for each parameterisation.
- D [ cell ] - Parameter databases for each parameterisation; if 'hardParameters=' true, the database will be empty.

### Options

See help on [sprintf](#) P236 for options available.

### Description

### Example

---

## ■ get

Query SVAR object properties

### Syntax

```
value = get(v,query)  
[value,value,...] = get(v,query,query,...)
```

### Input arguments

- `v [ SVAR ]` - SVAR object.
- `query [ char ]` - Name of the queried property.

### Output arguments

- `value [ ... ]` - Value of the queried property.

All properties accessible through the `get` function in VAR objects are also accessible in SVAR objects.

### Valid queries on SVAR objects

### Description

### Example

---

## ■ sort

Sort SVAR parameterisations by squared distance of shock responses to median

### Syntax

```
[B,~,Inx,Crit] = sort(A,[],SortBy,...)
[B,Data,Inx,Crit] = sort(A,Data,SortBy,...)
```

### Input arguments

- `A [ SVAR ]` - SVAR object with multiple parameterisations that will be sorted.
- `Data [ tseries | struct | empty ]` - SVAR data (endogenous variables and structural shocks); the structural shocks will be re-ordered according to the SVAR parameterisations. You can leave the input argument `Data` empty.
- `SortBy [ char ]` - Text string that will be evaluated to compute the criterion by which the parameterisations will be sorted; see Description for how to write `SortBy`.

### Output arguments

- B [ SVAR ] - SVAR object with parameterisations sorted by the specified criterion.
- Data [ tseries | struct | empty ] - SVAR data with the structural shocks re-ordered to correspond to the order of parameterisations.
- Inx [ numeric ] - Vector of indices so that  $B = A(\text{Inx})$ .
- Crit [ numeric ] - The value of the criterion based on the string SortBy for each parameterisation.

### Options

- 'progress=' [ true | false ] - Display progress bar in the command window.

### Description

The individual parameterisations within the SVAR object A are sorted by the sum squared distances of selected shock responses to the respective median responses. Formally, the following criterion is evaluated for each parameterisation

$$\sum_{i \in I, j \in J, k \in K} [S_{i,j}(k) - M_{i,j}(k)]^2$$

where  $S_{i,j}(k)$  denotes the response of the  $i$ -th variable to the  $j$ -th shock in period  $k$ , and  $M_{i,j}(k)$  is the median responses. The sets of variables, shocks and periods, i.e.  $I, J, K$ , respectively, over which the summation runs are determined by the user in the SortBy string.

How do you select the shock responses that enter the criterion in SortBy? The input argument SortBy is a text string that refers to array S, whose element  $S(i, j, k)$  is the response of the  $i$ -th variable to the  $j$ -th shock in period  $k$ .

Note that when you pass in SVAR data and request them to be sorted the same way as the SVAR parameterisations (the second line in Syntax), the number of parameterisations in A must match the number of data sets in Data.

### Example

Sort the parameterisations by squared distance to median of shock responses of all variables to the first shock in the first four periods. The parameterisation that is closest to the median responses

```
S2 = sort(S1,[],'S(:,1,1:4)')
```

---

## ■ `sprintf`

Format SVAR as a model code and write to text string

### Syntax

```
[C,D] = sprintf(S,...)
```

### Input arguments

- `S` [ SVAR ] - SVAR object that will be written as a model code.
- Output arguments
- `C` [ cellstr ] - Text string with the model code for each parameterisation.
- `D` [ cell ] - Parameter database for each parameterisation; if `'hardParameters='` is true, the databases will be empty.

### Options

- `'decimal='` [ numeric | empty ] - Precision (number of decimals) at which the coefficients will be written if `'hardParameters='` is true; if empty, the `'format='` options is used.
- `'declare='` [ true | false ] - Add declaration blocks and keywords for VAR variables, shocks, and equations.
- `'eNames='` [ cellstr | char | empty ] - Names that will be given to the VAR residuals; if empty, the names from the SVAR object will be used.
- `'format='` [ char | '%+.16e' ] - Numeric format for parameter values; it will be used only if `'decimal='` is empty.
- `'hardParameters='` [ true | false ] - Print coefficients as hard numbers; otherwise, create parameter names and return a parameter database.
- `'yNames='` [ cellstr | char | empty ] - Names that will be given to the variables; if empty, the names from the SVAR object will be used.

- 'tolerance=' [ numeric | getrealsmall() ] - Treat VAR coefficients smaller than 'tolerance=' in absolute value as zeros; zero coefficients will be dropped from the model code.

## Description

## Example

---

## ■ srf

Shock (impulse) response function

## Syntax

```
[R,Cum] = srf(V,NPer)
[R,Cum] = srf(V,Range)
```

## Input arguments

- V [ SVAR ] - SVAR object for which the impulse response function will be computed.
- NPer [ numeric ] - Number of periods.
- Range [ numeric ] - Date range.

## Output arguments

- R [ tseries | struct ] - Shock response functions.
- Cum [ tseries | struct ] - Cumulative shock response functions.

## Options

- 'presample=' [ true | false ] - Include zeros for pre-sample initial conditions in the output data.
- 'select=' [ cellstr | char | logical | numeric | Inf ] - Selection of shocks to which the responses will be simulated.

## Description

For backward compatibility, the following calls into the `srf` function is also possible:

```
[~,~,s,c] = srf(this,nper)
[~,~,s,c] = srf(this,range)
```

## Example

---

## ■ SVAR

Convert reduced-form VAR to structural VAR

### Syntax

```
[S,DATA,B,COUNT] = SVAR(V,DATA,...)
```

### Input arguments

- `V` [ VAR ] - Reduced-form VAR object.
- `DATA` [ struct | tseries ] - Data associated with the input VAR object.

### Output arguments

- `S` [ VAR ] - Structural VAR object.
- `DATA` [ struct | tseries ] - Data with transformed structural residuals.
- `B` [ numeric ] - Impact matrix of structural residuals.
- `COUNT` [ numeric ] - Number of draws actually performed (both successful and unsuccessful) when `'method'='draw'`; otherwise `COUNT=1`.

## Options

- 'maxIter=' [ numeric | 0 ] - Maximum number of attempts when 'method'='draw'.
- 'method=' [ 'chol' | 'draw' | 'qr' | 'svd' ] - Method that will be used to identify structural residuals.
- 'nDraw=' [ numeric | 0 ] - Target number of successful draws when 'method'='draw'.
- 'reorder=' [ numeric | empty ] - Re-order VAR variables before identifying structural residuals, and bring the variables back in original order afterwards. Use the option 'backorderResiduals=' to control if also the structural residuals are brought back in original order.
- 'output=' [ 'auto' | 'dbase' | 'tseries' ] - Format of output data.
- 'progress=' [ true | false ] - Display progress bar in the command window.
- 'rank=' [ numeric | Inf ] - Reduced rank of the covariance matrix of structural residuals when 'method=' 'svd'; Inf means full rank is preserved.
- 'backorderResiduals=' [ true | false ] - Bring the identified structural residuals back in original order.
- 'std=' [ numeric | 1 ] - Std deviation of structural residuals; the resulting structural covariance matrix will be re-scaled (divided) by this factor.
- 'test=' [ char ] - Works with 'method=draw' only; a string that will be evaluated for each random draw of the impact matrix B. The evaluation must result in true or false; only the matrices B that evaluate to true will be kept. See Description for more on how to write the option 'test='.

## Description

—*Identification random Householder transformations*

The structural impact matrices B are randomly generated using a Householder transformation algorithm. Each matrix is tested by evaluating the test string supplied by the user. If it evaluates to true the matrix is kept and one more SVAR parameterisation is created, if it is false the matrix is discarded.

The test string can refer to the following characteristics:

- S – the impulse (or shock) response function; the  $S(i, j, k)$  element is the response of the  $i$ -th variable to the  $j$ -th shock in period  $k$ .
- Y – the asymptotic cumulative response function; the  $Y(i, j)$  element is the asymptotic (long-run) cumulative response of the  $i$ -th variable to the  $j$ -th shock.

**Example**

## 15 Bayesian VAR prior dummies: BVAR package

The BVAR package can be used to create the basic types of prior dummy observations when estimating Bayesian VAR models. The dummy observations are passed in the `VAR/estimate` [P204](#) function through the 'BVAR=' option.

### Constructing dummy observations

- `covmat` [P241](#) - Covariance matrix prior dummy observations for BVARs.
- `litterman` [P242](#) - Litterman's prior dummy observations for BVARs.
- `sumofcoeff` [P243](#) - Doan et al sum-of-coefficient prior dummy observations for BVARs.
- `uncmean` [P243](#) - Unconditional-mean dummy (or Sims' initial dummy) observations for BVARs.
- `user` [P244](#) - User-supplied prior dummy observations for BVARs.

### Weights on prior dummy observations

The prior dummies produced by `litterman` [P242](#), `uncmean` [P243](#), `sumofcoeff` [P243](#) can be weighted up or down using the input argument `Mu`. To give the weight a clear interpretation, use the option 'stdize=' true when estimating the VAR. In that case, setting `Mu` to `sqrt(N)` means the prior dummies are worth a total of extra `N` artificial observations; the weight can be related to the actual number of observations used in estimation.

### Getting help on BVAR functions

```
help BVAR
help BVAR/function_name
```

## ■ covmat

Covariance matrix prior dummy observations for BVARs

### Syntax

```
O = BVAR.covmat(C,Rep)
```

### Input arguments

- `C` [ numeric ] - Prior covariance matrix of residuals; if `C` is a vector it will be converted to a diagonal matrix.
- `Rep` [ numeric ] - The number of times the dummy observations will be repeated.

### Output arguments

- `O` [ bvarobj ] - BVAR object that can be passed into the [VAR/estimate](#) P204 function.

### Description

### Example

---

## ■ litterman

Litterman's prior dummy observations for BVARs

### Syntax

```
O = BVAR.litterman(Rho,Sgm,Lmb)
```

### Input arguments

- `Rho` [ numeric ] - White-noise priors (`Rho = 0`) or random-walk priors (`Rho = 1`).
- `Mu` [ numeric ] - Weight on the dummy observations.
- `Lmb` [ numeric ] - Exponential increase in weight depending on the lag; `Lmb = 0` means all lags are weighted equally.

### Output arguments

- `O` [ bvarobj ] - BVAR object that can be passed into the [VAR/estimate](#) P204 function.

### Description

See [the section explaining the weights on prior dummies](#) [P241](#), i.e. the input argument Mu.

### Example

---

## ■ sumofcoeff

Doan et al sum-of-coefficient prior dummy observations for BVARs

### Syntax

```
O = BVAR.sumofcoeff(Mu)
```

### Input arguments

- Mu [ numeric ] - Weight on the dummy observations.

### Output arguments

- O [ bvarobj ] - BVAR object that can be passed into the [VAR/estimate](#) [P204](#) function.

### Description

See [the section explaining the weights on prior dummies](#) [P241](#), i.e. the input argument Mu.

### Example

---

## ■ uncmmean

Unconditional-mean dummy (or Sims' initial dummy) observations for BVARs

## Syntax

```
O = BVAR.uncmean(YBar,Mu)
```

## Input arguments

- YBar [ numeric ] - Vector of unconditional means imposed as priors.
- Mu [ numeric ] - Weight on the dummy observations.

## Output arguments

- X [ numeric ] - Array with prior dummy observations that can be used in the 'BVAR=' option of the [VAR/estimate](#) [P204](#) function.
- O [ bvarobj ] - BVAR object that can be passed into the [VAR/estimate](#) [P204](#) function.

## Description

See [the section explaining the weights on prior dummies](#) [P241](#), i.e. the input argument Mu.

## Example

---

## ■ user

User-supplied prior dummy observations for BVARs

## Syntax

```
O = BVAR.user(Y0,K0,Y1,G1)
```

## Input arguments

- Y0 [ numeric ] - Column-wise prior dummy observations on the LHS.
- K0 [ numeric ] - Column-wise prior dummy observations on the RHS constant.

## Bayesian VAR prior dummies: BVAR package: user

- `Y1` [ numeric ] - Column-wise prior dummy observations on the RHS lagged variables.
- `G1` [ numeric ] - Column-wise prior dummy observations on the RHS coefficients on the co-integrating vector.

### Output arguments

- `0` [ `bvarobj` ] - BVAR object that can be passed into the [VAR/estimate](#) `P204` function.

### Description

### Example

## 16 Factor-augmented vector autoregressions: FAVAR objects and functions

### Constructor

- [FAVAR](#) P249 - Create new FAVAR object.

### Getting information about FAVAR objects

- [comment](#) P246 - Get or set user comments in an IRIS object.
- [get](#) P252 - Query model object properties.
- [isempty](#) P253 - True if VAR based object is empty.
- [userdata](#) P254 - Get or set user data in an IRIS object.
- [VAR](#) P255 - Return a VAR object describing the factor dynamics.

### Estimation

- [estimate](#) P247 - Estimate FAVAR using static principal components.

### Filtering and forecasting

- [filter](#) P249 - Re-estimate the factors by Kalman filtering the data taking FAVAR coefficients as given.
- [forecast](#) P251 - Forecast FAVAR factors and observables.

### Getting on-line help on FAVAR functions

```
help FAVAR
help FAVAR/function_name
```

---

## ■ comment

Get or set user comments in an IRIS object

### Syntax for getting user comments

```
Cmt = comment(Obj)
```

### Syntax for assigning user comments

```
Obj = comment(Obj,Cmt)
```

### Input arguments

- Obj [ model | tseries | VAR | SVAR | FAVAR | sstate ] - One of the IRIS objects.
- Cmt [ char ] - User comment that will be attached to the object.

### Output arguments

- Cmt [ char ] - User comment that are currently attached to the object.

### Description

### Example

---

## ■ estimate

Estimate FAVAR using static principal components

### Syntax

```
[A,D,CC,F,U,E,CTF] = estimate(A,D,List,Range,[R,Q],...)  
[A,X,CC,F,U,E,CTF] = estimate(A,X,Range,[R,Q],...)
```

### Input arguments

- A [ FAVAR ] - Empty FAVAR object.

- `D [ struct ]` - Input database.
- `List [ cellstr ]` - List of series from the database on which the VAR will be estimated.
- `X [ tseries ]` - Tseries objects with input data.
- `Range [ numeric ]` - Estimation range.
- `R [ numeric ]` - Selection criterion for the number of factors: Minimum requested proportion of input data volatility explained by the factors.
- `Q [ numeric ]` - Selection criterion for the number of factors: Maximum number of factors.

### Output arguments

- `A [ FAVAR ]` - Estimated FAVAR object.
- `D [ struct ]` - Output database.
- `X [ tseries ]` - Output tseries object.
- `CC [ tseries ]` - Estimates of common components in the FAVAR observables.
- `F [ tseries ]` - Estimates of factors.
- `U [ struct | tseries ]` - Idiosyncratic residuals.
- `E [ tseries ]` - Factor VAR residuals.
- `CTF [ tseries ]` - Contributions of individual input series to the estimated factors.

### Options

- `'cross=' [ true | false | numeric ]` - Keep off-diagonal elements in the covariance matrix of idiosyncratic residuals; if false all cross-covariances are reset to zero; if a number between zero and one, all cross-covariances are multiplied by that number.
- `'order=' [ numeric | 1 ]` - Order of the VAR for factors.
- `'output=' [ 'auto' | 'dbase' | 'tseries' ]` - Format of output data.
- `'rank=' [ numeric | Inf ]` - Restriction on the rank of the factor VAR residuals.

### Description

### Example

## ■ FAVAR

Create new FAVAR object

### Syntax

```
F = FAVAR(YNames)
```

### Input arguments

- YNames [ cellstr | char ] - Names of observed variables in the FAVAR model.

### Output arguments

- F [ FAVAR ] - New FAVAR object.

### Description

This function creates a new empty FAVAR object. It is usually followed by the [estimate](#) P247 function to estimate the FAVAR parameters on data.

### Example

To estimate a FAVAR, you first need to create an empty VAR object, and then run the [FAVAR](#) P247 function on it, e.g.

```
list = {'DLCPI', 'DLGDP', 'R'};  
f = FAVAR(list);  
f = estimate(f,d,range);
```

---

## ■ filter

Re-estimate the factors by Kalman filtering the data taking FAVAR coefficients as given

## Syntax

```
[A,D,CC,F,U,E] = filter(A,D,Range,...)
```

## Input arguments

- A [ FAVAR ] - Estimated FAVAR object.
- D [ struct | tseries ] - Input database or tseries object with the FAVAR observables.
- Range [ numeric ] - Filter date range.

## Output arguments

- A [ FAVAR ] - FAVAR object.
- D [ struct ] - Output database or tseries object with the FAVAR observables.
- CC [ struct | tseries ] - Re-estimated common components in the observables.
- F [ tseries ] - Re-estimated common factors.
- U [ tseries ] - Re-estimated idiosyncratic residuals.
- E [ tseries ] - Re-estimated structural residuals.

## Options

- 'cross=' [ true | false | numeric ] - Run the filter with the off-diagonal elements in the covariance matrix of idiosyncratic residuals; if false all cross-covariances are reset to zero; if a number between zero and one, all cross-covariances are multiplied by that number.
- 'invFunc=' [ 'auto' | function\_handle ] - Inversion method for the FMSE matrices.
- 'meanOnly=' [ true | false ] - Return only mean data, i.e. point estimates.
- 'persist=' [ true | false ] - If filter or forecast is used with 'persist=' set to true for the first time, the forecast MSE matrices and their inverses will be stored; subsequent calls of the filter or forecast functions will re-use these matrices until filter or forecast is called.
- 'output=' [ 'auto' | 'dbase' | 'tseries' ] - Format of output data.
- 'tolerance=' [ numeric | 0 ] - Numerical tolerance under which two FMSE matrices computed in two consecutive periods will be treated as equal and their inversions will be re-used, not re-computed.

## Description

It is the user's responsibility to make sure that `filter` and `forecast` called with `'persist='` set to `true` are valid, i.e. that the previously computed FMSE matrices can be really re-used in the current run.

## Example

---

### ■ forecast

Forecast FAVAR factors and observables

#### Syntax

```
[D,CC,F,U,E] = forecast(A,D,RANGE,J,...)
```

#### Input arguments

- A [ FAVAR ] - FAVAR object.
- D [ struct | tseries ] - Input data with initial condition for the FAVAR factors.
- RANGE [ numeric ] - Forecast range.
- J [ struct | tseries ] - Conditioning data with hard tunes on the FAVAR observables.

#### Output arguments

- D [ struct ] - Output database or tseries object with the FAVAR observables.
- CC [ struct | tseries ] - Projection of common components in the observables.
- F [ tseries ] - Projection of common factors.
- U [ tseries ] - Conditional idiosyncratic residuals.
- E [ tseries ] - Conditional structural residuals.

## Options

See help on [FAVAR/filter](#) P249 for options available.

## Description

## Example

---

## ■ get

Query model object properties

### Syntax

```
Ans = get(A, Query)
[Ans, Ans, ...] = get(A, Query, Query, ...)
```

### Input arguments

- A [ FAVAR ] - FAVAR object.
- Query [ char ] - Query to the FAVAR object.

### Output arguments

- Ans [ ... ] - Answer to the query.

### Valid queries to FAVAR objects

—*System matrices*

- 'A\*' Returns [ numeric ] the transition matrix of the underlying VAR system on factors.
- 'B' Returns [ numeric ] the matrix mapping the impact of structural residuals on the factors in the underlying VAR.
- 'C' Returns [ numeric ] the matrix mapping the factors into the observables.

Factor-augmented vector autoregressions: FAVAR objects and functions: isempty

- 'Omega' Returns [ numeric ] the reduced-form covariance matrix of the residuals in the underlying VAR.
- 'Sigma' Returns [ numeric ] the covariance matrix of idiosyncratic shocks.

—*Underlying VAR*

- 'VAR' Returns [ VAR ] a VAR object describing the factor dynamics.

—*Eigenvalues and singular values*

- 'eig' Returns [ numeric ] the vector of eigenvalues of the underlying VAR.
- 'sing' Returns [ numeric ] the vector of singular values from the principal component estimation step.

—*Observables and factors*

- 'mean' Returns [ numeric ] the estimated mean of the observables used to standardise the input data.
- 'std' Returns [ numeric ] the estimated std deviations of the observables used to standardise the input data.
- 'ny' Returns [ numeric ] the number of observables.
- 'nx' Returns [ numeric ] the number of factors.
- 'yList' Returns [ cellstr ] the list of the names of observables.

## Description

## Example

---

## ■ isempty

True if VAR based object is empty

## Syntax

Flag = isempty(X)

### Input arguments

- `X` [ VAR | SVAR | FAVAR ] - VAR based object.

### Output argument

- Flag [ true | false ] - True if the VAR based object, `X`, is empty.

### Description

### Example

---

## ■ userdata

Get or set user data in an IRIS object

### Syntax for getting user data

```
X = userdata(OBJ)
```

### Syntax for assigning user data

```
OBJ = userdata(OBJ,X)
```

### Input arguments

- `OBJ` [ model | tseries | VAR | SVAR | FAVAR | sstate ] - One of the IRIS objects with access to user data functions.
- `X` [ ... ] - Any kind of data that will be attached to, and stored within, the object `OBJ`.

### Output arguments

- `X` [ ... ] - User data that are currently attached to the object.
- `OBJ` [ model | tseries | VAR | SVAR | FAVAR | sstate ] - The object with its user data updated.

**Description**

**Example**

---

**■ VAR**

Return a VAR object describing the factor dynamics

**Syntax**

`v = VAR(a)`

**Input arguments**

`a` [ FAVAR ] - FAVAR object.

**Output arguments**

`v` [ VAR ] - VAR object describing the dynamic system of the FAVAR factors.

**Description**

**Example**

Part IV —

# Time series and database management

## 17 Dates and date ranges

### Creating IRIS serial date numbers

- `bb` [P258](#) - IRIS serial date numbers for dates with bi-monthly frequency.
- `bbtoday` [P259](#) - IRIS serial date number for current bi-month.
- `hh` [P273](#) - IRIS serial date numbers for dates with half-yearly frequency.
- `hhtoday` [P274](#) - IRIS serial date number for current half-year.
- `mm` [P274](#) - IRIS serial date numbers for dates with monthly frequency.
- `mmtoday` [P275](#) - IRIS serial date number for current month.
- `qq` [P275](#) - IRIS serial date numbers for dates with quarterly frequency.
- `qqtoday` [P276](#) - IRIS serial date number for current quarter.
- `yy` [P278](#) - IRIS serial date numbers for dates with yearly frequency.
- `yytoday` [P279](#) - IRIS serial date number for current year.

### Computing special dates (daily dates only)

- `datbom` [P265](#) - Beginning of month for the specified daily date.
- `datboq` [P266](#) - Beginning of quarter for the specified daily date.
- `datboy` [P266](#) - Beginning of year for the specified daily date.
- `dateom` [P269](#) - End of month for the specified daily date.
- `dateoq` [P270](#) - End of quarter for the specified daily date.
- `dateoy` [P270](#) - End of year for the specified daily date.

### Creating date ranges

- `daterange` [P271](#) - Use the colon operator to create date ranges.
- `datxtick` [P271](#) - Change ticks, labels and/or date frequency on x-axis in existing tseries graphs.

### Converting dates

- [clp2dat](#) P259 - Convert text in system clipboard to dates.
- [dat2char](#) P260 - Convert dates to character array.
- [dat2charlist](#) P261 - Convert dates to a comma-separated list.
- [dat2clp](#) P262 - Convert dates to text and paste to system clipboard.
- [dat2dec](#) P263 - Convert dates to their decimal representations.
- [dat2str](#) P263 - Convert IRIS dates to cell array of strings.
- [dat2ypf](#) P265 - Convert IRIS serial date number to year, period and frequency.
- [dec2dat](#) P272 - Convert decimal numbers to IRIS serial date numbers.
- [str2dat](#) P277 - Convert strings to IRIS serial date numbers.

### Date comparison

- [datcmp](#) P267 - Compare two IRIS serial date numbers.
- [datdiff](#) P268 - Number of periods between two dates with check for date frequency.
- [rngcmp](#) P276 - Compare two IRIS date ranges.

### Getting on-line help on date functions

```
help dates  
help dates/function_name
```

---

## ■ bb

IRIS serial date numbers for dates with bi-monthly frequency

### Syntax

```
d = bb(y)  
d = bb(y,b)
```

### Input arguments

- y [ numeric ] - Years.
- q [ numeric ] - B-months; if missing, first bi-month is assumed.

### Output arguments

- d [ numeric ] - IRIS serial date numbers representing the input bi-months.

### Description

### Example

---

## ■ bbtoday

IRIS serial date number for current bi-month

### Syntax

Dat = bbtoday()

### Output arguments

- Dat [ numeric ] - IRIS serial date number for current bi-month.

### Description

### Example

---

## ■ clp2dat

Convert text in system clipboard to dates

### Syntax

```
D = clp2dat(...)
```

### Output arguments

- D [ numeric ] - IRIS serial date numbers based on the current content of the system clipboard converted by the [str2dat](#) P277 function.

### Options

See help on [str2dat](#) P277 for options available.

### Description

### Example

---

## ■ dat2char

Convert dates to character array

### Syntax

```
C = dat2char(D,...)
```

### Input arguments

- D [ numeric ] - IRIS serial date numbers that will be converted to character array.

### Output arguments

- C [ char ] - Character array representing the input dates; each line of the array represents one date from D.

## Options

See help on [dat2str](#) P263 for options available.

## Description

### Example

We create a quarterly date using the function `qq`; this function returns an IRIS serial date number. We then use `dat2char` to print a human-readable text representation of that date.

```
d = qq(2015,3)
d =
    8.0620e+03
dat2char(d)
ans =
    2015Q3
```

---

## ■ dat2charlist

Convert dates to a comma-separated list

### Syntax

```
C = dat2charlist(D,...)
```

### Input arguments

- `D [ numeric ]` - IRIS serial date numbers that will be converted to a comma-separated list.

### Output arguments

- `C [ char ]` - Text string with a comma-separated list of dates.

### Options

See help on [dat2str](#) P263 for options available.

### Description

### Example

---

## ■ dat2clp

Convert dates to text and paste to system clipboard

### Syntax

```
C = dat2clp(D, ...)
```

### Input arguments

- D [ numeric ] - IRIS serial date numbers that will be converted to character array and pasted to the system clipboard.

### Output arguments

- C [ char ] - Character array representing the input dates pasted to the system clipboard; each line of the array represents one date from D.

### Options

See help on [dat2str](#) P263 for options available.

### Description

### Example

---

## ■ dat2dec

Convert dates to their decimal representations

### Syntax

```
DEC = dat2dec(DAT)
```

### Input arguments

- DAT [ numeric ] - IRIS serial date number.

### Output arguments

- DEC [ numeric ] - Decimal number representing the input dates, computed as  $\text{year} + (\text{per}-1)/\text{freq}$ .

### Description

### Example

---

## ■ dat2str

Convert IRIS dates to cell array of strings

### Syntax

```
S = dat2str(DAT,...)
```

### Input arguments

- DAT [ numeric ] - IRIS serial date number(s).

### Output arguments

- S [ cellstr ] - Cellstr with strings representing the input dates.

## Options

- 'dateFormat=' [ char | 'YYYYFP' ] - Date format string.
- 'freqLetters=' [ char | 'YHQBM' ] - Letters representing the five possible frequencies (annual,semi-annual,quarterly,bimontly,monthly).
- 'months=' [ cellstr | English names of months ] - Cell array of twelve strings representing the names of months.
- 'standinMonth=' [ numeric | 'last' | 1 ] - Which month will represent a lower-than-monthly-frequency date if month is part of the date format string.

## Description

The date format string can include any combination of the following fields:

- 'Y=' - Year.
- 'YYYY=' - Four-digit year.
- 'YY=' - Two-digit year.
- 'P=' - Period within the year (half-year, quarter, bi-month, month).
- 'PP=' - Two-digit period within the year.
- 'R=' - Upper-case roman numeral for the period within the year.
- 'r=' - Lower-case roman numeral for the period within the year.
- 'M=' - Month numeral.
- 'MM=' - Two-digit month numeral.
- 'MMMM=', 'Mmmm', 'mmm' - Case-sensitive name of month.
- 'MMM=', 'Mmm', 'mmm' - Case-sensitive three-letter abbreviation of month.
- 'F=' - Upper-case letter representing the date frequency.
- 'f=' - Lower-case letter representing the date frequency.

To get some of the above letters printed literally in the date string, use a percent sign as an escape character, i.e. '%Y', etc.

## Example

---

### ■ dat2ypf

Convert IRIS serial date number to year, period and frequency

#### Syntax

```
[y,p,f] = dat2ypf(dat)
```

#### Input arguments

- dat [ numeric ] - IRIS serial date numbers.

#### Output arguments

- y [ numeric ] - Years.
- p [ numeric ] - Periods within year.
- f [ numeric ] - Date frequencies.

#### Description

## Example

---

### ■ datbom

Beginning of month for the specified daily date

#### Syntax

```
Bom = datebom(D)
```

### Input arguments

- D [ numeric ] - Daily serial date number.

### Output arguments

- Bom [ numeric ] - Daily serial date number for the first day of the same month as D.

### Description

### Example

---

## ■ datboq

Beginning of quarter for the specified daily date

### Syntax

Boq = datboq(D)

### Input arguments

- D [ numeric ] - Daily serial date number.

### Output arguments

- Boq [ numeric ] - Daily serial date number for the first day of the same quarter as D.

### Description

### Example

---

## ■ datboy

Beginning of year for the specified daily date

### Syntax

```
Boy = dateboy(D)
```

### Input arguments

- `D` [ numeric ] - Daily serial date number.

### Output arguments

- `Boy` [ numeric ] - Daily serial date number for the first day of the same year as `D`.

### Description

### Example

---

## ■ `datecmp`

Compare two IRIS serial date numbers

### Syntax

```
Flag = datecmp(Dat1,Dat2)
```

### Input arguments

- `Dat1, Dat2` [ numeric ] - IRIS serial date numbers or vectors.

### Output arguments

- `Flag` [ true | false ] - True for numbers that represent the same date.

### Description

The two date vectors must either be the same lengths, or one of them must be scalar.

Use this function instead of the plain comparison operator, `==`, to compare dates. The plain comparison can sometimes give false results because of round-off errors.

### Example

```
d1 = qq(2010,1);
d2 = qq(2009,1):qq(2010,4);
datcmp(d1,d2)
ans =
    0    0    0    0    1    0    0    0
```

---

## ■ datdiff

Number of periods between two dates with check for date frequency

### Syntax

```
D = datdiff(D1,D2)
```

### Input arguments

- D1, D2 [ numeric ] - IRIS dates of vectors of IRIS dates.

### Output arguments

- D [ numeric ] - Number of periods between D1 and D2, positive for D1 greater than D2, negative for D1 smaller than D2, or NaN for dates of different frequencies.

### Description

### Example

```
d1 = mm(2010,12);
```

```
d2 = mm(2011,12);
```

```
datdiff(d1,d2)
```

```
ans =  
    -12
```

```
datdiff(d2,d1)
```

```
ans =  
     12
```

```
d3 = yy(2011);
```

```
datdiff(d1,d3)
```

```
ans =  
    NaN
```

---

## ■ dateom

End of month for the specified daily date

### Syntax

```
Eom = dateom(D)
```

### Input arguments

- D [ numeric ] - Daily serial date number.

### Output arguments

- Eom [ numeric ] - Daily serial date number for the last day of the same month as D.

### Description

### Example

---

## ■ dateoq

End of quarter for the specified daily date

### Syntax

Eoq = dateoq(D)

### Input arguments

- D [ numeric ] - Daily serial date number.

### Output arguments

- Eoq [ numeric ] - Daily serial date number for the last day of the same quarter as D.

### Description

### Example

---

## ■ dateoy

End of year for the specified daily date

### Syntax

Eoy = dateoy(D)

### Input arguments

- D [ numeric ] - Daily serial date number.

### Output arguments

- Eoy [ numeric ] - Daily serial date number for the last day of the same year as D.

## Description

## Example

---

## ■ daterange

Use the colon operator to create date ranges

## Syntax

```
startdate : enddate  
startdate : increment : enddate
```

## Input arguments

- startdate [ numeric ] - IRIS serial date number representing the startdate.
- enddate [ numeric ] - IRIS serial date number representing the enddate; startdate and enddate must be the same frequency.
- increment [ numeric ] - Number of periods (specific to each frequency) between the dates in the date vector.

## Description

You can use the colon operator to create continuous date ranges because the IRIS serial date numbers are designed so that whatever the frequency two consecutive dates are represented by numbers that differ exactly by one.

## Example

---

## ■ datxtick

Change ticks, labels and/or date frequency on x-axis in existing tseries graphs

## Syntax

```
datxtick(Range,...)  
datxtick(Ax,Range,...)
```

## Input arguments

- Ax [ numeric ] - Handle to the axes object where the changes will be made; if not specified, the current axes object, gca(), is changed.
- Range [ numeric ] - New date range to which the x-axis will be changed.

## Options

- 'datePosition=' [ 'start' | 'centre' | 'end' ] - Where within each given period the date tick will be placed (at the beginning of the period, in the middle of the period, or at the end of the period).
- 'dateTicks=' [ numeric | Inf ] - Individual date ticks; if Inf, the ticks will be determined automatically using the standard Matlab algorithm.

See [dat2str](#) P263 for date formatting options available.

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## Description

### Example

Create a graph plotting a quarterly series, and then change the ticks and labels on the x-axis to monthly:

```
x = tseries(qq(2010,1):qq(2011,4),@rand);  
plot(x);  
datxtick(mm(2010,1):mm(2011,12),'dateFormat=' , 'Mmm YYYY');
```

---

## ■ dec2dat

Convert decimal numbers to IRIS serial date numbers

### Syntax

```
dat = dec2dat(dec, freq)
```

### Input arguments

- dec [ numeric ] - Decimal numbers representing dates.
- freq [ freq ] - Date frequency.

### Output arguments

- dat [ numeric ] - IRIS serial data numbers corresponding to the input decimals.
- 

## ■ hh

IRIS serial date numbers for dates with half-yearly frequency

### Syntax

```
d = hh(y)  
d = hh(y, h)
```

### Input arguments

- y [ numeric ] - Years.
- h [ numeric ] - Half-years; if missing, first half-year is used.

### Output arguments

- d [ numeric ] - IRIS serial date numbers representing the input half-years.

**Description**

**Example**

---

■ **hhtoday**

IRIS serial date number for current half-year

**Syntax**

Dat = hhtoday()

**Output arguments**

- Dat [ numeric ] - IRIS serial date number for current half-year.

**Description**

**Example**

---

■ **mm**

IRIS serial date numbers for dates with monthly frequency

**Syntax**

d = mm(y)  
d = mm(y,m)

**Input arguments**

- y [ numeric ] - Years.
- m [ numeric ] - Months; if missing, first month (January) is assumed.

### Output arguments

- d [ numeric ] - IRIS serial date numbers representing the input months.

### Description

### Example

---

## ■ **mmtoday**

IRIS serial date number for current month

### Syntax

Dat = mmtoday()

### Output arguments

- Dat [ numeric ] - IRIS serial date number for current month.

### Description

### Example

---

## ■ **qq**

IRIS serial date numbers for dates with quarterly frequency

### Syntax

d = qq(y)  
d = qq(y,q)

### Input arguments

- y [ numeric ] - Years.
- q [ numeric ] - Quarters; if missing, first quarter is assumed.

### Output arguments

- d [ numeric ] - IRIS serial date numbers representing the input quarterly dates.

### Description

### Example

---

## ■ **qtoday**

IRIS serial date number for current quarter

### Syntax

```
Dat = qtoday()
```

### Output arguments

- Dat [ numeric ] - IRIS serial date number for current quarter.

### Description

### Example

---

## ■ **rngcmp**

Compare two IRIS date ranges

### Syntax

```
Flag = rngcmp(R1,R2)
```

### Input arguments

- R1, R2 [ numeric ] - Two IRIS date ranges that will be compared.

### Output arguments

- Flag [ true | false ] - True if the two date ranges are the same.

### Description

An IRIS date range is distinct from a vector of dates in that only the first and the last dates matter. Often, date ranges are context sensitive. In that case, you can use `-Inf` for the start date (meaning the earliest possible date in the given context) and `Inf` for the end date (meaning the latest possible date in the given context), or simply `Inf` for the whole range (meaning from the earliest possible date to the latest possible date in the given context).

### Example

```
r1 = qq(2010,1):qq(2020,4);  
r2 = [qq(2010,1),qq(2020,4)];  
  
rngcmp(r1,r2)  
ans =  
    1
```

---

## ■ str2dat

Convert strings to IRIS serial date numbers

### Syntax

```
Dat = str2dat(S,...)
```

### Input arguments

- S [ char | cellstr ] - Strings representing dates.

### Output arguments

- Dat [ numeric ] - IRIS serial date numbers.

### Options

- 'freq=' [ 1 | 2 | 4 | 6 | 12 | empty ] - Enforce frequency.

See help on [dat2str](#) P263 for other options available.

### Description

#### Example

```
d = str2dat('04-2010','dateformat','MM-YYYY');  
dat2str(d)  
ans =  
    '2010M04'
```

```
d = str2dat('04-2010','dateformat','MM-YYYY','freq',4);  
dat2str(d)  
ans =  
    '2010Q2'
```

---

## ■ yy

IRIS serial date numbers for dates with yearly frequency

### Syntax

d = yy(y)

### Input arguments

- y [ numeric ] - Years.

### Output arguments

- d [ numeric ] - IRIS serial date numbers representing the input years.

### Description

### Example

---

## ■ yytoday

IRIS serial date number for current year

### Syntax

Dat = yytoday()

### Output arguments

- Dat [ numeric ] - IRIS serial date number for current year.

### Description

### Example

## 18 Time series objects and functions

Tseries methods:

### Constructor

- [tseries](#) P341 - Create new time series (tseries) object.

### Getting information about tseries objects

- [daily](#) P298 - Calendar view of a daily tseries object.
- [enddate](#) P302 - Date of the last available observation in a tseries object.
- [freq](#) P306 - Frequency of a tseries object.
- [get](#) P307 - Query tseries object property.
- [length](#) P313 - Length of tseries object.
- [ndims](#) P318 - Number of dimensions in tseries object data.
- [size](#) P333 - Size of tseries object data.
- [startdate](#) P336 - Date of the first available observation in a tseries object.
- [yearly](#) P347 - Display tseries object one full year per row.

### Referencing tseries objects

- [subsasgn](#) P338 - Subscripted assignment for tseries objects.
- [subsref](#) P339 - Subscripted reference function for tseries objects.

### Maths and statistics functions and operators

Some of the following functions require the Statistics Toolbox.

+, -, \*, \, /, ^, &, |, ~, ==, ~=, >=, >, <, <=, abs, acos, asin, atan, atan2, ceil, cos, exp, fix, floor, imag, isinf, isnan, log, log10, real, round, sin, sqrt, tan, normpdf, normcdf, prctile, lognpdf, logncdf

The behaviour of the following functions depend on the dimension along which they are performed.

Some of the following functions require the Statistics Toolbox.

## Time series objects and functions

all, any, cumprod, cumsum, find, geomean, max, mean, median, min, mode, nanmean, nanstd, nansum, nanvar, prod, std, sum, var

### Filters

- [arf](#) [P286](#) - Run autoregressive function on a tseries object.
- [bpass](#) [P289](#) - Band-pass filter.
- [bwf](#) [P292](#) - Butterworth filter with tunes.
- [bwf2](#) [P292](#) - Swap output arguments of the Butterworth filter with tunes.
- [detrnd](#) [P299](#) - Remove a linear time trend.
- [expsmooth](#) [P304](#) - Exponential smoothing.
- [hpf](#) [P308](#) - Hodrick-Prescott filter with tunes (aka LRX filter).
- [hpf2](#) [P312](#) - Swap output arguments of the Hodrick-Prescott filter with tunes.
- [fft](#) [P305](#) - Discrete Fourier transform of tseries object.
- [llf](#) [P314](#) - Local level filter (aka random walk plus white noise) with tunes.
- [llf2](#) [P317](#) - Swap output arguments of the local linear trend filter with tunes.
- [moving](#) [P318](#) - Apply function to moving window of observations.
- [trend](#) [P340](#) - Estimate a time trend.
- [x12](#) [P343](#) - Access to X12 seasonal adjustment program.

### Estimation and sample characteristics

Note that most of the sample characteristics are listed above in the Maths and statistics functions and operators section.

- [acf](#) [P283](#) - Sample autocovariance and autocorrelation functions.
- [hpd](#) [P308](#) - Highest probability density interval.
- [chowlin](#) [P293](#) - Chow-Lin distribution of low-frequency observations over higher-frequency periods.
- [regress](#) [P327](#) - Ordinary or weighted least-square regression.

### Visualising tseries objects

- [area](#) P285 - Area graph for tseries objects.
- [bar](#) P287 - Bar graph for tseries objects.
- [barcon](#) P288 - Contribution bar graph for tseries objects.
- [errorbar](#) P303 - Line plot with error bars.
- [plot](#) P321 - Line graph for tseries objects.
- [plotcmp](#) P323 - Comparison graph for two time series.
- [plotpred](#) P324 - Plot Kalman filter predictions.
- [plotyy](#) P325 - Line plot function with LHS and RHS axes for time series.
- [scatter](#) P331 - Scatter graph for tseries objects.
- [spy](#) P335 - Visualise tseries observations that pass a test.
- [stem](#) P337 - Plot tseries as discrete sequence data.

### Manipulating tseries objects

- [empty](#) P302 - Empty tseries object preserving its size in 2nd and higher dimensions.
- [permute](#) P321 - Permute dimensions of a tseries object.
- [redate](#) P326 - Change time dimension of a tseries object.
- [reshape](#) P328 - Reshape size of time series in 2nd and higher dimensions.
- [resize](#) P329 - Clip tseries object down to a specified date range.
- [sort](#) P334 - Sort tseries columns by specified criterion.

### Converting tseries objects

- [convert](#) P295 - Convert tseries object to a different frequency.
- [double](#) P301 - Return tseries observations as double-precision numeric array.
- [doubldata](#) P301 - Convert tseries observations to double precision.
- [single](#) P332 - Return tseries observations as single-precision numeric array.
- [singldata](#) P333 - Convert tseries observations to single precision.

### Other tseries functions

- [apct](#) P284 - Annualised percent rate of change.
- [bsxfun](#) P291 - Standard BSXFUN implemented for tseries objects.
- [cumsumk](#) P296 - Cumulative sum with a k-period leap.
- [destdise](#) P298 - Destandardise tseries object by applying specified standard deviation and mean to it.
- [diff](#) P300 - First difference.
- [interp](#) P312 - Interpolate missing observations.
- [normalise](#) P319 - Normalise (or rebase) data to particular date.
- [pct](#) P320 - Percent rate of change.
- [round](#) P330 - Round tseries data to specified number of decimals.
- [rmse](#) P329 - Compute RMSE for given observations and predictions.
- [stdise](#) P336 - Standardise tseries data by subtracting mean and dividing by std deviation.
- [windex](#) P342 - Simple weighted or Divisia index.
- [wmean](#) P342 - Weighted average of time series observations.

### Getting on-line help on tseries functions

```
help tseries  
help tseries/function_name
```

---

## ■ acf

### Sample autocovariance and autocorrelation functions

#### Syntax

```
[C,R] = acf(X)  
[C,R] = acf(X,DATES,...)
```

### Input arguments

- X [ tseries ] - Tseries object.
- DATES [ numeric | Inf ] - Dates or date range on which tseries data will be used.

### Output arguments

- C [ numeric ] - Auto-/cross-covariance matrices.
- R [ numeric ] - Auto-/cross-correlation matrices.

### Options

- 'demean=' [ true | false ] - Remove mean from the data before computing the ACF.
- 'order=' [ numeric | 0 ] - Order up to which the ACF will be computed.
- 'smallSample=' [ true | false ] - Adjust degrees of freedom for small samples.

### Description

### Example

---

## ■ apct

Annualised percent rate of change

### Syntax

```
X = apct(X)
```

### Input arguments

- X [ tseries ] - Input tseries object.

### Output arguments

- X [ tseries ] - Annualised percentage rate of change in the input data.

## Description

## Example

---

## ■ area

Area graph for tseries objects

## Syntax

```
[h,range] = area(x,...)
[h,range] = area(range,x,...)
[h,range] = area(a,range,x,...)
```

## Input arguments

- a [ numeric ] - Handle to axes in which the graph will be plotted; if not specified, the current axes will be used.
- range [ numeric ] - Date range; if not specified the entire range of the input tseries object will be plotted.
- x [ tseries ] - Input tseries object whose columns will be plotted as an area graph.

## Output arguments

- h [ numeric ] - Handle(s) to the area(s) plotted.
- range [ numeric ] - Actually plotted date range.

## Options

- 'dateformat=' [ char | irisget('plotdateformat') ] - Date format for the tick marks on the x-axis.
- 'datetick=' [ numeric | Inf ] - Vector of dates locating tick marks on the x-axis; Inf means they will be created automatically.
- 'tight=' [ true | false ] - Make the y-axis tight.

See help on built-in area function for other options available.

## Description

## Example

---

## ■ arf

Run autoregressive function on a tseries object

## Syntax

```
X = arf(X,A,Z,RANGE,...)
```

## Input arguments

- X [ tseries ] - Input data from which initial condition will be taken.
- A [ numeric ] - Vector of coefficients of the autoregressive polynomial.
- Z [ numeric | tseries ] - Exogenous input or constantn in the autoregressive process.
- RANGE [ numeric | Inf ] - Date range on which the new time series observations will be computed; RANGE does not include pre-sample initial condition. Inf means the entire possible range will be used (taking into account the length of pre-sample initial condition needed).

## Output arguments

- X [ tseries ] - Output data with new observations created by running an autoregressive process described by A and Z.

## Description

The autoregressive process has one of the following forms:

$$a_1*x + a_2*x(-1) + \dots + a_n*x(-n) = z,$$

or

$$a_1x + a_2x(+1) + \dots + a_nx(+n) = z,$$

depending on whether the range is increasing (running forward in time), or decreasing (running backward in time). The coefficients  $a_1, \dots, a_n$  are gathered in the A vector,

$$A = [a_1, a_2, \dots, a_n].$$

### Example

The following two lines create an autoregressive process constructed from normally distributed residuals,

$$x_t = \rho x_{t-1} + \epsilon_t$$

```
rho = 0.8;
X = tseries(1:20,@randn);
X = arf(X,[1,-rho],X,2:20);
```

## ■ bar

Bar graph for tseries objects

### Syntax

```
[h,range] = bar(x,...)
[h,range] = bar(range,x,...)
[h,range] = bar(a,range,x,...)
```

### Input arguments

- a [ numeric ] - Handle to axes in which the graph will be plotted; if not specified, the current axes will be used.

## Time series objects and functions: barcon

- range [ numeric ] - Date range; if not specified the entire range of the input tseries object will be plotted.
- x [ tseries ] - Input tseries object whose columns will be plotted as a bar graph.

### Output arguments

- h [ numeric ] - Handles to the bars plotted.
- range [ numeric ] - Actually plotted date range.

### Options

- 'dateformat=' [ char | irisget('plotdateformat') ] - Date format for the tick marks on the x-axis.
- 'datetick=' [ numeric | Inf ] - Vector of dates locating tick marks on the x-axis; Inf means they will be created automatically.
- 'tight=' [ true | false ] - Make the y-axis tight.

See help on built-in bar function for other options available.

### Description

### Example

---

## ■ barcon

Contribution bar graph for tseries objects

### Syntax

```
[H,Range] = barcon(X,...)
[H,Range] = barcon(Range,X,...)
[H,Range] = barcon(Ax,Range,X,...)
```

### Input arguments

- Ax [ numeric ] - Handle to axes in which the graph will be plotted; if not specified, the current axes will be used.
- Range [ numeric ] - Date range; if not specified the entire range of the input tseries object will be plotted.
- X [ tseries ] - Input tseries object whose columns will be plotted as a contribution bar graph.

### Output arguments

- H [ numeric ] - Handle(s) to the bars plotted.
- Range [ numeric ] - Actually plotted date range.

### Options

- 'barWidth=' [ numeric | 0.8 ] - Width of bars as a percentage of the space each period occupies on the x-axis.
- 'colorMap=' [ numeric | get(gcf(),'colorMap') ] - Color map used to fill the contribution bars.
- 'dateFormat=' [ char | irisget('plotdateformat') ] - Date format for the tick marks on the x-axis.
- 'dateTick=' [ numeric | Inf ] - Vector of dates locating tick marks on the x-axis; Inf means they will be created automatically.
- 'evenlySpread=' [ true | false ] - Colors picked for the contribution bars are evenly spread across the color map.
- 'ordering=' [ 'ascend' | 'descend' | 'preserve' | numeric ] - Ordering of contributions with the same sign within each period; 'preserve' means the original order will be preserved.

### Description

### Example

---

## ■ bpass

Band-pass filter

## Syntax

```
[X,T] = bpass(X,Band,Range,...)
```

## Output arguments

- X [ tseries ] - Band-pass filtered tseries object.
- T [ tseries ] - Estimated trend tseries object.

## Input arguments

- X [ tseries ] - Input tseries object that will be filtered.
- Range [ numeric | Inf ] Date range on which the data will be filtered.
- Band [ numeric ] - Band of periodicities to be retained in the output data, Band = [LOW,HIGH].

## Options

- 'addTrend=' [ true | false ] - Add the estimated linear time trend back to filtered output series if band includes Inf.
- 'detrend=' [ true | false ] - Remove an estimated time trend from the data before filtering.
- 'log=' [ true | false ] - Logarithmise the data before filtering, de-logarithmise afterwards.
- 'method=' [ 'cf' | 'hwfsf' ] - Type of band-pass filter: Christiano-Fitzgerald, or h-windowed frequency-selective filter.
- 'unitRoot=' [ true | false ] - Assume unit root in the input data.

See help on [tseries/trend](#) P340 for other options available when 'detrend=' is set to true.

## Description

Christiano, L.J. and T.J.Fitzgerald (2003). The Band Pass Filter. *International Economic Review*, 44(2), 435–465.

Iacobucci, A. & A. Noullez (2005). A Frequency Selective Filter for Short-Length Time Series. *Computational Economics*, 25, 75–102.

## Example

---

### ■ bsxfunc

Standard BSXFUN implemented for tseries objects

#### Syntax

```
Z = bsxfun(Func,X,Y)
```

#### Input arguments

- Func [ function\_handle ] - Function that will be applied to the input series, FUN(X,Y).
- X [ tseries | numeric ] - Input time series or numeric array.
- Y [ tseries | numeric ] - Input time series or numeric array.

#### Output arguments

- Z [ tseries ] - Result of Func(X,Y) with X and/or Y expanded properly in singleton dimensions.

#### Description

See help on built-in bsxfun for more help.

#### Example

We create a multivariate time series and subtract mean from its individual columns.

```
x = tseries(1:10,rand(10,4));  
xx = bsxfun(@minus,x,mean(x));
```

## ■ bwf

Swap output arguments of the Butterworth filter with tunes

See help on [tseries/bwf](#) P292.

---

## ■ bwf

Butterworth filter with tunes

### Syntax

```
[T,C,CutOff,Lambda] = bwf(X,Order)
[T,C,CutOff,Lambda] = bwf(X,Order,Range,...)
```

### Syntax with output arguments swapped

```
[T,C,CutOff,Lambda] = bwf2(X,Order)
[T,C,CutOff,Lambda] = bwf2(X,Order,Range,...)
```

### Input arguments

- X [ tseries ] - Input tseries object that will be filtered.
- Order [ numeric ] - Order of the Butterworth filter; note that Order=2 reproduces the Hodrick-Prescott filter (hpf) and Order=1 reproduces the local linear filter (llf).
- Range [ numeric ] - Date Range on which the input data will be filtered; Range can be Inf, [startdata, Inf], or [-Inf, enddate]; if not specified, Inf (i.e. the entire available Range of the input series) is used.

### Output arguments

- T [ tseries ] - Lower-frequency (trend) component.
- C [ tseries ] - Higher-frequency (cyclical) component.
- CutOff [ numeric ] - Cut-off periodicity; periodicities above the cut-off are attributed to trends, periodicities below the cut-off are attributed to gaps.

- `Lambda` [ numeric ] - Smoothing parameter actually used; this output argument is useful when the option `'CutOff='` is used instead of `'Lambda='`.

### Options

- `'CutOff='` [ numeric | empty ] - Cut-off periodicity in periods (depending on the time series frequency); this option can be specified instead of `'Lambda='`; the smoothing parameter will be then determined based on the cut-off periodicity.
- `'CutOffYear='` [ numeric | empty ] - Cut-off periodicity in years; this option can be specified instead of `'Lambda='`; the smoothing parameter will be then determined based on the cut-off periodicity.

`'infoSet='` [ 1 | 2 ] - Information set assumption used in the filter: 1 runs a one-sided filter, 2 runs a two-sided filter.

- `'Lambda='` [ numeric |  $(10 \text{ freq})^{\text{Order}}$  ] - Smoothing parameter; needs to be specified for tseries objects with indeterminate frequency.
- `'level='` [ tseries ] - Time series with soft and hard tunes on the level of the trend.
- `'change='` [ tseries ] - Time series with soft and hard tunes on the change in the trend.
- `'log='` [ true | false ] - Logarithmise the data before filtering, de-logarithmise afterwards.

### Description

### Example

---

## ■ chowlin

Chow-Lin distribution of low-frequency observations over higher-frequency periods

### Syntax

```
[Y2,B,RHO,U1,U2] = chowlin(Y1,X2)
[Y2,B,RHO,U1,U2] = chowlin(Y1,X2,range,...)
```

### Input arguments

- Y1 [ tseries ] - Low-frequency input tseries object that will be distributed over higher-frequency observations.
- X2 [ tseries ] - Tseries object with regressors used to distribute the input data.
- range [ numeric ] - Low-frequency date range on which the distribution will be computed.

### Output arguments

- Y2 [ tseries ] - Output data distributed with higher frequency.
- B [ numeric ] - Vector of regression coefficients.
- RHO [ numeric ] - Actually used autocorrelation coefficient in the residuals.
- U1 [ tseries ] - Low-frequency regression residuals.
- U2 [ tseries ] - Higher-frequency regression residuals.

### Options

- 'constant=' [ true | false ] - Include a constant term in the regression.
- 'log=' [ true | false ] - Logarithmise the data before distribution, de-logarithmise afterwards.
- 'ngrid=' [ numeric | 200 ] - Number of grid search points for finding autocorrelation coefficient for higher-frequency residuals.
- 'rho=' [ 'estimate' | 'positive' | 'negative' | numeric ] - How to determine the autocorrelation coefficient for higher-frequency residuals.
- 'timeTrend=' [ true | false ] - Include a time trend in the regression.

### Description

Chow,G.C., and A.Lin (1971). Best Linear Unbiased Interpolation, Distribution and Extrapolation of Time Series by Related Times Series. Review of Economics and Statistics, 53, pp. 372-75.

See also Appendix 2 in Robertson, J.C., and E.W.Tallman (1999). Vector Autoregressions: Forecasting and Reality. FRB Atlanta Economic Review, 1st Quarter 1999, pp.4-17.

### Example

---

## ■ convert

Convert tseries object to a different frequency

### Syntax

```
Y = convert(X,NewFreq)
Y = convert(X,NewFreq,Range,...)
```

### Input arguments

- X [ tseries ] - Input tseries object that will be converted to a new frequency, freq, aggregating or interpolating the data.
- NewFreq [ numeric | char ] - New frequency to which the input data will be converted: 1 or 'A' for annual, 2 or 'H' for half-yearly, 4 or 'Q' for quarterly, 6 or 'B' for bi-monthly, and 12 or 'M' for monthly.
- Range [ numeric ] - Date range on which the input data will be converted.

### Output arguments

- Y [ tseries ] - Output tseries created by converting X to the new frequency.

### Options

- 'ignoreNaN=' [ true | false ] - Exclude NaNs from aggregation.
- 'missing=' [ numeric | NaN | 'last' ] - Replace missing observations with this value.

### Options for high- to low-frequency conversion (aggregation)

- 'method=' [ function\_handle | 'first' | 'last' | @mean ] - Method that will be used to aggregate the high frequency data.
- 'select=' [ numeric | Inf ] - Select only these high-frequency observations within each low-frequency period; Inf means all observations will be used.

### Options for low- to high-frequency conversion (interpolation)

- 'method=' [ char | 'cubic' | 'quadsum' | 'quadavg' ] - Interpolation method; any option available in the built-in interp1 function can be used.
- 'position=' [ 'centre' | 'start' | 'end' ] - Position of the low-frequency date grid.

### Description

The function handle that you pass in through the 'method' option when you aggregate the data (convert higher frequency to lower frequency) should behave like the built-in functions mean, sum etc. In other words, it is expected to accept two input arguments:

- the data to be aggregated,
- the dimension along which the aggregation is calculated.

The function will be called with the second input argument set to 1, as the data are processed en block columnwise. If this call fails, convert will attempt to call the function with just one input argument, the data, but this is not a safe option under some circumstances since dimension mismatch may occur.

### Example

---

## ■ cumsumk

Cumulative sum with a k-period leap

### Syntax

```
Y = cumsumk(X,K,RHO,RANGE)
Y = cumsumk(X,K,RHO)
Y = cumsumk(X,K)
Y = cumsumk(X)
```

### Input arguments

- X [ tseries ] - Input data.

## Time series objects and functions: cumsumk

- `K` [ numeric ] - Number of periods that will be leapt the cumulative sum will be taken; if not specified, `K` is chosen to match the frequency of the input data (e.g. `K = -4` for quarterly data), or `K = -1` for indeterminate frequency.
- `RHO` [ numeric ] - Autoregressive coefficient; if not specified, `RHO = 1`.
- `RANGE` [ numeric ] - Range on which the cumulative sum will be computed and the output series returned.

### Output arguments

- `Y` [ tseries ] - Output data constructed as described below.

### Options

- `'log='` [ true | false ] - Logarithmise the input data before, and de-logarithmise the output data back after, running `x12`.

### Description

If  $K < 0$ , the first  $K$  observations in the output series  $Y$  are copied from  $X$ , and the new observations are given recursively by

$$Y\{t\} = \text{RHO} * Y\{t-K\} + X\{t\}.$$

If  $K > 0$ , the last  $K$  observations in the output series  $Y$  are copied from  $X$ , and the new observations are given recursively by

$$Y\{t\} = \text{RHO} * Y\{t+K\} + X\{t\},$$

going backwards in time.

If  $K == 0$ , the input data are returned.

### Example

Construct random data with seasonal pattern, and run `X12` to seasonally adjust these series.

```
x = tseries(qq(1990,1):qq(2020,4),@randn);  
x1 = cumsumk(x,-4,1);  
x2 = cumsumk(x,-4,0.7);  
x1sa = x12(x1);  
x2sa = x12(x2);
```

The new series `x1` will be a unit-root process while `x2` will be stationary. Note that the command on the second line could be replaced with `x1 = cumsumk(x)`.

---

## ■ DAILY

Calendar view of a daily tseries object

### Syntax

```
daily(X)
```

### Input arguments

- `X [ tseries ]` - Tseries object with indeterminate frequency whose date ticks will be interpreted as Matlab serial date numbers.

### Description

### Example

---

## ■ destdise

Destandardise tseries object by applying specified standard deviation and mean to it

### Syntax

```
X = destdise(X,XMean,XStd)
```

### Input arguments

- X [ tseries ] - Input tseries object.
- XMean [ numeric ] - Mean that will be added the data.
- XStd [ numeric ] - Standard deviation that will be added to the data.

### Output arguments

- X [ tseries ] - Destandardised output data.

### Description

### Example

---

## ■ detrend

Remove a linear time trend

### Syntax

```
X = detrend(X)
X = detrend(X,Range)
```

### Input arguments

- X [ tseries ] - Input time series.
- Range [ numeric | Inf ] - The date range on which the trend will be computed; Inf means the entire range available will be used.

### Output arguments

- x [ tseries ] - Output time series with a trend removed.

## Options

See [tseries/trend](#) P340 for options available.

## Description

## Example

---

## ■ diff

First difference

## Syntax

```
X = diff(X)
X = diff(X,K)
```

## Input arguments

- X [ tseries ] - Input tseries object.
- K [ numeric ] - Number of periods over which the first difference will be computed;  $Y = X - X\{K\}$ . Note that K must be a negative number for the usual backward differencing. If not specified, K will be set to -1.

## Output arguments

- X [ tseries ] - First difference of the input data.

## Description

## Example

---

## ■ double

Return tseries observations as double-precision numeric array

### Syntax

```
y = double(x)
```

### Input arguments

- x [ tseries ] - Tseries object whose observations will be returned as double-precision numeric array.

### Output arguments

- y [ numeric ] - Double-precision numeric array with the input tseries observations in columns.

### Description

### Example

---

## ■ doubledata

Convert tseries observations to double precision

### Syntax

```
x = doubledata(x)
```

### Input arguments

- x [ tseries ] - Tseries object whose observations will be converted to double precision.

### Output arguments

- y [ numeric ] - Tseries object with double-precision observations.

## Description

## Example

---

### ■ empty

Empty tseries object preserving its size in 2nd and higher dimensions

## Syntax

```
x = empty(x)
```

## Input arguments

- x [ tseries ] - Tseries object that will be emptied.

## Output arguments

- x [ tseries ] - Empty tseries object with the 2nd and higher dimensions the same size as the input tseries object, and comments preserved.

## Description

## Example

---

### ■ enddate

Date of the last available observation in a tseries object

## Syntax

```
d = enddate(x)
```

### Input arguments

- x [ tseries ] - Tseries object.

### Output arguments

- d [ numeric ] - IRIS serial date number representing the date of the last observation available in the input tseries.

### Description

The startdate function is equivalent to calling

```
get(x, 'endDate')
```

### Example

---

## ■ errorbar

Line plot with error bars

### Syntax

```
[LL,EE,Range] = errorbar(X,B,...)
[LL,EE,Range] = errorbar(Range,X,B,...)
[LL,EE,Range] = errorbar(AA,Range,X,B,...)
[LL,EE,Range] = errorbar(X,Lo,Hi,...)
[LL,EE,Range] = errorbar(Range,X,Lo,Hi,...)
[LL,EE,Range] = errorbar(AA,Range,X,Lo,Hi,...)
```

### Input arguments

- AA [ numeric ] - Handle to axes in which the graph will be plotted; if not specified, the current axes will be used.

- Range [ numeric ] - Date range; if not specified the entire range of the input tseries object will be plotted.
- X [ tseries ] - Tseries object whose data will be plotted as a line graph.
- B [ tseries ] - Width of the bands that will be plotted around the lines.
- Lo [ tseries ] - Width of the band below the line.
- Hi [ tseries ] - Width of the band above the line.

### Output arguments

- LL [ numeric ] - Handles to lines plotted.
- EE [ numeric ] - Handles to error bars plotted.
- Range [ numeric ] - Actually plotted date range.

### Options

- 'dateformat=' [ char | irisget('plotdateformat') ] - Date format for the tick marks on the x-axis.
- 'datetick=' [ numeric | Inf ] - Vector of dates locating tick marks on the x-axis; Inf means they will be created automatically.
- 'relative=' [ true | false ] - If true, the data for the lower and upper bounds are relative to the centre, i.e. the bounds will be added to the centre (in this case, Lo must be negative numbers and Hi must be positive numbers). If false, the bounds are absolute data (in this case Lo must be lower than X, and Hi must be higher than X).

See help on built-in plot function for other options available.

---

## ■ ews

### Exponential smoothing

#### Syntax

X = expsmooth(X,BETA,...)

### Input arguments

- `x [ tseries ]` - Input time series.
- `Beta [ numeric ]` - Exponential factor.

### Output arguments

- `x [ tseries ]` - Exponentially smoothed series.

### Options

- `'init=' [ numeric | NaN ]` - Add this value before the first observation to initialise the smoothing.
- `'log=' [ true | false ]` - Logarithmise the data before filtering, de-logarithmise afterwards.

### Description

### Examples

---

## ■ `fft`

Discrete Fourier transform of `tseries` object

### Syntax

```
[y,range,freq,per] = fft(x)
[y,range,freq,per] = fft(x,range,...)
```

### Input arguments

- `x [ tseries ]` - Input `tseries` object that will be transformed.
- `range [ numeric | Inf ]` - Date range.

### Output arguments

- `y` [ numeric ] - Fourier transform with data organised in columns.
- `range` [ numeric ] - Actually used date range.
- `freq` [ numeric ] - Frequencies corresponding to FFT vector elements.
- `per` [ numeric ] - Periodicities corresponding to FFT vector elements.

### Options

- `'full='` [ true | false ] - Return Fourier transform on the whole interval  $[0,2\pi]$ ; if false only the interval  $[0,\pi]$  is returned.

### Description

### Example

```
}
```

---

## ■ freq

Frequency of a tseries object

### Syntax

```
f = freq(x)
```

### Input arguments

- `x` [ tseries ] - Tseries object.

### Output arguments

- `f` [ 0 | 1 | 2 | 4 | 6 | 12 ] - Frequency of observations in the input tseries object (`f` is the number of periods within a year).

## Description

The freq function is equivalent to calling

```
get(x, 'freq')
```

## Example

---

### ■ get

Query tseries object property

#### Syntax

```
Value = get(x, Query)  
[Value, Value, ...] = get(x, Query, Query, ...)
```

#### Input arguments

- x [ model ] - Tseries object.
- Query [ char ] - Name of the queried property.

#### Output arguments

- Value [ ... ] - Value of the queried property.

#### Valid queries on tseries objects

- 'end=' Returns [ numeric ] the date of the last observation.
- 'freq=' Returns [ numeric ] the frequency (periodicity) of the time series.
- 'nanEnd=' Returns [ numeric ] the last date at which observations are available in all columns; for scalar tseries, this query always returns the same as 'end'.
- 'nanRange=' Returns [ numeric ] the date range from 'nanstart' to 'nanend'; for scalar time series, this query always returns the same as 'range'.

- 'nanStart=' Returns [ numeric ] the first date at which observations are available in all columns; for scalar tseries, this query always returns the same as 'start'.
- 'range=' Returns [ numeric ] the date range from the first observation to the last observation.
- 'start=' Returns [ numeric ] the date of the first observation.

## Description

---

### ■ hpdi

Highest probability density interval

#### Syntax

```
int = hpdi(x,prob)
```

#### Input arguments

- x [ tseries ] - Input data with random draws in each period.
- prob [ numeric ] - Percent coverage of the computed interval, between 0 and 100.

#### Output arguments

- int [ tseries ] - Output tseries object with two columns, i.e. lower bounds and upper bounds for each period.

## Description

### Example

---

### ■ hpf

Hodrick-Prescott filter with tunes (aka LRX filter)

## Syntax

```
[T,C,CutOff,Lambda] = hpf(X)
[T,C,CutOff,Lambda] = hpf(X,Range,...)
```

## Syntax with output arguments swapped

```
[C,T,CutOff,Lambda] = hpf2(X)
[C,T,CutOff,Lambda] = hpf2(X,Range,...)
```

## Input arguments

- X [ tseries ] - Input tseries object that will be filtered.
- Range [ numeric ] - Date Range on which the input data will be filtered; Range can be Inf, [startdata,Inf], or [-Inf,enddate]; if not specified, Inf (i.e. the entire available Range of the input series) is used.

## Output arguments

- T [ tseries ] - Low-frequency (trend) component.
- C [ tseries ] - High-frequency (cyclical or gap) component.
- CutOff [ numeric ] - Cut-off periodicity; periodicities above the cut-off are attributed to trends, periodicities below the cut-off are attributed to gaps.
- Lambda [ numeric ] - Smoothing parameter actually used; this output argument is useful when the option 'cutoff=' is used instead of 'lambda='.

## Options

- 'cutoff=' [ numeric | empty ] - Cut-off periodicity in periods (depending on the time series frequency); this option can be specified instead of 'lambda='; the smoothing parameter will be then determined based on the cut-off periodicity.
- 'cutoffYear=' [ numeric | empty ] - Cut-off periodicity in years; this option can be specified instead of 'lambda='; the smoothing parameter will be then determined based on the cut-off periodicity.

- 'gamma=' [ numeric | tseries | 1 ] - Weight or weights on the deviations of the trend from observations; it only makes sense to use this option to make the signal-to-noise ratio time-varying; see the optimisation problem below.

'infoSet=' [ 1 | 2 ] - Information set assumption used in the filter: 1 runs a one-sided filter, 2 runs a two-sided filter.

- 'lambda=' [ numeric | 100 freq^2 ] - Smoothing parameter; needs to be specified for tseries objects with indeterminate frequency.
- 'level=' [ tseries ] - Time series with hard tunes and soft tunes on the level of the trend.
- 'change=' [ tseries ] - Time series with hard tunes and soft tunes on the change in the trend.
- 'log=' [ true | false ] - Logarithmise the data before filtering, de-logarithmise afterwards.

## Description

—*The underlying optimisation problem*

The function hpf solves a constrained optimisation problem described by the following Lagrangian

$$\begin{aligned} \min_{\bar{y}_t, \omega_t, \sigma_t} & \underbrace{\sum \lambda (\Delta \bar{y}_t - \Delta \bar{y}_{t-1})^2 + \sum \gamma_t (\bar{y}_t - y_t)^2}_{\text{Plain HP with time-varying signal-to-noise ratio}} + \dots \\ & \dots + \underbrace{\sum u_t (\bar{y}_t - a_t)^2}_{\text{Soft level tunes}} + \underbrace{\sum v_t (\Delta \bar{y}_t - b_t)^2}_{\text{Soft growth tunes}} + \underbrace{\sum \omega_t (\bar{y}_t - c_t)}_{\text{Hard level tunes}} + \underbrace{\sum \sigma_t (\Delta \bar{y}_t - d_t)}_{\text{Hard growth tunes}}, \end{aligned}$$

where

- $\Delta$  is the first-difference operator;
- $\lambda$  is a (scalar) smoothing parameter;
- $y_t$  are user-supplied observations;
- $\bar{y}_t$  is the fitted trend;
- $\gamma_t$  are user-supplied weights to modify the basic signal-to-noise ratio over time (the default setting is  $\gamma_t = 1$ ), entered in the option 'gamma=';
- $a_t$  and  $u_t$  are soft tunes on the level of the trend and the weights associated with these soft level tunes, respectively, entered together as complex numbers in the option 'level=';

- $b_t$  and  $v_t$  are soft tunes on the change in the level of the trend and the weights associated with these soft growth tunes, respectively, entered together as complex numbers in the option 'growth=';
- $c_t$  are hard tunes on the level of the trend, entered as real numbers in the option 'level=';
- $d_t$  are hard tunes on the change in the level of the trend, entered as real numbers in the option 'growth=';
- $\omega_t$  are lagRange multipliers on the hard level tunes (note that these are computed as part of the optimisation problem, not entered by the user);
- $\sigma_t$  are lagRange multipliers on the hard growth tunes (note that these are computed as part of the optimisation problem, not entered by the user).

Each of the summations in the above Lagrangian goes over those periods in which the respective bracketed terms are defined (observations or tunes exist). You can combine any number of any tunes in one run of hpf, including out-of-sample tunes (see below).

—*How to enter the tunes*

- The hard tunes and soft tunes on the level of the trend are entered as time series through the option 'level='.
- The hard tunes and soft tunes on the change in the trend are entered as time series through the option 'change='.
- In the tseries objects entered through 'level=' and/or 'change=', you can combine any number of hard and soft tune. In each particular period, you can obviously specify only a hard tune or only a soft tune. You can think of hard tunes as a special case of soft tunes with infinitely large weights.
- A hard tune is specified as a plain real number (i.e. a number with a zero complex part).
- A soft tune must be entered as a complex number whose real part specifies the tune itself, and the imaginary part specifies the inverse of the weight, i.e.  $1/v_t$  or  $1/u_t$ , on that tune in that period. Note that if the weight goes to infinity, the imaginary part becomes zero and the tune becomes a hard tune.

—*Out-of-sample tunes*

Tunes can be imposed also at dates before the first observation of the input series, or after the last observation. In other words, the time series in 'level=' and/or 'growth=' can have a more extended Range (at either side) than the filtered input series.

—*Default smoothing parameters*

If the user does not specify the smoothing parameter using the 'lambda=' option, a default value is used. The default value is based on common practice and can be calculated using the date frequency of the input time series as  $\lambda = 100 \cdot f^2$ , where  $f$  is the frequency (yearly=1, half-yearly=2, quarterly=4, bi-monthly=6, monthly=12). This gives the following default values:

- 100 for yearly time series (cut-off periodicity of 19.79 years);
- 400 for half-yearly time series (cut-off periodicity of 14.02 years);
- 1,600 for quarterly time series (cut-off periodicity of 9.92 years);
- 3,600 for bi-monthly time series (cut-off periodicity of 8.11 years);
- 14,400 for monthly time series (cut-off periodicity of 5.73 years).

Note that there is no default value for data with indeterminate or daily frequency: for these types of time series, you must always use the option "lambda=".

**Example**

---

■ **hpf2**

Swap output arguments of the Hodrick-Prescott filter with tunes

See help on [tseries/hpf](#) P308.

---

■ **interp**

Interpolate missing observations

**Syntax**

`X = interp(X,RANGE,...)`

### Input arguments

- `X [ tseries ]` - Input time series.
- `RANGE [ tseries ]` - Date range on which any missing, i.e. NaN, observations will be interpolated.

### Output arguments

- `x [ tseries ]` - Tseries object with the missing observations interpolated.

### Options

- `'method=' [ char | 'cubic' ]` - Any valid method accepted by the built-in `interp1` function.

### Description

### Example

---

## ■ length

Length of tseries object

### Syntax

```
n = length(x)
```

### Input arguments

- `x [ tseries ]` Tseries object.

### Output arguments

- `n [ numeric ]` - Number of periods from the first to the last available observation in the input tseries object.

## Description

## Example

---

### ■ l1f

Local level filter (aka random walk plus white noise) with tunes

## Syntax

```
[T,C,CutOff,Lambda] = l1f(X)
[T,C,CutOff,Lambda] = l1f(X,Range,...)
```

## Syntax with output arguments swapped

```
[C,T,CutOff,Lambda] = l1f2(X)
[C,T,CutOff,Lambda] = l1f2(X,Range,...)
```

## Input arguments

- X [ tseries ] - Input tseries object that will be filtered.
- Range [ numeric ] - Date range on which the input data will be filtered; Range can be Inf, [startdata,Inf], or [-Inf,enddate]; if not specified, Inf (i.e. the entire available range of the input series) is used.

## Output arguments

- T [ tseries ] - Low-frequency (trend) component.
- C [ tseries ] - High-frequency (cyclical or gap) component.
- CutOff [ numeric ] - Cut-off periodicity; periodicities above the cut-off are attributed to trends, periodicities below the cut-off are attributed to gaps.
- Lambda [ numeric ] - Smoothing parameter actually used; this output argument is useful when the option 'cutoff=' is used instead of 'lambda='.

## Options

- 'cutoff=' [ numeric | empty ] - Cut-off periodicity in periods (depending on the time series frequency); this option can be specified instead of 'lambda='; the smoothing parameter will be then determined based on the cut-off periodicity.
- 'cutoffYear=' [ numeric | empty ] - Cut-off periodicity in years; this option can be specified instead of 'lambda='; the smoothing parameter will be then determined based on the cut-off periodicity.
- 'gamma=' [ numeric | tseries | 1 ] - Weight or weights on the deviations of the trend from observations; it only makes sense to use this option to make the signal-to-noise ratio time-varying; see the optimisation problem below.
- 'drift=' [ numeric | tseries | 0 ] - Deterministic drift in the trend.

'infoSet=' [ 1 | 2 ] - Information set assumption used in the filter: 1 runs a one-sided filter, 2 runs a two-sided filter.

- 'lambda=' [ numeric | 10 freq ] - Smoothing parameter; needs to be specified for tseries objects with indeterminate frequency.
- 'level=' [ tseries ] - Time series with soft and hard tunes on the level of the trend.
- 'change=' [ tseries ] - Time series with soft and hard tunes on the change in the trend.
- 'log=' [ true | false ] - Logarithmise the data before filtering, de-logarithmise afterwards.

## Description

—*The underlying optimisation problem*

The function l1f solves a constrained optimisation problem described by the following Lagrangian

$$\begin{aligned} \min_{\bar{y}_t, \omega_t, \sigma_t} & \underbrace{\sum \lambda (\Delta \bar{y}_t - \delta_t)^2 + \sum \gamma_t (\bar{y}_t - y_t)^2}_{\text{Plain local level filter with time-varying signal-to-noise ratio}} + \dots \\ & \dots + \underbrace{\sum u_t (\bar{y}_t - a_t)^2}_{\text{Soft level tunes}} + \underbrace{\sum v_t (\Delta \bar{y}_t - b_t)^2}_{\text{Soft growth tunes}} + \underbrace{\sum \omega_t (\bar{y}_t - c_t)}_{\text{Hard level tunes}} + \underbrace{\sum \sigma_t (\Delta \bar{y}_t - d_t)}_{\text{Hard growth tunes}}, \end{aligned}$$

where

- $\Delta$  is the first-difference operator;

- $\lambda$  is a (scalar) smoothing parameter;
- $y_t$  are user-supplied observations;
- $\bar{y}_t$  is the fitted trend;
- $\delta_t$  is a user-supplied drift, either constant or time-varying, entered in the option 'drift=';
- $\gamma_t$  are user-supplied weights to modify the basic signal-to-noise ratio over time (the default setting is  $\gamma_t = 1$ ), entered in the option 'gamma=';
- $a_t$  and  $u_t$  are soft tunes on the level of the trend and the weights associated with these soft level tunes, respectively, entered together as complex numbers in the option 'level=';
- $b_t$  and  $v_t$  are soft tunes on the change in the level of the trend and the weights associated with these soft growth tunes, respectively, entered together as complex numbers in the option 'growth=';
- $c_t$  are hard tunes on the level of the trend, entered as real numbers in the option 'level=';
- $d_t$  are hard tunes on the change in the level of the trend, entered as real numbers in the option 'growth=';
- $\omega_t$  are lagrange multipliers on the hard level tunes (note that these are computed as part of the optimisation problem, not entered by the user);
- $\sigma_t$  are lagrange multipliers on the hard growth tunes (note that these are computed as part of the optimisation problem, not entered by the user).

Each of the summations in the above Lagrangian goes over those periods in which the respective bracketed terms are defined (observations or tunes exist). You can combine any number of any tunes in one run of llf, including out-of-sample tunes (see below).

—*How to enter the tunes*

- The soft and hard tunes on the level of the trend are entered as time series through the option 'level='.
- The soft and hard tunes on the change in the trend are entered as time series through the option 'change='.
- In the tseries objects entered through 'level=' and/or 'change=', you can combine any number of hard and soft tune. In each particular period, you can obviously specify only a hard tune or only a soft tune. You can think of hard tunes as a special case of soft tunes with infinitely large weights.
- A hard tune is specified as a plain real number (i.e. a number with a zero complex part).

- A soft tune must be entered as a complex number whose real part specifies the tune itself, and the imaginary part specifies the inverse of the weight, i.e.  $1/v_t$  or  $1/u_t$ , on that tune in that period. Note that if the weight goes to infinity, the imaginary part becomes zero and the tune becomes a hard tune.

—*Out-of-sample tunes*

Tunes can be imposed also at dates before the first observation of the input series, or after the last observation. In other words, the time series in 'level=' and/or 'growth=' can have a more extended range (at either side) than the filtered input series.

—*Default smoothing parameters*

If the user does not specify the smoothing parameter using the 'lambda=' option, a default value is used. The default value is based on common practice and can be calculated using the date frequency of the input time series as  $\lambda = 10 \cdot f$ , where  $f$  is the frequency (yearly=1, half-yearly=2, quarterly=4, bi-monthly=6, monthly=12). This gives the following default values:

- 10 for yearly time series (cut-off periodicity of 19.79 years);
- 20 for half-yearly time series (cut-off periodicity of 14.02 years);
- 40 for quarterly time series (cut-off periodicity of 9.92 years);
- 60 for bi-monthly time series (cut-off periodicity of 8.11 years);
- 120 for monthly time series (cut-off periodicity of 5.73 years).

Note that there is no default value for data with indeterminate or daily frequency: for these types of time series, you must always use the option "lambda=".

**Example**

---

■ **llf2**

Swap output arguments of the local linear trend filter with tunes

See help on [tseries/llf](#) P314.

---

## ■ moving

Apply function to moving window of observations

### Syntax

```
X = moving(X)
X = moving(X,Range,...)
```

### Input arguments

- X [ tseries ] - Tseries object on whose observations the function will be applied.
- Range [ numeric | Inf ] - Range on which the moving function will be applied; Inf means the entire range on which the time series is defined.

### Output arguments

- X [ tseries ] - Output time series.

### Options

- 'function=' [ function\_handle | @mean ] - Function to be applied to a moving window of observations.
- 'window=' [ numeric | Inf ] - The window of observations where 0 means the current date, -1 means one period lag, etc. Inf means that the last n observations (including the current one) are used, where n is the frequency of the input data.

### Description

### Example

---

## ■ ndims

Number of dimensions in tseries object data

### Syntax

```
N = ndims(X)
```

### Input arguments

- X [ tseries ] - Input tseries object.

### Output arguments

- N [ numeric ] - Number of dimensions in the input object.

### Description

### Example

---

## ■ normalise

Normalise (or rebase) data to particular date

### Syntax

```
x = normalise(x)  
x = normalise(x, normdate, ...)
```

### Input arguments

- x [ tseries ] - Input tseries object that will be normalised.
- normdate [ numeric | 'start' | 'end' | 'nanstart' | 'nanend' ] - Date relative to which the input data will be normalised; if not specified, 'nanstart' (the first date for which all columns have an observation) will be used.

### Output arguments

- x [ tseries ] - Normalised tseries object.

### Options

- 'mode=' [ 'add' | 'mult' ] - Additive or multiplicative normalisation. Description =====

### Example

---

## ■ pct

Percent rate of change

### Syntax

```
X = pct(X)
X = pct(X,K,...)
```

### Input arguments

- X [ tseries ] - Input tseries object.
- K [ numeric ] - Time shift over which the rate of change will be computed, i.e. between time t and t+k; if not specified K will be set to -1.

### Output arguments

- X [ tseries ] - Percentage rate of change in the input data.

### Options

- 'outputFreq=' [ 1 | 2 | 4 | 6 | 12 | Inf ] - Convert the rate of change to the requested date frequency; Inf means plain rate of change with no conversion.

### Description

### Example

In this example, x is a monthly time series. The following command computes the annualised rate of change between month t and t-1:

```
pct(x,-1,'outputfreq=',1)
```

while the following line computes the annualised rate of change between month t and t-3:

```
pct(x,-3,'outputFreq=',1)
```

---

## ■ permute

Permute dimensions of a tseries object

### Syntax

```
X = permute(X,Order)
```

### Input arguments

- X [ tseries ] - Tseries object whose dimensions, except the first (time) dimension, will be rearranged in the order specified by the vector order.
- Order [ numeric ] - New order of dimensions; because the time dimension cannot be permuted, order(1) must be always 1.

### Output arguments

- X [ tseries ] - Output tseries object with its dimensions permuted.

### Description

### Example

---

## ■ plot

Line graph for tseries objects

## Syntax

```
[h,range] = plot(x,...)
[h,range] = plot(range,x,...)
[h,range] = plot(a,range,x,...)
```

## Input arguments

- a [ numeric ] - Handle to axes in which the graph will be plotted; if not specified, the current axes will be used.
- range [ numeric ] - Date range; if not specified the entire range of the input tseries object will be plotted.
- x [ tseries ] - Input tseries object whose columns will be plotted as a line graph.

## Output arguments

- h [ numeric ] - Handles to the lines plotted.
- range [ numeric ] - Actually plotted date range.

## Options

- 'dateFormat=' [ char | irisget('plotdateformat') ] - Date format for the tick marks on the x-axis.
- 'datePosition=' [ 'centre' | 'end' | 'start' ] - Position of each date point within a given period span.
- 'datetick=' [ numeric | Inf ] - Vector of dates locating tick marks on the x-axis; Inf means they will be created automatically.
- 'tight=' [ true | false ] - Make the y-axis tight.

See help on built-in plot function for other options available.

## Description

## Example

## ■ plotcmp

Comparison graph for two time series

### Syntax

```
[Ax,Lhs,Rhs] = plotcmp(X,...)
[Ax,Lhs,Rhs] = plotcmp(Range,X,...)
```

### Input arguments

- Range [ numeric ] - Date range; if not specified the entire range of the input tseries object will be plotted.
- X [ tseries ] - Tseries object with two or more columns; the difference (between the second and the first column (or any other linear combination of its columns specified through the option 'compare=') will be displayed as an RHS area or bar graph.

### Output arguments

- Ax [ numeric ] - Handles to the LHS and RHS axes.
- Lhs [ numeric ] - Handles to the two original lines.
- Rhs [ numeric ] - Handles to the area or bar difference graph.

### Options

- 'compare=' [ numeric | [-1;1] ] - Linear combination of the observations that will be plotted in the RHS graph; [-1;1] means a difference between the second series and the first series,  $X\{:,2\}-X\{:,1\}$ .
- 'cmpColor=' [ numeric | [1,0.75,0.75] ] - Color that will be used to plot the area or bar difference (comparison) graph.
- 'cmpPlotFunc=' [ @area | @bar ] - Function that will be used to plot the difference (comparison) data on the RHS.

See help on [tseries/plotyy](#) P325 for other options available.

## Description

## Example

---

## ■ plotpred

Plot Kalman filter predictions

### Syntax

```
[H1,H2,H3] = plotpred(X,Y,...)
[H1,H2,H3] = plotpred(Ax,X,Y,...)
[H1,H2,H3] = plotpred(Ax,Range,X,Y,...)
```

### Input arguments

- X [ tseries ] - Input data with time series observations.
- Y [ tseries ] - Input data with predictions calculated in a Kalman filter run with an 'ahead=' option.
- Ax [ numeric ] - Handle to axes object in which the data will be plotted.
- Range [ numeric | Inf ] - Date range on which the input data will be plotted.

### Output arguments

- H1 [ numeric ] - Handles to a line object showing the time series observations (the first column, X, in the input data).
- H2 [ numeric ] - Handles to line objects showing the Kalman filter predictions (the second and further columns, Y, in the input data).
- H3 [ numeric ] - Handles to one-point line objects displaying a marker at the start of each line.

### Options

- 'connect=' [ true | false ] - Connect the prediction lines, Y, with the corresponding observation in X.

- 'firstMarker=' [ 'none' | char ] - Type of marker displayed at the start of each prediction line.
- 'showNaNLines=' [ true | false ] - Show or remove lines with whose starting points are NaN (missing observations).

See help on [plot](#) P321 and on the built-in function plot for options available.

## Description

## Example

---

## ■ plotyy

Line plot function with LHS and RHS axes for time series

### Syntax

```
[Ax,Lhs,Rhs,Range] = plotyy(X,Y,...)
[Ax,Lhs,Rhs,Range] = plotyy(Range,X,Y,...)
```

### Input arguments

- Range [ numeric ] - Date range; if not specified the entire range of the input tseries object will be plotted.
- X [ tseries ] - Input tseries object whose columns will be plotted and labelled on the LHS.
- Y [ tseries ] - Input tseries object whose columns will be plotted and labelled on the RHS.

### Output arguments

- Ax [ numeric ] - Handles to the LHS and RHS axes.
- Lhs [ numeric ] - Handles to series plotted on the LHS axis.
- Rhs [ numeric ] - Handles to series plotted on the RHS axis.
- Range [ numeric ] - Actually plotted date range.

## Options

- 'conincident=' [ true | false ] - Make the LHS and RHS y-axis grids coincident.
- 'dateFormat=' [ char | irisget('plotdateformat') ] - Date format for the tick marks on the x-axis.
- 'dateTick=' [ numeric | Inf ] - Vector of dates locating tick marks on the x-axis; Inf means they will be created automatically.
- 'freqLetters=' [ char | 'YHQB<sup>M</sup>' ] - Five letters to represent the five date frequencies (yearly, half-yearly, quarterly, bi-monthly, and monthly).
- 'lhsPlotFunc=' [ @area | @bar | @plot | @stem ] - Function that will be used to plot the LHS data.
- 'lhsTight=' [ true | false ] - Make the LHS y-axis tight.
- 'rhsPlotFunc=' [ @area | @bar | @plot | @stem ] - Function that will be used to plot the RHS data.
- 'rhsTight=' [ true | false ] - Make the RHS y-axis tight.

## Description

## Example

---

## ■ redat

Change time dimension of a tseries object

## Syntax

```
X = redat(X,oldDate,newDate)
```

## Input arguments

- X [ tseries ] - Input tseries object.
- OldDate [ numeric ] - Base date that will be converted to a new date.
- NewDate [ numeric ] - A new date to which the base date oldDate will be changed; NewDate need not be the same frequency as OldDate.

### Output arguments

- `X [ tseries ]` - Output `tseries` object with identical data as the input `tseries` object, but with its time dimension changed.

### Description

### Example

---

## ■ regress

Ordinary or weighted least-square regression

### Syntax

```
[B,BStd,E,EStd,YFit,Range,BCov] = regress(Y,X)
[B,BStd,E,EStd,YFit,Range,BCov] = regress(Y,X,Range,...)
```

### Input arguments

- `Y [ tseries ]` - `Tseries` object with independent (LHS) variables.
- `X [ tseries ]` - `Tseries` object with regressors (RHS) variables.
- `Range [ numeric ]` - Date range on which the regression will be run; if not specified, the entire range available will be used.

### Output arguments

- `B [ numeric ]` - Vector of estimated regression coefficients.
- `BStd [ numeric ]` - Vector of std errors of the estimates.
- `E [ tseries ]` - `Tseries` object with the regression residuals.
- `EStd [ numeric ]` - Estimate of the std deviation of the regression residuals.
- `YFit [ tseries ]` - `Tseries` object with fitted LHS variables.
- `Range [ numeric ]` - The actually used date range.
- `bBCov [ numeric ]` - Covariance matrix of the coefficient estimates.

### Options

- 'constant=' [ true | false ] - Include a constant vector in the regression; if true the constant will be placed last in the matrix of regressors.
- 'weighting=' [ tseries | empty ] - Tseries object with weights on the observations in the individual periods.

### Description

This function calls the built-in lscov function.

### Example

---

## ■ reshape

Reshape size of time series in 2nd and higher dimensions

### Syntax

```
x = reshape(x,newsiz)
```

### Input arguments

- x [ tseries ] - Tseries object whose data will be reshaped in 2nd and/or higher dimensions.
- newsiz [ numeric ] - New size of the tseries object data; the first dimension (time) must be preserved.

### Output arguments

- x [ tseries ] - Reshaped tseries object.

### Description

### Example

```
}
```

---

## ■ resize

Clip tseries object down to a specified date range

### Syntax

```
X = resize(X,Range)
```

### Input arguments

- X [ tseries ] - Input tseries object whose date range will be clipped down.
- Range [ numeric ] - New date range to which the input tseries object will be resized; the range can be specified as a [startDate,endDate] vector where -Inf and Inf can be used for the dates.

### Output arguments

- X [ tseries ] - Output tseries object with its date range clipped down to Range.

### Description

### Example

---

## ■ rmse

Compute RMSE for given observations and predictions

## Syntax

```
[Rmse,Pe] = rmse(Obs,Pred)
[Rmse,Pe] = rmse(Obs,Pred,Range,...)
```

## Input arguments

- Obs [ tseries ] - Input data with observations.
- Pred [ tseries ] - Input data with predictions (a different prediction horizon in each column); Pred is typically the outcome of the Kalman filter, [model/filter](#) [P93] or [VAR/filter](#) [P207], called with the option 'ahead='.
- Range [ numeric | Inf ] - Date range on which the RMSEs will be evaluated; Inf means the entire possible range available.

## Output arguments

- Rmse [ numeric ] - Numeric array with RMSEs for each column of Pred.
- Pe [ tseries ] - Prediction errors, i.e. the difference Obs - Pred evaluated within Range.

## Description

## Example

---

## ■ round

Round tseries data to specified number of decimals

## Syntax

```
X = round(X)
X = round(X,Dec)
```

### Input arguments

- X [ tseries ] - Tseries object whose data will be rounded.
- Dec [ numeric ] - Number of decimals to which the tseries data will be rounded; if not specified, the data are rounded to nearest integer.

### Output arguments

- X [ tseries ] - Rounded tseries object.

### Description

The number of decimals, to which the tseries data will be rounded, can be positive, zero, or negative.

### Example

---

## ■ scatter

Scatter graph for tseries objects

### Syntax

```
[H,Range] = scatter([X,Y],...)  
[H,Range] = scatter(Range,[X,Y],...)  
[H,Range] = scatter(Ax,Range,[X,Y],...)
```

### Input arguments

- ax [ numeric ] - Handle to axes in which the graph will be plotted; if not specified, the current axes will be used.
- Range [ numeric ] - Date range; if not specified the entire range of the input tseries object will be plotted.
- X, Y [ tseries ] - Two scalar tseries objects plotted on the x-axis and the y-axis, respectively.

### Output arguments

- `H` [ numeric ] - Handles to the lines plotted.
- `Range` [ numeric ] - Actually plotted date range.

### Options

- `'dateformat='` [ char | `irisget('plotdateformat')` ] - Date format for the tick marks on the x-axis.
- `'datetick='` [ numeric | `Inf` ] - Vector of dates locating tick marks on the x-axis; `Inf` means they will be created automatically.

See help on built-in plot function for other options available.

### Description

### Example

---

## ■ single

Return tseries observations as single-precision numeric array

### Syntax

```
y = single(x)
```

### Input arguments

- `x` [ tseries ] - Tseries object whose observations will be returned as single-precision numeric array.

### Output arguments

- `y` [ numeric ] - Single-precision numeric array with the input tseries observations in columns.

## Description

## Example

---

### ■ singledata

Convert tseries observations to single precision

## Syntax

```
x = singledata(x)
```

## Input arguments

- x [ tseries ] - Tseries object whose observations will be converted to single precision.

## Output arguments

- y [ numeric ] - Tseries object with single-precision observations.

## Description

## Example

---

### ■ size

Size of tseries object data

## Syntax

```
S = size(X)  
[S1,S2,...,Sn] = size(X)
```

### Input arguments

- `X [ tseries ]` - Tseries object whose size will be returned.

### Output arguments

- `S [ numeric ]` - Vector of sizes of the tseries object data in each dimension, `S = [S1, S2, . . . , Sn]`.
- `S1, S2, . . . , Sn [ numeric ]` - Sizes of the tseries object data in each dimension.

### Description

### Example

---

## ■ sort

Sort tseries columns by specified criterion

### Syntax

```
[Y,INDEX] = sort(X,CRIT)
```

### Input arguments

- `X [ tseries ]` - Input tseries object whose columns will be sorted in order determined by the criterion `crit`.
- `CRIT [ 'sumsq' | 'sumabs' | 'max' | 'maxabs' | 'min' | 'minabs' ]` - Criterion used to sort the input tseries object columns.

### Output arguments

- `Y [ tseries ]` - Output tseries object with columns sorted in order determined by the input criterion, `CRIT`.
- `INDEX [ numeric ]` - Vector of indices, `y = x{: , index}`.

## Description

## Example

---

### ■ spy

Visualise tseries observations that pass a test

## Syntax

```
[AA,LL] = spy(X,...)
[AA,LL] = spy(RANGE,X,...)
```

## Input arguments

- X [ tseries ] - Input tseries object whose non-NaN observations will be plotted as markers.
- RANGE [ tseries ] - Date range on which the tseries observations will be visualised; if not specified the entire available range will be used.

## Output arguments

- AA [ tseries ] - Handle to the axes created.
- LL [ tseries ] - Handle to the marks plotted.

## Options

- 'dateformat=' [ char | irisget('plotdateformat') ] - Date format for the tick marks on the x-axis.
- 'datetick=' [ numeric | Inf ] - Vector of dates locating tick marks on the x-axis; Inf means they will be created automatically.
- 'names=' [ cellstr ] - Names that will be used to annotate individual columns of the input tseries object.
- 'test=' [ function\_handle | @(x)~isnan(x) ] - Test applied to each observations; only the values returning a true will be displayed.

## Description

## Example

---

### ■ startdate

Date of the first available observation in a tseries object

## Syntax

```
d = startdate(x)
```

## Input arguments

- x [ tseries ] - Tseries object.

## Output arguments

- d [ numeric ] - IRIS serial date number representing the date of the first observation available in the input tseries.

## Description

The startdate function is equivalent to calling

```
get(x, 'startDate')
```

## Example

---

### ■ stdise

Standardise tseries data by subtracting mean and dividing by std deviation

### Syntax

```
[X,M,S] = stdise(X)
[X,M,S] = stdise(X,Flag)
```

### Input arguments

- X [ tseries ] - Input tseries object whose data will be normalised.
- Flag [ 0 | 1 ] - flag==0 normalises by N-1, flag==1 normalises by N, where N is the sample length.

### Output arguments

- X [ tseries ] - Output tseries object with standardised data.
- XMeam [ numeric ] - Estimated mean subtracted from the input tseries observations.
- XStd [ numeric ] - Estimated std deviation by which the input tseries observations have been divided.

### Description

### Example

---

## ■ stem

Plot tseries as discrete sequence data

### Syntax

```
[h,range] = stem(x,...)
[h,range] = stem(range,x,...)
[h,range] = stem(a,range,x,...)
```

### Input arguments

- a [ numeric ] - Handle to axes in which the graph will be plotted; if not specified, the current axes will be used.
- range [ numeric ] - Date range; if not specified the entire range of the input tseries object will be plotted.
- x [ tseries ] - Input tseries object whose columns will be plotted as a stem graph.

### Output arguments

- h [ numeric ] - Vector of handles to the stems plotted.
- range [ numeric ] - Actually plotted date range.

### Options

- 'dateformat=' [ char | irisget('plotdateformat') ] - Date format for the tick marks on the x-axis.
- 'datetick=' [ numeric | Inf ] - Vector of dates locating tick marks on the x-axis; Inf means they will be created automatically.
- 'tight=' [ true | false ] - Make the y-axis tight.

See help on built-in stem function for other options available.

### Description

### Example

---

## ■ subsasgn

Subscripted assignment for tseries objects

### Syntax

```
x(dates) = values;  
x(dates,i,j,k,...) = values;
```

### Input arguments

- `x [ tseries ]` - Tseries object that will be assigned new observations.
- `dates [ numeric ]` - Dates for which the new observations will be assigned.
- `i, j, k, ... [ numeric ]` - References to 2nd and higher dimensions of the tseries object.
- `values [ numeric ]` - New observations that will assigned at specified dates.

### Output arguments

- `x [ tseries ]` - Tseries object with newly assigned observations.

### Description

### Example

---

## ■ subsref

Subscripted reference function for tseries objects

### Syntax returning numeric array

```
... = X(Dates)
... = X(Dates, ...)
```

### Syntax returning tseries object

```
... = X{Dates}
... = X{Dates, ...}
```

### Input arguments

- `X [ tseries ]` - Tseries object.
- `Dates [ numeric ]` - Dates for which the time series observations will be returned, either as a numeric array or as another tseries object.

## Description

## Example

---

## ■ trend

Estimate a time trend

## Syntax

```
X = trend(X,range)
```

## Input arguments

- X [ tseries ] - Input time series.
- Range [ tseries ] - Range for which the trend will be computed.

## Output arguments

- X [ tseries ] - Output trend time series.

## Options

- 'break=' [ numeric | empty ] - Vector of breaking points at which the trend may change its slope.
- 'connect=' [ true | false ] - Calculate the trend by connecting the first and the last observations.
- 'diff=' [ true | false ] - Estimate the trend on differenced data.
- 'log=' [ true | false ] - Logarithmise the input data, de-logarithmise the output data.
- 'season=' [ true | false | 2 | 4 | 6 | 12 ] - Include deterministic seasonal factors in the trend.

## Description

## Example

---

## ■ tseries

Create new time series (tseries) object

### Syntax

```
X = tseries()  
X = tseries(DATES, VALUES)  
X = tseries(DATES, VALUES, COMMENTS)
```

### Input arguments

- DATES [ numeric ] - Dates for which observations will be supplied; dates do not have to be sorted in ascending order. If dates is scalar and values have multiple rows, then the date in dates is interpreted as a startdate for the time series.
- VALUES [ numeric | function\_handle ] - Numerical values (observations) arranged columnwise, or a function that will be used to create an N-by-1 array of values, where N is the number of dates.
- COMMENTS [ char | cellstr ] - Comment or comments attached to each column of observations.

### Output arguments

- X [ tseries ] - New tseries object.

## Description

## Example

---

## ■ windex

Simple weighted or Divisia index

### Syntax

```
Y = windex(X,W,Range)
```

### Input arguments

- X [ tseries ] - Input times series.
- W [ tseries | numeric ] - Fixed or time-varying weights on the input time series.
- Range [ numeric ] - Range on which the Divisia index is computed.

### Output arguments

- Y [ tseries ] - Weighted index based on X.

### Options

- 'method=' [ 'divisia' | 'simple' ] - Weighting method.
- 'log=' [ true | false ] - Logarithmise the input data before computing the index, delogarithmise the output data.

### Description

### Example

---

## ■ wmean

Weighted average of time series observations

### Syntax

```
Y = wmean(X,RANGE,BETA)
```

### Input arguments

- X [ tseries ] - Input tseries object whose data will be averaged column by column.
- RANGE [ numeric ] - Date range on which the weighted average will be computed.
- BETA [ numeric ] - Discount factor; the last observation gets a weight of 1, the N-minus-1st observation gets a weight of BETA, the N-minus-2nd gets a weight of BETA<sup>2</sup>, and so on.

### Output arguments

- Y [ numeric ] - Array with weighted average of individual columns; the sizes of Y are identical to those of the input tseries object in 2nd and higher dimensions.

### Description

### Example

---

## ■ x12

Access to X12 seasonal adjustment program

### Syntax with a single type of output requested

```
[Y,OutpFile,ErrFile,Model,X] = x12(X)
[Y,OutpFile,ErrFile,Model,X] = x12(X,Range,...)
```

### Syntax with mutliple types of output requested

```
[Y1,Y2,...,OutpFile,ErrFile,Model,X] = x12(X,Range,...)
```

See the option 'output=' for the types of output data available from X12.

### Input arguments

- X [ tseries ] - Input data that will seasonally adjusted or filtered by the Census X12 Arima.

- Range [ numeric ] - Date range on which the X12 will be run; if not specified or Inf the entire available range will be used.

### Output arguments

- Y, Y1, Y2, ... [ tseries ] - Requested output data, by default only one type of output is returned, the seasonally adjusted data; see the option 'output='.
- OutpFile [ cellstr ] - Contents of the output log files produced by X12; each cell contains the log file for one type of output requested.
- ErrFile [ cellstr ] - Contents of the error files produced by X12; each cell contains the error file for one type of output requested.
- Model [ struct ] - Struct array with model specifications and parameter estimates for each of the ARIMA models fitted; Model matches the size of X is 2nd and higher dimensions.
- X [ tseries ] - Original input data with forecasts and/or backcasts appended if the options 'forecast=' and/or 'backcast=' are used.

### Options

- 'backcast=' [ numeric | 0 ] - Run a backcast based on the fitted ARIMA model for this number of periods back to improve on the seasonal adjustment; see help on the x11 specs in the X12-ARIMA manual. The backcast is included in the output argument X.
- 'cleanup=' [ true | false ] - Delete temporary X12 files when done; the temporary files are named iris\_x12a.\*.
- 'log=' [ true | false ] - Logarithmise the input data before, and de-logarithmise the output data back after, running x12.
- 'forecast=' [ numeric | 0 ] - Run a forecast based on the fitted ARIMA model for this number of periods ahead to improve on the seasonal adjustment; see help on the x11 specs in the X12-ARIMA manual. The forecast is included in the output argument X.
- 'display=' [ true | false ] - Display X12 output messages in command window; if false the messages will be saved in a TXT file.
- 'dummy=' [ tseries | empty ] - Dummy variable or variables (in case of a multivariate tseries object) used in X12-ARIMA regression; the dummy variables can also include values for forecasts and backcasts if you request them.
- 'dummyType=' [ 'ao' | 'holiday' | 'td' ] - Type of dummy; see the X12-ARIMA documentation.

- 'mode=' [ 'auto' | 'add' | 'logadd' | 'mult' | 'pseudoadd' | 'sign' ] - Seasonal adjustment mode (see help on the x11 specs in the X12-ARIMA manual); 'auto' means that series with only positive or only negative numbers will be adjusted in the 'mult' (multiplicative) mode, while series with combined positive and negative numbers in the 'add' (additive) mode.
- 'maxIter=' [ numeric | 1500 ] - Maximum number of iterations for the X12 estimation procedure. See help on the estimation specs in the X12-ARIMA manual.
- 'maxOrder=' [ numeric | [2,1] ] - A 1-by-2 vector with maximum order for the regular ARMA model (can be 1, 2, 3, or 4) and maximum order for the seasonal ARMA model (can be 1 or 2). See help on the automdl specs in the X12-ARIMA manual.
- 'missing=' [ true | false ] - Allow for in-sample missing observations, and fill in values predicted by an estimated ARIMA process; if false, the seasonal adjustment will not run and a warning will be thrown.
- 'output=' [ char | cellstr | 'SA' ] - List of requested output data; the cellstr or comma-separated list can combine 'IR' for the irregular component, 'SA' for the final seasonally adjusted series, 'SF' for seasonal factors, 'TC' for the trend-cycle, and 'MV' for the original series with missing observations replaced with ARIMA estimates. See also help on the x11 specs in the X12-ARIMA manual.
- 'saveAs=' [ char | empty ] - Name (or a whole path) under which X12-ARIMA output files will be saved.
- 'specFile=' [ char | 'default' ] - Name of the X12-ARIMA spec file; if 'default' the IRIS default spec file will be used, see description.
- 'tdays=' [ true | false ] - Correct for the number of trading days. See help on the x11regression specs in the X12-ARIMA manual.
- 'tolerance=' [ numeric | 1e-5 ] - Convergence tolerance for the X12 estimation procedure. See help on the estimation specs in the X12-ARIMA manual.

## Description

### —Missing observations

If you keep 'missing=' false (this is the default for backward compatibility), x12 will not run on series with in-sample missing observations, and a warning will be thrown.

If you set 'missing=' true, you allow for in-sample missing observations. The X12-ARIMA program handles missing observations by filling in values predicted by the estimated ARIMA process. You can request the series with missing values filled in by including MV in the option 'output='.

*—Spec file*

The default X12-ARIMA spec file is `+thirdparty/x12/default.spc`. You can create your own spec file to include options that are not available through the IRIS interface. You can use the following pre-defined placeholders letting IRIS fill in some of the information needed (check out the default file):

- `$series_data$` is replaced with a column vector of input observations;
- `$series_freq$` is replaced with a number representing the date frequency: either 4 for quarterly, or 12 for monthly (other frequencies are currently not supported by X12-ARIMA);
- `$series_startyear$` is replaced with the start year of the input series;
- `$series_startper$` is replaced with the start quarter or month of the input series;
- `$transform_function$` is replaced with `log` or `none` depending on the mode selected by the user;
- `$forecast_maxlead$` is replaced with the requested number of ARIMA forecast periods used to extend the series before seasonal adjustment.
- `$forecast_maxlead$` is replaced with the requested number of ARIMA forecast periods used to extend the series before seasonal adjustment.
- `$tolerance$` is replaced with the requested convergence tolerance in the estimation spec.
- `$maxiter$` is replaced with the requested maximum number of iterations in the estimation spec.
- `$maxorder$` is replaced with two numbers separated by a blank space: maximum order of regular ARIMA, and maximum order of seasonal ARIMA.
- `$x11_mode$` is replaced with the requested mode: `'add'` for additive, `'mult'` for multiplicative, `'pseudoadd'` for pseudo-additive, or `'logadd'` for log-additive;
- `$x12_save$` is replaced with the list of the requested output series: `'d10'` for seasonals, `'d11'` for final seasonally adjusted series, `'d12'` for trend-cycle, `'d13'` for irregular component.

Two of the placeholders, `'$series_data$` and `$x12_output$`, are required; if they are not found in the spec file, IRIS throws an error.

*—Estimates of ARIMA model parameters*

The ARIMA model specification, `Model`, is a struct with three fields:

- `.spec` - a cell array with the first cell giving the structure of the non-seasonal ARIMA, and the second cell giving the structure of the seasonal ARIMA; both specifications follow the usual Box-Jenkins notation, e.g. `[0 1 1]`.
- `.ar` - a numeric array with the point estimates of the AR coefficients (non-seasonal and seasonal).
- `.ma` - a numeric array with the point estimates of the MA coefficients (non-seasonal and seasonal).

### Example 1

If you wish to run `x12` on the entire range on which the input time series is defined, and do not use any options, you can omit the second input argument (the date range). These following three calls to `x12` do exactly the same:

```
xsa = x12(x);  
xsa = x12(x,Inf);  
xsa = x12(x,get(x,'range'));
```

### Example 2

If you wish to specify some of the options, you have to enter a date range or use `Inf`:

```
xsa = x12(x,Inf,'mode=', 'add');
```

---

## ■ yearly

Display tseries object one full year per row

### Syntax

```
yearly(X)
```

## Time series objects and functions: yearly

### Input arguments

- `X [ tseries ]` - Tseries object that will be displayed one full year of observations per row.

### Description

### Example

## 19 Basic database management

### Loading and saving databases

- [dbload](#) P358 - Create database by loading CSV file.
- [dbsave](#) P369 - Save database as CSV file.
- [xls2csv](#) P373 - Convert XLS file to CSV file.

### Getting information about databases

- [dbnames](#) P364 - List of database entries filtered by name and/or class.
- [dbprintuserdata](#) P366 - Print names of database tseries along with specified fields of their userdata.
- [dbrange](#) P367 - Find a range that encompasses the ranges of the listed tseries objects.
- [dbsearchuserdata](#) P371 - Search database to find tseries by matching the content of their userdata fields.
- [dbuserdatalov](#) P372 - List of values found in a specified user data field in tseries objects.

### Converting databases

- [array2db](#) P350 - Convert numeric array to database.
- [db2array](#) P351 - Convert tseries database entries to numeric array.
- [db2tseries](#) P352 - Combine tseries database entries in one multivariate tseries object.

### Batch processing

- [dbbatch](#) P352 - Run a batch job to create new database fields.
- [dbclip](#) P354 - Clip all tseries entries in a database down to the specified date range.
- [dbcol](#) P356 - Retrieve the specified column or columns from database entries.
- [dbfun](#) P357 - Apply a function to database fields.
- [dbplot](#) P365 - Plot from database.
- [dbredate](#) P368 - Redate all tseries objects in a database.

### Combining databases

- [dbextend](#) P356 - Combine tseries observations from two or more databases.
- [dbmerge](#) P362 - Merge two or more databases.
- [dbminuscontrol](#) P362 - Create simulation-minus-control database.

### Getting on-line help on database functions

```
help dbase
help dbase/function_name
```

---

## ■ array2db

Convert numeric array to database

### Syntax

```
D = array2db(X,RANGE,LIST)
```

### Input arguments

- X [ numeric ] - Numeric array with individual time series organised row-wise.
- RANGE [ numeric ] - Date range for the columns in X.
- LIST [ cellstr | char ] - List of names for the time series in individual rows of X.

### Output arguments

- D [ struct ] - Output database.

### Description

### Example

---

## ■ db2array

Convert tseries database entries to numeric array

### Syntax

```
[X,Incl,Range] = db2array(D)
[X,Incl,Range] = db2array(D,List)
[X,Incl,Range] = db2array(D,List,Range)
```

### Input arguments

- `D` [ struct ] - Input database with tseries objects that will be converted to a numeric array.
- `List` [ char | cellstr ] - List of tseries names that will be converted to a numeric array; if not specified, all tseries entries found in the input database, `D`, will be included in the output arrays, `X`.
- `Range` [ numeric | Inf ] - Date range; `Inf` means a range from the very first non-NaN observation to the very last non-NaN observation.

### Output arguments

- `X` [ numeric ] - Numeric array with observations from individual tseries objects in columns.
- `Incl` [ cellstr ] - List of tseries names that have been actually found in the database.
- `Range` [ numeric ] - Date range actually used; this output argument is useful when the input argument `Range` is missing or `Inf`.

### Description

The output array, `X`, is always `NPer-by-NList-by-NAlt`, where `NPer` is the length of the `Range` (the number of periods), `NList` is the number of tseries included in the `List`, and `NAlt` is the maximum number of columns that any of the tseries included in the `List` have.

All tseries with more than one dimension (i.e. with more than one column) are always expanded along 3rd dimension only. For instance, a 10-by-2-by-3 tseries will occupy a 10-by-1-by-6 space in `X` at its respective location.

## Example

---

### ■ db2tseries

Combine tseries database entries in one multivariate tseries object

#### Syntax

```
[X,INCL,RANGE] = db2tseries(D,LIST,RANGE)
```

#### Input arguments

- D [ struct ] - Input database with tseries objects that will be combined in one multivariate tseries object.
- LIST [ char | cellstr ] - List of tseries names that will be combined.
- RANGE [ numeric | Inf ] - Date range.

#### Output arguments

- X [ numeric ] - Combined multivariate tseries object.
  - INCL [ cellstr ] - List of tseries names that have been actually found in the database.
  - RANGE [ numeric ] - The date range actually used.
- 

### ■ dbbatch

Run a batch job to create new database fields

#### Syntax

```
[D,Processed,Added] = dbbatch(D,NewName,Expr,...)
```

### Input arguments

- `D [ struct ]` - Input database.
- `NewName [ char ]` - Pattern that will be used to create names for new database fields based on the existing ones; use '\$0' to refer to the name of the currently processed database field; use '\$1', '\$2', etc. to refer to tokens captured in regular expression specified in the 'namefilter=' option.
- `Expr [ char ]` - Expression that will be evaluated on a selection of existing database entries to create new database entries; the expression can include '\$0', '\$1', etc.

### Output arguments

- `D [ struct ]` - Output database.
- `Processed [ cellstr ]` - List of database fields that have been used to create new fields.
- `Added [ cellstr ]` - List of new database fields created by evaluating `Expr` on the corresponding field in `Processed`.

### Options

- `'classFilter=' [ char | Inf ]` - From the existing database entries, select only those that are objects of the specified class or classes, and evaluate the expression `Expr` on these.
- `'fresh=' [ true | false ]` - If true, the output database will only contain the newly created entries; if false the output database will also include all the entries from the input database.
- `'nameFilter=' [ char | empty ]` - From the existing database entries, select only those that match this regular expression, and evaluate the expression `Expr` on these.
- `'nameList=' [ cellstr | Inf ]` - Evaluate the `COMMAND` on this list of existing database entries.
- `'stringList=' [ cellstr | empty ]` - Evaluate the expression `Expr` on this list of strings; the strings do not need to be names existing in the database; this options can be comined with 'nameFilter=', 'nameList=', and/or 'classFilter=' to narrow the selection.

### Description

This function is primarily meant to create new database fields, each based on an existing one. If you, on the otherhand, only wish to modify a number of existing fields without adding any new ones, use `dbfun` [P357](#) instead.

The expression Expr is evaluated in the caller workspace, and hence may refer to any variables existing in the workspace, not only to the database and its fields.

To convert the strings \$0, \$1, \$2, etc. to lower case or upper case, use the dot or colon syntax: \$.0, \$.1, \$.2 for ower case, and \$:0, \$:1, \$:2 for upper case.

### Example 1

For each field (all assumed to be tseries) create a first difference, and name the new series DX where X is the name of the original series.

```
d = dbbatch(d, 'D$0', 'diff(d.$0)');
```

Note that the original series will be presered in the database, together with the newly created ones.

### Example 2

Suppose that in database D you want to seasonally adjust all time series whose names end with \_u, and give these seasonally adjusted series names without the \_u.

```
d = dbbatch(d, '$1', 'x12(d.$0)', 'nameFilter', '(.*)u');
```

or, if you want to make sure only tseries objects will be selected (in case there are database entries ending with a u other than tseries objects)

```
d = dbbatch(d, '$1', 'x12(d.$0)', ...  
            'nameFilter=', '(.*)u', 'classFilter=', 'tseries');
```

---

## ■ dbclip

Clip all tseries entries in a database down to the specified date range

### Syntax

```
D = dbclip(D, Range)
```

**Input arguments**

- `D [ struct ]` - Database or nested databases with tseries objects.
- `Range [ numeric | cell ]` - Range or a cell array of ranges to which all tseries objects will be clipped; multiple ranges can be specified, each for a different date frequency/periodicity.

**Output arguments**

- `D [ struct ]` - Database with tseries objects cut down to range.

**Description**

This functions looks up all tseries objects within the database `d`, including tseries objects nested in sub-databases, and cuts off any values preceding the start date of `Range` or following the end date of `range`. The tseries object comments, if any, are preserved in the new database.

If a tseries entry does not match the date frequency of the input range, a warning is thrown.

Multiple ranges can be specified in `Range` (as a cell array), each for a different date frequency/periodicity (i.e. one or more of the following: monthly, bi-monthly, quarterly, half-yearly, yearly, indeterminate). Each tseries entry will be clipped to the range that matches its date frequency.

**Example**

```
d = struct();
d.x = tseries(qq(2005,1):qq(2010,4),@rand);
d.y = tseries(qq(2005,1):qq(2010,4),@rand)

d =
  x: [24x1 tseries]
  y: [24x1 tseries]

dbclip(d,qq(2007,1):qq(2007,4))

ans =
  x: [4x1 tseries]
  y: [4x1 tseries]
```

---

## ■ dbcol

Retrieve the specified column or columns from database entries

### Syntax

```
D = dbcol(D,K)
```

### Input arguments

- D [ struct ] - Input database with (possibly) multivariate tseries objects and numeric arrays.
- K [ numeric | logical | 'end' ] - Column or columns that will be retrieved from each tseries object or numeric array in the input database, D, and returned in the output database.

### Output arguments

- D [ struct ] - Output database with tseries objects and numeric arrays reduced to the specified column.

### Description

### Example

---

## ■ dbextend

Combine tseries observations from two or more databases

### Syntax

```
D = dbextend(D,D1,D2,...)
```

### Input arguments

- D [ struct ] - Primary input database.

- D1, D2, ... [ struct ] - Databases whose tseries observations will be used to extend or overwrite observations in the tseries objects of the same name in the primary database.

### Output arguments

- D [ struct ] - Output database.

### Description

If more than two databases are combined then they are processed one-by-one: the first is combined with the second, then the result is combined with the third, and so on, using the following rules:

- If two non-empty tseries objects with the same frequency are combined, the observations are spliced together. If some of the observations overlap the observations from the second tseries are used.
- If two empty tseries objects are combined the first is used.
- If a non-empty tseries is combined with an empty tseries, the non-empty one is used.
- If two objects are combined of which at least one is a non-tseries object, the second input object is used.

### Example

---

## ■ dbfun

Apply a function to database fields

### Syntax

```
[D,Flag,ErrList,WarnList] = dbfun(Func,D1,...)
[D,Flag,ErrList,WarnList] = dbfun(Func,D1,D2,...)
```

### Input arguments

- Func [ function\_handle | char ] - Function that will be applied to each field.

## Basic database management: dbload

- D1 [ struct ] - First input database.
- D2, D3, ... [ struct ] - Second and further input databases (when Func accepts two input arguments).

### Output arguments

- D [ struct ] - Output database whose fields will be created by applying Func to each field of the input database or databases.
- Flag [ true | false ] - True if no error occurs when evaluating the function.
- ErrList [ cellstr ] - List of fields on which the function has thrown an error.
- WarnList [ cellstr ] - List of fields on which the function has thrown a warning.

### Options

- 'cascade=' [ true | false ] - Cascade through subdatabases applying the function Func to their fields, too.
- 'classList=' [ cell | cellstr | Inf ] - Apply Func only to the fields of specified classes.
- 'fresh=' [ true | false ] - Keep upprocessed fields in the output database.
- 'nameList=' [ cell | cellstr | Inf ] - Apply Func only to the specified field names; can be still combined with the option 'classList='.
- 'onError=' [ 'keep' | 'NaN' | 'remove' ]

### Description

### Example

---

## ■ dbload

Create database by loading CSV file

### Syntax

```
D = dbload(FName, ...)  
D = dbload(D,FName, ...)
```

### Input arguments

- FName [ char | cellstr ] - Name of the Input CSV data file or a cell array of CSV file names that will be combined.
- D [ struct ] - An existing database (struct) to which the new entries from the input CSV data file entries will be added.

### Output arguments

- D [ struct ] - Database created from the input CSV file(s).

### Options

- 'case=' [ 'lower' | 'upper' | empty ] - Change case of variable names.
- 'commentRow=' [ char | cellstr | {'comment', 'comments'} ] - Label at the start of row that will be used to create tseries object comments.
- 'convert=' [ numeric | cellstr | empty ] - If non-empty, frequency conversion will be run on all time series loaded; specify the target frequency (numeric) or a cell array of input arguments and options in a call to the function convert.
- 'dateFormat=' [ char | 'YYYYFP' ] - Format of dates in first column.
- 'delimiter=' [ char | ',' ] - Delimiter separating the individual values (cells) in the CSV file; if different from a comma, all occurrences of the delimiter will be replaced with commas – note that this will also affect text in comments.
- 'firstDateOnly=' [ true | false ] - Read and parse only the first date string, and fill in the remaining dates assuming a range of consecutive dates.
- 'freq=' [ 0 | 1 | 2 | 4 | 6 | 12 | 365 | 'daily' | empty ] - Advise frequency of dates; if empty, frequency will be automatically recognised.
- 'freqLetters=' [ char | 'YHQB' ] - Letters representing frequency of dates in date column.
- 'inputFormat=' [ 'auto' | 'csv' | 'xls' ] - Format of input data file; 'auto' means the format will be determined by the file extension.
- 'nameRow=' [ char | numeric | empty ] - String at the beginning of the row with variable names, or the line number at which the row with variable names appears (first row is numbered 1).
- 'nameFunc=' [ cell | function\_handle | empty ] - Function used to change or transform the variable names. If a cell array of function handles, each function will be applied in the given order.

## Basic database management: dbload

- 'nan=' [ char | NaN ] - String representing missing observations (case insensitive).
- 'preProcess=' [ function\_handle | cell | empty ] - Apply this function, or cell array of functions, to the raw text file before parsing the data.
- 'skipRows=' [ char | cellstr | numeric | empty ] - Skip rows whose first cell matches the string or strings (regular expressions); or, skip a vector of row numbers.
- 'userData=' [ char | Inf ] - Field name under which the database userdata loaded from the CSV file (if they exist) will be stored in the output database; if 'userData'=Inf the field name will be read from the CSV file (and will be thus identical to the originally saved database).
- 'userDataField=' [ char | '.' ] - A leading character denoting userdata fields for individual time series. If empty, no userdata fields will be read.
- 'userDataFieldList=' [ cellstr | numeric | empty ] - List of row headers, or vector of row numbers, that will be included as user data in each time series.

### Description

Use the 'freq=' option whenever there is ambiguity in interpreting the date strings, and IRIS is not able to determine the frequency correctly (see Example 1).

—*Structure of CSV database files*

The minimalist structure of a CSV database file has a leading row with variables names, a leading column with dates in the basic IRIS format, and individual columns with numeric data:

```
+-----+-----+-----+--
|          |      Y |      P |
+-----+-----+-----+--
| 2010Q1 |      1 |      10 |
+-----+-----+-----+--
| 2010Q2 |      2 |      20 |
+-----+-----+-----+--
|          |      |      |
```

You can add a comment row (must be placed before the data part, and start with a label 'Comment' in the first cell) that will also be read in and assigned as comments to the individual tseries objects created in the output database.

```
+-----+-----+-----+--
|          |      Y |      P |
```

## Basic database management: dbload

```
+-----+-----+-----+--
| Comment | Output | Prices |
+-----+-----+-----+--
| 2010Q1 |      1 |      10 |
+-----+-----+-----+--
| 2010Q2 |      2 |      20 |
+-----+-----+-----+--
|         |         |         |
```

You can use a different label in the first cell to denote a comment row; in that case you need to set the option 'commentRow=' accordingly.

All CSV rows whose names start with a character specified in the option 'userdataField=' (a dot by default) will be added to output tseries objects as fields of their userdata.

```
+-----+-----+-----+--
|         |      Y |      P |
+-----+-----+-----+--
| Comment | Output | Prices |
+-----+-----+-----+--
| .Source | Stat  | IMFIFS |
+-----+-----+-----+--
| .Update | 17Feb11 | 01Feb11 |
+-----+-----+-----+--
| .Units  | Bil USD | 2010=1 |
+-----+-----+-----+--
| 2010Q1 |      1 |      10 |
+-----+-----+-----+--
| 2010Q2 |      2 |      20 |
+-----+-----+-----+--
|         |         |         |
```

### Example 1

Typical example of using the 'freq=' option is a quarterly database with dates represented by the corresponding months, such as a sequence 2000-01-01, 2000-04-01, 2000-07-01, 2000-10-01, etc. In this case, you can use the following options:

```
d = dbload('filename.csv', 'dateFormat', 'YYYY-MM-01', 'freq', 4);
```

## ■ dbmerge

Merge two or more databases

### Syntax

```
D = dbmerge(D1,D2,...)
```

### Input arguments

- D1, D2, ... [ struct ] - Input databases whose entries will be combined in the output datase.

### Output arguments

- D [ struct ] - Output database that combines entries from all input database; if some entries are found in more than one input databases, the last occurrence is used.

### Description

### Example

```
d1 = struct('a',1,'b',2);  
d2 = struct('a',10,'c',20);  
d = dbmerge(d1,d2)  
d =  
  a: 10  
  b: 2  
  c: 20
```

---

## ■ dbminuscontrol

Create simulation-minus-control database

## Syntax

```
[D,C] = dbminuscontrol(M,D)
[D,C] = dbminuscontrol(M,D,C)
```

## Input arguments

- M [ model ] - Model object on which the databases D and C are based.
- D [ struct ] - Simulation database.
- C [ struct ] - Control database; if the input argument C is not specified, the steady-state database of the model M is used for the control database.

## Output arguments

- D [ struct ] - Simulation-minus-control database, in which all log-variables are  $d.x/c.x$ , and all other variables are  $d.x-c.x$ .
- C [ struct ] - Control database.

## Description

### Example

We run a shock simulation in full levels using a steady-state (or balanced-growth-path) database as input, and then compute the deviations from the steady state.

```
d = sstatedb(m,1:40);
... % Set up a shock or shocks here.
s = simulate(m,d,1:40);
s = dbextend(d,s);
s = dbminuscontrol(m,s,d);
```

Note that this is equivalent to running

```
d = zerodb(m,1:40);
... % Set up a shock or shocks here.
s = simulate(m,d,1:40,'deviation',true);
s = dbextend(d,s);
```

## ■ dbnames

List of database entries filtered by name and/or class

### Syntax

```
List = dbnames(D,...)
```

### Input arguments

- D [ struct ] - Input database.

### Output arguments

- List [ cellstr ] - List of input database entries that pass the name or class test.

### Options

- 'nameFilter=' [ char | Inf ] - Regular expression against which the database entry names will be matched; Inf means all names will be matched.
- 'classFilter=' [ char | Inf ] - Regular expression against which the database entry class names will be matched; Inf means all classes will be matched.

### Description

### Example

Notice the differences in the following calls to dbnames:

```
dbnames(d,'nameFilter=','L_')
```

matches all names that contain 'L\_' (at the beginning, in the middle, or at the end of the string), such as 'L\_A', 'DL\_A', 'XL\_', or just 'L\_'.

```
dbnames(d,'nameFilter=', '^L_')
```

matches all names that start with 'L\_', such as 'L\_A' or 'L\_'.

```
dbnames(d,'nameFilter=', '^L_.')
```

matches all names that start with 'L\_' and have at least one more character after that, such as 'L\_A' (but not 'L\_').

---

## ■ dbplot

Plot from database

### Syntax

```
[FF,AA,PDb] = dbplot(D,List,Range,...)  
[FF,AA,PDb] = dbplot(D,Range,List,...)
```

### Input arguments

- D [ struct ] - Database with input data.
- List [ cellstr ] - List of expressions (or labelled expressions) that will be evaluated and plotted in separate graphs.
- Range [ numeric ] - Date range.

### Output arguments

- FF [ numeric ] - Handles to figures created by qplot.
- AA [ cell ] - Handles to axes created by qplot.
- PDB [ struct ] - Database with actually plotted series.

## Options

- 'plotFunc=' [ @bar | @hist | @plot | @plotpred | @stem ] - Plot function used to create the graphs.

See help on [qreport/qplot](#) P421 for other options available.

## Description

The function `dbplot` opens a new figure window (as many as needed to accommodate all graphs given the option 'subplot='), and creates a graph for each entry in the cell array `List`.

`List` can contain the names of the database time series, expression referring to the database fields evaluating to time series. You can also add labels (that will be displayed as graph titles) enclosed in double quotes and preceding the expressions. If you start the expression with a ^ (hat) symbol, the function specified in the 'transform=' option will not be applied to that expression.

## Example

```
dbplot(d,qq(2010,1):qq(2015,4),{'x','"Series Y" y','^"Series z"', ...
    'transform=',@(x) 100*(x-1)});
```

## ■ dbprintuserdata

Print names of database tseries along with specified fields of their userdata

### Syntax

```
dbprintuserdata(D,Field,...)
```

### Input arguments

- `D` [ struct ] - Database whose tseries objects will be reported.
- `Field` [ char | cellstr ] - Names of the userdata fields whose content will printed (if char or numeric scalar).

### Options

- 'output=' [ 'html' | 'prompt' ] - Where to display the information.

### Description

### Example

---

## ■ dbrange

Find a range that encompasses the ranges of the listed tseries objects

### Syntax

```
[Range,FreqList] = dbrange(D)
[Range,FreqList] = dbrange(D,List,...)
[Range,FreqList] = dbrange(D,Inf,...)
```

### Input arguments

- D [ struct ] - Input database.
- List [ char | cellstr | Inf ] - List of tseries objects that will be included in the range search; Inf means all tseries objects existing in the input databases will be included.

### Output arguments

- Range [ numeric | cell ] - Range that encompasses the observations of the tseries objects in the input database; if tseries objects with different frequencies exist, the ranges are returned in a cell array.
- FreqList [ numeric ] - Vector of date frequencies corresponding to the returned ranges.

### Options

- 'startDate=' [ 'maxRange' | 'minRange' ] - 'maxRange' means the range will start at the earliest start date of all tseries included in the search; 'minRange' means the range will start at the latest start date found.

- 'endDate=' [ 'maxRange' | 'minRange' ] - 'maxRange' means the range will end at the latest end date of all tseries included in the search; 'minRange' means the range will end at the earliest end date.

## Description

## Example

---

## ■ dbredate

Redate all tseries objects in a database

## Syntax

```
D = redate(D,OldDate,NewDate)
```

## Input arguments

- D [ struct ] - Input database with tseries objects.
- OldDate [ numeric ] - Base date that will be converted to a new date in all tseries objects.
- NewDate [ numeric ] - A new date to which the base date OldDate will be changed in all tseries objects; newDate need not be the same frequency as OldDate.

## Output arguments

- d [ struct ] - Output database where all tseries objects have identical data as in the input database, but with their time dimension changed.

## Description

## Example

---

## ■ dbsave

Save database as CSV file

### Syntax

```
List = dbsave(D,FName)
List = dbsave(D,FName,Dates,...)
```

### Output arguments

- List [ cellstr ] - - List of actually saved database entries.

### Input arguments

- D [ struct ] - Database whose tseries and numeric entries will be saved.
- FName [ char ] - Filename under which the CSV will be saved, including its extension.
- Dates [ numeric | Inf ] Dates or date range on which the tseries objects will be saved.

### Options

- 'class=' [ true | false ] - Include a row with class and size specifications.
- 'comment=' [ true | false ] - Include a row with comments for tseries objects.
- 'decimal=' [ numeric | empty ] - Number of decimals up to which the data will be saved; if empty the 'format' option is used.
- 'format=' [ char | '%.8e' ] Numeric format that will be used to represent the data, see `sprintf` for details on formatting, The format must start with a '%', and must not include identifiers specifying order of processing, i.e. the '\$' signs, or left-justify flags, the '-' signs.
- 'freqLetters=' [ char | 'YHQBM' ] - Five letters to represent the five possible date frequencies (annual, semi-annual, quarterly, bimonthly, monthly).
- 'nan=' [ char | 'NaN' ] - String that will be used to represent NaNs.
- 'saveSubdb=' [ true | false ] - Save sub-databases (structs found within the struct D); the sub-databases will be saved to separate CSF files.
- 'userData=' [ char | 'userdata' ] - Field name from which any kind of userdata will be read and saved in the CSV file.

**Description**

The data saved include also imaginary parts of complex numbers.

—*Saving user data with the database*

If your database contains field named 'userdata=', this will be saved in the CSV file on a separate row. The 'userdata=' field can be any combination of numeric, char, and cell arrays and 1-by-1 structs.

You can use the 'userdata=' field to describe the database or preserve any sort of metadata. To change the name of the field that is treated as user data, use the 'userData=' option.

**Example 1**

Create a simple database with two time series.

```
d = struct();
d.x = tseries(qq(2010,1):qq(2010,4),@rand);
d.y = tseries(qq(2010,1):qq(2010,4),@rand);
```

Add your own description of the database, e.g.

```
d.userdata = {'My database',datestr(now())};
```

Save the database as CSV using dbsave,

```
dbsave(d,'mydatabase.csv');
```

When you later load the database,

```
d = dbload('mydatabase.csv')
```

```
d =
```

```
  userdata: {'My database' '23-Sep-2011 14:10:17'}
         x: [4x1 tseries]
         y: [4x1 tseries]
```

the database will preserve the 'userdata=' field.

*—Example 2*

To change the field name under which you store your own user data, use the 'userdata=' option when running dbsave,

```
d = struct();
d.x = tseries(qq(2010,1):qq(2010,4),@rand);
d.y = tseries(qq(2010,1):qq(2010,4),@rand);
d.MYUSERDATA = {'My database',datestr(now())};
dbsave(d,'mydatabase.csv',Inf,'userData=', 'MYUSERDATA');
```

The name of the user data field is also kept in the CSV file so that dbload works fine in this case, too, and returns a database identical to the saved one,

```
d = dbload('mydatabase.csv')

d =

    MYUSERDATA: {'My database'   '23-Sep-2011 14:10:17'}
             x: [4x1 tseries]
             y: [4x1 tseries]
```

## ■ dbsearchuserdata

Search database to find tseries by matching the content of their userdata fields

### Syntax

```
[List,SubD] = dbsearchuserdata(D,Field1,Regexp1,Field2,Regexp2,...)
[List,SubD] = dbsearchuserdata(D,Flag,Field1,Regexp1,Field2,Regexp2,...)
```

### Input arguments

- D [ struct ] - Input database whose tseries fields will be searched.
- Flag [ '-all' | '-any' ] - Specifies if all conditions or any condition must be met for the series to pass the test; if not specified, '-all' is assumed.

- Field1, Field2, ... [ char ] - Names of fields in the userdata struct.
- Regexp1, Regexp2, ... [ char ] - Regular expressions against which the respective userdata fields will be matched.

### Output arguments

- List [ cellstr ] - Names of tseries that pass the test.
- Subd [ struct ] - Sub-database with only those tseries that pass the test.

### Description

For a successful match, the userdata must be a struct, and the tested fields must be text strings.

Use an equal sign, =, after the name of the userdata fields in Field1, Field2, etc. to request a case-insensitive match, and an equal-shart sign, =#, to indicate a case-sensitive match.

### Example

```
[list,dd] = dbsearchuserdata(d,'.DESC=', 'Exchange rate', '.SOURCE=#', 'IMF');
```

Each individual tseries object in the database D will be tested for two conditions:

- whether its user data is a struct including a field named DESC, and the field contains a string 'Exchange rate' in it (case insensitive, e.g. 'eXcHaNgE rAtE' will also be matched);
- whether its user data is a struct including a field named SOURCE, and the field contains a string 'IMF' in it (case sensitive, e.g. 'Imf' will not be matched).

All tseries object that pass both of these conditions are returned in the List and the output database D.

---

## ■ dbuserdatalov

List of values found in a specified user data field in tseries objects

## Syntax

```
LOV = dbuserdatalov(D,FIELD)
```

## Input arguments

- D [ struct ] - Input database whose tseries objects will be searched.
- FIELD [ char ] - Name of a userdata field whose values will be collected across all tseries objects.

## Output arguments

- LOV [ cellstr ] - List of values found in the field FIELD of all tseries objects; only char values (text strings) are included; each value is included only once in LOV.

## Description

## Example

---

## ■ xls2csv

Convert XLS file to CSV file

## Syntax

```
xls2csv(InpFile)  
xls2csv(InpFile,OutpFile,...)
```

## Input arguments

- InpFile [ char ] - Name of an XLS input file that will be converted to CSV.
- OutpFile [ empty | char ] - Name of the CSV output file; if not supplied or empty, the CSV file name will be derived from the XLS input file name.

## Options

- 'sheet=' [ numeric | char | 1 ] - Worksheet in the XLS file that will be saved; can be either the sheet number or the sheet name.

## Description

This function calls a third-party JavaScript (courtesy of Christopher West). The script uses an MS Excel application on the background, and hence MS Excel must be installed on the computer.

Only one worksheet at a time can be saved to CSV. By default, it is the first worksheet found in the input XLS file; use the option 'sheet=' to control which worksheet will be saved.

See also `$irisroot/+thirdparty/xls2csv.js` for copyright information.

## Example 1

Save the first worksheets of the following XLS files to CSV files.

```
xls2csv('myDataFile.xls');  
xls2csv('C:\Data\myDataFile.xls');
```

## Example 2

Save the worksheet named 'Sheet3' to a CSV file; the name of the CSV file will be 'myDataFile.csv'.

```
xls2csv('myDataFile.xls',[],'sheet=','Sheet3');
```

## Example 3

Save the second worksheet to a CSV file under the name 'myDataFile\_2.csv'.

```
xls2csv('myDataFile.xls','myDataFile_2.csv','sheet=',2);
```

Part V —  
Reporting and publishing

## 20 Report functions

### New report

- `new` [P398](#) - Create new, empty report object.
- `copy` [P383](#) - Create a copy of a report object.

### Compiling PDF report

- `publish` [P399](#) - Compile PDF from report object.

### Top-level objects

- `table` [P407](#) - Start new table.
- `figure` [P386](#) - Start new figure.
- `usefigure` [P412](#) - Insert existing figure window.
- `matrix` [P393](#) - Insert matrix or numeric array.
- `modelfile` [P397](#) - Write formatted model file.
- `array` [P379](#) - Insert array with user data.
- `tex` [P410](#) - Include  $\text{\LaTeX}$  code or verbatim text input in report.

### Inspecting and manipulating report objects

- `disp` [P384](#) - Display the structure of report object.
- `display` [P384](#) - Display the structure of report object.
- `findall` [P388](#) - Find all objects of a given type within report object.

### Figure objects

- `graph` [P389](#) - Add graph to figure.

### Table and graph objects

- `band` [P381] - Add new data with lower and upper bounds to graph or table.
- `fanchart` [P385] - Add fanchart to graph.
- `series` [P402] - Add new data to graph or table.
- `subheading` [P406] - Enter subheading in table.
- `vline` [P413] - Add vertical line to graph.
- `highlight` [P391] - Highlight range in graph.

### Structuring reports

- `align` [P378] - Vertically align the following K objects.
- `empty` [P385] - Empty report object.
- `include` [P392] - Include text or LaTeX input file in the report.
- `merge` [P396] - Merge the content of two or more report objects.
- `pagebreak` [P399] - Force page break.
- `section` [P402] - Start new section in report.

### Getting on-line help on report functions

```
help report  
help report/function_name
```

### Generic options

The following generic options can be used on any of the report objects.

- `'saveAs='` [ char | `empty` ] - (Not inheritable from parent objects) Save the LaTeX code generated for the respective report element in a text file under the specified name.

## ■ align

Vertically align the following K objects

### Syntax

```
P.align(Caption,K,NCol,...)
```

### Input arguments

- P [ struct ] - Report object created by the [report.new](#) P398 function.
- Caption [ char ] - Caption displayed only when describing the structure of the report on the screen, but not in the actual PDF report.
- K [ numeric ] - Number of objects following this align that will be vertically aligned.
- NCol [ numeric ] - Number of columns in which the objects will vertically aligned.

### Options

- 'hspace=' [ numeric | 2 ] - Horizontal space (in em units) inserted between two neighbouring objects.
- 'separator=' [ char | '\medskip\par ] - (Inheritable from parent objects) L<sup>A</sup>T<sub>E</sub>X commands that will be inserted after the aligned objects.
- 'shareCaption=' [ 'auto' | true | false ] - (Inheritable from parent objects) Place a shared caption (title and subtitle) over each row of objects; the title of the first object in each row is used; 'auto' means that the caption will be shared if they are identical for all objects in a row.
- 'typeface=' [ char | empty ] - (Not inheritable from parent objects) L<sup>A</sup>T<sub>E</sub>X code specifying the typeface for the align element as a whole; it must use the declarative forms (such as \itshape) and not the command forms (such as \textit{...}).

### Description

Vertically aligned can be the following types of objects:

- [figure](#) P386

- [table](#) P407
- [matrix](#) P393
- [array](#) P379

Note that the `align` object itself has no caption (even if you specify one it will not be used). Only the objects within `align` will be given captions. If the objects aligned on one row have identical captions (i.e. both titles and subtitles), only one caption will be displayed centred above the objects.

Because [empty](#) P385 objects count in the total number of objects included in `align`, you can use [empty](#) P385 in to create blank space in a particular position.

### Example

---

## ■ array

Insert array with user data

### Syntax

```
P.array(Caption,Data)
```

### Input arguments

- `P` [ struct ] - Report object created by the [report.new](#) P398 function.
- `Caption` [ char | cellstr ] - Title or a cell array with title and subtitle displayed at the top of the array; see Description for splitting the title or subtitle into multiple lines.
- `Data` [ cell ] - Cell array with input data; numeric and text entries are allowed.

### Options

- `'arrayStretch='` [ numeric | 1.15 ] - (Inherited) Stretch between lines in the array (in pts).
- `'captionTypeface='` [ cellstr | char | '\large\bfseries' ] - (Inherited) L<sup>A</sup>T<sub>E</sub>X format commands for typesetting the array caption; the subcaption format can be entered as the second cell in a cell array.

## Report functions: array

- `'colWidth='` [ numeric | NaN ] - (Inheritable from parent objects) Width, or a vector of widths, of the array columns in emunits; NaN means the width of the column will adjust automatically.
- `'format='` [ char | `'%.2f'` ] - (Inherited) Numeric format string; see help on the built-in `sprintf` function.
- `'footnote='` [ char | `empty` ] - (Inherited) Footnote at the array title; only shows if the title is non-empty.
- `'heading='` [ char | cellstr | `empty` ] - (Inherited) User-supplied heading, i.e. an extra row or rows at the top of the array. The heading can be either a  $\LaTeX$  code, or a cell array whose size is consistent with `Data`. The heading is repeated at the top of each new page when used with `'long=' true`.
- `'inf='` [ char | `'$\infty$'` ] - (Inherited)  $\LaTeX$  string that will be used to typeset Infs.
- `'long='` [ true | false ] - (Inherited) If true, the array may stretch over more than one page.
- `'longFoot='` [ char | `empty` ] - (Inherited) Footnote that appears at the bottom of the array (if it is longer than one page) on each page except the last one; works only with `'long=' true`.
- `'longFootPosition='` [ 'centre' | 'left' | 'right' ] - (Inherited) Horizontal alignment of the footnote in long arrays; works only with `'long=' true`.
- `'nan='` [ char | `'$\cdots$'` ] - (Inherited)  $\LaTeX$  string that will be used to typeset NaNs.
- `'pureZero='` [ char | `empty` ] - (Inherited)  $\LaTeX$  string that will be used to typeset pure zero entries; if empty the zeros will be printed using the current numeric format.
- `'printedZero='` [ char | `empty` ] - (Inherited)  $\LaTeX$  string that will be used to typeset the entries that would appear as zero under the current numeric format used; if empty these numbers will be printed using the current numeric format.
- `'separator='` [ char | `'\medskip\par'` ] - (Inherited)  $\LaTeX$  commands that will be inserted after the array.
- `'sideways='` [ true | false ] - (Inherited) Print the array rotated by 90 degrees.
- `'tabcolsep='` [ NaN | numeric ] - (Inherited) Space between columns in the array, measured in em units; NaN means the  $\LaTeX$  default.
- `'typeface='` [ char | `empty` ] - (Not inherited)  $\LaTeX$  code specifying the typeface for the array as a whole; it must use the declarative forms (such as `\itshape`) and not the command forms (such as `\textit{...}`).

### Generic options

See help on [generic options](#) P376 in report objects.

**Description**

The input cell array `Data` can contain either strings or numeric values, or horizontal rules. Numeric values are printed using the standard `sprintf` function and formatted using the `'format='` option. Horizontal rules must be entered as a string of five (or more) dashes, `'-----'`, in the first cell of the respective row, with all other cells empty in that row. If you wish to include a  $\LaTeX$  command or a piece of  $\LaTeX$  code, you must enclose it in curly brackets.

*—Titles and subtitles*

The input argument `Caption` can be either a text string, or a 1-by-2 cell array of strings. In the latter case, the first cell will be printed as a title, and the second cell will be printed as a subtitle.

To split the title or subtitle into multiple lines, use the following  $\LaTeX$  commands wrapped in curly brackets: `{\}` or `{\}[Xpt]}`, where `X` is the width of an extra vertical space (in points) added between the respective lines.

**Example**

These commands create a table with two rows separated by a horizontal rule, and three columns in each of them. The middle columns will have Greek letters printed in  $\LaTeX$  math mode.

```
A = { ...
    'First row','{\textbackslash alpha\$}',10000; ...
    '-----','',''; ...
    'Second row','{\textbackslash beta\$}',20000; ...
};

P.array('My table',A);
```

**■ band**

Add new data with lower and upper bounds to graph or table

**Syntax**

```
P.series(Caption,X,Low,High,...)
```

### Input arguments

- `P` [ struct ] - Report object created by the [report.new](#) P398 function.
- `Caption` [ char ] - Caption used as a default legend entry in a graph, or in the leading column in a table.
- `X` [ tseries ] - Input data with the centre of the band.
- `Low` [ tseries ] - Input data with lower bounds; can be specified either relative to the centre or absolute, see the option `'relative='`.
- `High` [ tseries ] - Input data with upper bounds; can be specified either relative to the centre or absolute, see the option `'relative='`.

### Options for table and graph bands

- `'low='` [ char | `'Low'` ] - (Inheritable from parent objects) Mark used to denote the lower bound.
- `'high='` [ char | `'High'` ] - (Inheritable from parent objects) Mark used to denote the upper bound.
- `'relative='` [ `true` | `false` ] - (Inheritable from parent objects) If true, the data for the lower and upper bounds are relative to the centre, i.e. the bounds will be added to the centre (in this case, LOW must be negative numbers and HIGH must be positive numbers). If false, the bounds are absolute data (in this case LOW must be lower than X, and HIGH must be higher than X).

### Options for table bands

- `'bandTypeface='` [ char | `'\footnotesize'` ] - (Inheritable from parent objects) LaTeX format string used to typeset the lower and upper bounds.%

### Options for graph bands

- `'plotType='` [ `'errorbar'` | `'patch'` ] - Type of plot used to draw the band.
- `'relative='` [ `true` | `false` ] - (Inheritable from parent objects) If true the lower and upper bounds will be, respectively, subtracted from and added to to the middle line.
- `'white='` [ numeric | `0.8` ] - (Inheritable from parent objects) Proportion of white colour mixed with the line colour and used to fill the area that depicts the band.

See help on [report/series](#) P402 for other options available.

## Generic options

See help on [generic options](#) P376 in report objects.

## Description

## Example

---

## ■ copy

Create a copy of a report object

## Syntax

```
Q = copy(P)
```

## Input arguments

- P [ report ] - Report object whose copy will be created.

## Output arguments

- Q [ report ] - Copy of the input report object.

## Description

Because report is a handle class object, a plain assignment

```
Q = P;
```

creates a handle to the same copy of a report object. In other words, changes in Q will also change P and vice versa. To make a new, independent copy of an existing report object, you need to run

```
Q = copy(P);
```

---

## ■ disp

Display the structure of report object

### Syntax

X

### Input arguments

- X [ report ] - Report object.

### Description

### Example

---

## ■ disp

Display the structure of report object

### Syntax

disp(X)

### Input arguments

- X [ report ] - Report object.

### Description

### Example

---

## ■ empty

Empty report object

### Syntax

```
P.empty()  
P.empty(Caption,...)
```

### Input arguments

- P [ struct ] - Report object created by the [report.new](#) P398 function.
- Caption [ char ] - Caption for the empty object; the caption is only displayed in the on-screen report structure.

### Generic options

See help on [generic options](#) P376 in report objects.

### Description

The empty object does not produce any visible output in the report. It can be used in [align](#) P378 or [figure](#) P386 to create blank space.

### Example

---

## ■ fanchart

Add fanchart to graph

### Syntax

```
P.fanchart(Cap,X,Std,Prob,...)
```

### Input arguments

- `P` [ struct ] - Report object created by the [report.new](#) P398 function.
- `Cap` [ char ] - Caption used as a legend entry for the line (mean of fanchart)
- `X` [ tseries ] - Tseries object with input data to be displayed.
- `Std` [ tseries ] - Tseries object with standard deviations of input data.
- `Prob` [ numeric ] - Confidence probabilities of intervals to be displayed.

### Options for fancharts

- `'asym='` [ numeric | tseries | 1 ] - Ratio of asymmetry (area of upper part to one of lower part).
- `'exclude='` [ numeric | true | false ] - Exclude some of the confidence intervals.
- `'factor='` [ numeric | 1 ] - factor to increase or decrease input standard deviations
- `'fanLegend='` [ cell | NaN | Inf ] - Legend entries used instead of confidence interval values; Inf means all confidence intervals values will be used to construct legend entries; NaN means the intervals will be excluded from legend; NaN in cellstr means the intervals of respective fancharts will be excluded from legend.

See help on [report/series](#) P402 for other options available.

### Description

The confidence intervals are based on normal distributions with standard deviations supplied by the user. Optionally, the user can also specify assumptions about asymmetry and/or common correction factors.

### Example

---

## ■ figure

Start new figure

## Syntax

```
P.figure(Caption,...)
```

## Syntax to capture an existing figure window

This is an obsolete syntax, and will be removed from IRIS in a future release. Use [report/userfigure](#) P412 instead.

```
P.figure(Caption,H,...)
```

## Input arguments

- P [ struct ] - Report object created by the [report.new](#) P398 function.
- Caption [ char | cellstr ] - Title or a cell array with title and subtitle displayed at the top of the figure; see Description for splitting the title or subtitle into multiple lines.
- H [ numeric ] - See help on [report/userfigure](#) P412.

## Options

- 'captionTypeface=' [ cellstr | char | '\large\bfseries' ] - LaTeX format commands for typesetting the figure caption; the subcaption format can be entered as the second cell in a cell array.
- 'close=' [ true | false ] - (Inheritable from parent objects) Close Matlab the underlying figure window when finished.
- 'separator=' [ char | '\medskip\par' ] - (Inheritable from parent objects) LaTeX commands that will be inserted after the figure.
- 'figureOptions=' [ cell | empty ] - Figure options that will be applied to the figure handle after all graphs are drawn.
- 'figureScale=' [ numeric | 0.85 ] - (Inheritable from parent objects) Scale of the figure in the LaTeX document.
- 'footnote=' [ char | empty ] - Footnote at the figure title; only shows if the title is non-empty.
- 'sideways=' [ true | false ] - (Inheritable from parent objects) Print the table rotated by 90 degrees.

- 'style=' [ struct | empty ] - Apply this cascading style structure to the figure; see [qstyle](#) P423.
- 'subplot=' [ numeric | 'auto' ] - (Inheritable from parent objects) Subplot division of the figure.
- 'typeface=' [ char | empty ] - (Not inheritable from parent objects) LaTeX code specifying the typeface for the figure as a whole; it must use the declarative forms (such as `\itshape`) and not the command forms (such as `\textit{...}`).
- 'visible=' [ true | false ] - (Inheritable from parent objects) Visibility of the underlying Matlab figure window.

### Generic options

See help on [generic options](#) P376 in report objects.

### Description

Figures are top-level report objects and cannot be nested within other report objects, except [align](#) P378. Figure objects can have the following types of children:

- [graph](#) P389;
- [empty](#) P385.

#### —Titles and subtitles

The input argument `Caption` can be either a text string, or a 1-by-2 cell array of strings. In the latter case, the first cell will be printed as a title, and the second cell will be printed as a subtitle.

To split the title or subtitle into multiple lines, use the following LaTeX commands wrapped in curly brackets: `{\}` or `{\}[Xpt]}`, where `X` is the width of an extra vertical space (in points) added between the respective lines.

### Example

## ■ findall

Find all objects of a given type within report object

### Syntax

```
Obj = findall(X,Type1,Type2,...)
```

### Input arguments

- X [ report ] - Report object.
- Type1, Type2 [ char ] - Names of report objects that will be looked for in report X.

### Output arguments

- Obj [ cell ] - Cell array of all objects of the give type(s) found in report X.

### Description

### Example

---

## ■ graph

Add graph to figure

### Syntax

```
P.graph(Caption,...)
```

### Input arguments

- P [ struct ] - Report object created by the [report.new](#) P398 function.
- Caption [ char | cellstr ] - Title, or cell array with title and subtitle, displayed at the top of the graph.

## Options

- 'axesOptions=' [ cell | empty ] - (Inheritable) Options executed by calling set on the axes handle before running 'postProcess='.
- 'dateFormat=' [ char | 'YYYY:P' ] - (Inheritable) Date format string, see help on [dat2str](#) P263.
- 'dateTick=' [ numeric | Inf ] - (Inheritable) Date tick spacing.
- 'legend=' [ false | true ] - (Inheritable) Add legend to the graph.
- 'legendLocation=' [ char | 'best' | 'bottom' ] - (Inheritable) Location of the legend box; see help on legend for values available.
- 'postProcess=' [ char | empty ] - (Inheritable) String with Matlab commands executed after the graph has been drawn and styled; the commands have access to variable H, a handle to the current axes object.
- 'preProcess=' [ char | empty ] - (Inheritable) String with Matlab commands executed before the graph has been drawn and styled; the commands have access to variable H, a handle to the current axes object.
- 'range=' [ numeric | Inf ] - (Inheritable) Graph range.
- 'rhsAxesOptions=' [ cell | empty ] - (Inheritable) Options executed by calling set on the RHS axes handle before running 'postProcess='.
- 'style=' [ struct | empty ] - (Inheritable) Apply this style structure to the graph and its children; see help on [qstyle](#) P423.
- 'tight=' [ true | false ] - (Inheritable) Set the y-axis limits to the minimum and maximum of displayed data.
- 'xLabel=' [ char | empty ] - Label the x-axis.
- 'yLabel=' [ char | empty ] - Label the y-axis.
- 'zeroLine=' [ true | false ] - (Inheritable) Add a horizontal zero line if zero is included on the y-axis.

## Generic options

See help on [generic options](#) P376 in report objects.

## Description

## Example

---

## ■ highlight

Highlight range in graph

## Syntax

```
P.highlight(Caption,Range,...)
```

## Input arguments

- P [ struct ] - Report object created by the [report.new](#) [P398](#) function.
- Caption [ char ] - Caption used to annotate the highlighted area.
- Range [ cell | numeric ] - Date range, or a cell array of ranges, that will be highlighted.

## Options

- 'hPosition=' [ 'bottom' | 'middle' | 'top' ] - (Inheritable from parent objects) Horizontal position of the caption.
- 'vPosition=' [ 'centre' | 'left' | 'right' ] - (Inheritable from parent objects) Vertical position of the caption relative to the edges of the highlighted area.

## Generic options

See help on [generic options](#) [P376](#) in report objects.

## Description

## Example

---

## ■ include

Include text or LaTeX input file in the report

### Syntax

```
P.include(Caption,FileName,...)
```

### Input arguments

- P [ struct ] - Report object created by the function [report.new](#) P398.
- Caption [ char ] - Caption displayed at the top of the file included.
- FileName [ char ] - File name that will be included here.

### Options

- 'centering=' [ true | false ] - (Inheritable from parent objects) Centre the content of the file on the page.
- 'separator=' [ char | empty ] - (Not inheritable from parent objects)  $\LaTeX$  commands that will be inserted after the table.
- 'typeface=' [ char | empty ] - (Not inheritable from parent objects)  $\LaTeX$  code specifying the typeface for the include element as a whole; it must use the declarative forms (such as `\itshape`) and not the command forms (such as `\textit{...}`).
- 'verbatim=' [ true | false ] - (Not inheritable from parent objects) Enclose the content of the file in a verbatim environment.

### Generic options

See help on [generic options](#) P376 in report objects.

### Description

### Example

---

## ■ matrix

Insert matrix or numeric array

### Syntax

```
P.matrix(Caption,Data,...)
```

### Input arguments

- P [ struct ] - Report object created by the `report.new` [P398](#) function.
- Caption [ char | cellstr ] - Title or a cell array with title and subtitle displayed at the top of the matrix; see Description for splitting the title or subtitle into multiple lines.
- Data [ numeric ] - Numeric array with input data.

### Options

- 'arrayStretch=' [ numeric | 1.15 ] - (Inheritable from parent objects) Stretch between lines in the matrix (in pts).
- 'captionTypeface=' [ cellstr | char | '\*' ] - **L<sup>A</sup>T<sub>E</sub>X** format commands for typesetting the matrix caption; the subcaption format can be entered as the second cell in a cell array.
- 'colNames=' [ cellstr | empty ] - (Inheritable from parent objects) Names for individual matrix columns, displayed at the top of the matrix.
- 'colWidth=' [ numeric | NaN ] - (Inheritable from parent objects) Width, or a vector of widths, of the matrix columns in emunits; NaN means the width of the column will adjust automatically.
- 'condFormat=' [ struct | empty ] - (Inheritable from parent objects) Structure with `.test` and `.format` fields describing conditional formatting of individual matrix entries.
- 'footnote=' [ char | empty ] - Footnote at the matrix title; only shows if the title is non-empty.

- 'format=' [ char | '%.2f' ] - (Inheritable from parent objects) Numeric format string; see help on the built-in sprintf function.
- 'heading=' [ char | empty ] - (Inheritable from parent objects) User-supplied heading, i.e. an extra row or rows at the top of the matrix.
- 'inf=' [ char | '\$\infty\$' ] - (Inheritable from parent objects)  $\LaTeX$  string that will be used to typeset Infs.
- 'long=' [ true | false ] - (Inheritable from parent objects) If true, the matrix may stretch over more than one page.
- 'longFoot=' [ char | empty ] - (Inheritable from parent objects) Works only with 'long=' true: Footnote that appears at the bottom of the matrix (if it is longer than one page) on each page except the last one.
- 'longFootPosition=' [ 'centre' | 'left' | 'right' ] - (Inheritable from parent objects) Works only with 'long=' true: Horizontal alignment of the footnote in long matrices.
- 'nan=' [ char | '\$\cdots\$' ] - (Inheritable from parent objects)  $\LaTeX$  string that will be used to typeset NaNs.
- 'pureZero=' [ char | empty ] - (Inheritable from parent objects)  $\LaTeX$  string that will be used to typeset pure zero entries; if empty the zeros will be printed using the current numeric format.
- 'printedZero=' [ char | empty ] - (Inheritable from parent objects)  $\LaTeX$  string that will be used to typeset the entries that would appear as zero under the current numeric format used; if empty these numbers will be printed using the current numeric format.
- 'rotateColNames=' [ true | false | numeric ] - Rotate the names of columns by the specified number of degrees; true means rotate by 90 degrees.
- 'rowNames=' [ cellstr | empty ] - (Inheritable from parent objects) Names for individual matrix rows, displayed left of the matrix.
- 'separator=' [ char | '\medskip\par' ] - (Inheritable from parent objects)  $\LaTeX$  commands that will be inserted after the matrix.

- 'sideways=' [ true | false ] - (Inheritable from parent objects) Print the matrix rotated by 90 degrees.
- 'tabcolsep=' [ NaN | numeric ] - (Inheritable from parent objects) Space between columns in the matrix, measured in em units; NaN means the  $\LaTeX$  default.
- 'typeface=' [ char | empty ] - (Not inheritable from parent objects)  $\LaTeX$  code specifying the typeface for the matrix as a whole; it must use the declarative forms (such as `\itshape`) and not the command forms (such as `\textit{...}`).

### Generic options

See help on [generic options](#) P376 in report objects.

### Description

—*Conditional formatting*

The conditional format struct (or an array of structs) specified through the 'condFormat=' option must have two fields, `.test` and `.format`.

The `.test` field is a text string with a Matlab expression. The expression must evaluate to a scalar true or false, and can refer to the following attributes associated with each entry in the data part of the matrix:

- `value` - the numerical value of the entry;
- `row` - the row number within the data part of the matrix;
- `col` - the column number within the data part of the matrix;
- `rowname` - the row name right of which the entry appears;
- `colname` - the column name under which the entry appears;
- `rowvalues` - a row vector of all values in the current row;
- `colvalues` - a column vector of all values in the current column;
- `allvalues` - a matrix of all values.

You can combine a number of attributes within one test, using the logical operators, e.g.

## Report functions: merge

```
value > 0 && row > 3  
value == max(rowvalues) && strcmp(rowname, 'x')
```

The `.format` fields of the conditional format structure consist of LaTeX commands that will be used to typeset the corresponding entry. The reference to the entry itself is through a question mark. The entries are typeset in math mode; this for instance means that for bold or italic typface, you must use the `\mathbf{...}` and `\mathit{...}` commands.

In addition to standard LaTeX commands, you can use the following IRIS commands in the format strings:

- `\sprintf{FFFF}` - to modify the way each numeric entry that passes the test is printed by the `sprintf` function; `FFFF` is one of the standard `sprintf` formatting strings.

You can combine multiple tests and their corresponding formats in one structure; they will be all applied to each entry in the specified order.

### —*Titles and subtitles*

The input argument `Caption` can be either a text string, or a 1-by-2 cell array of strings. In the latter case, the first cell will be printed as a title, and the second cell will be printed as a subtitle.

To split the title or subtitle into multiple lines, use the following LaTeX commands wrapped in curly brackets: `{\}` or `{\[\Xpt]}`, where `X` is the width of an extra vertical space (in points) added between the respective lines.

### Example

---

## ■ merge

Merge the content of two or more report objects

### Syntax

```
P.merge(P1,P2,...)
```

### Input arguments

- P [ report ] - Report object created by the `report.new` [P398](#) function.
- P1, P2 [ report ] - Other report objects whose contents will be added to P in order of appearance.

### Description

### Example

---

## ■ modelfile

Write formatted model file

### Syntax

```
P.modelfile(Caption,FileName,...)
P.modelfile(Caption,FileName,M,...)
```

### Input arguments

- P [ report ] - Report object created by the `report.new` [P398](#) function.
- Caption [ char | cellstr ] - Title and subtitle displayed at the top of the table.
- FileName [ char ] - Model file name.
- M [ model ] - Model object from which the values of parameters and std devs of shocks will be read; if missing no parameter values or std devs will be printed.

### Options

- 'latexAlias' [ true | false ] - Treat alias in labels as LaTeX code and typeset it that way.
- 'lines=' [ numeric | Inf ] - Print only selected lines of the model file FileName; Inf means all lines will be printed.
- 'lineNumbers=' [ true | false ] - Display line numbers.

## Report functions: new

- 'footnote=' [ char | empty ] - Footnote at the model file title; only shows if the title is non-empty.
- 'paramValues=' [ true | false ] - Display the values of parameters and std devs of shocks next to each occurrence of a parameter or a shock; this option works only if a model object M is entered as the 3rd input argument.
- 'syntax=' [ true | false ] - Highlight model file syntax; this includes model language keywords, descriptions of variables, shocks and parameters, and equation labels.
- 'typeface=' [ char | empty ] - (Not inheritable from parent objects) LaTeX code specifying the typeface for the model file as a whole; it must use the declarative forms (such as `\itshape`) and not the command forms (such as `\textit{...}`).

### Description

If you enter a model object with multiple parameterisations, only the first parameterisation will get reported.

At the moment, the syntax highlighting in model file reports does not handle correctly comment blocks, i.e. `%{ ... %}`.

### Example

---

## ■ new

Create new, empty report object

### Syntax

```
P = report.new(Caption,...)
```

### Output arguments

- P [ struct ] - Report object with function handles through which the individual report elements can be created.
- Caption [ char ] - Report caption; the caption will also be printed on the title page of the report if published with the option 'makeTitle=' true.

## Options

- 'centering=' [ `true` | `false` ] - All report elements, except `tex` [P410](#), will be centered on the page.
- 'orientation=' [ `'landscape'` | `'portrait'` ] - Paper orientation of the published report.

Report options are cascading. You can specify any of an object's options in any of his parent (or ascendant) objects.

---

## ■ pagebreak

Force page break

### Syntax

```
P.pagebreak(Caption,...)
```

### Input arguments

- P [ report ] - Report object created by the `report.new` [P398](#) function.
- Caption [ char ] - Caption for the pagebreak objet; the caption only displays in the on-screen report structure.

### Generic options

See help on [generic options](#) [P376](#) in report objects.

### Description

### Example

---

## ■ publish

Compile PDF from report object

## Syntax

```
[OutpFile,Rerun] = P.publish(InpFile,...)
```

## Input arguments

- P [ struct ] - Report object created by the report.new function.
- InpFile [ char ] - File name under which the compiled PDF will be saved.

## Output arguments

- OutpFile [ char ] - Name of the resulting PDF.
- Rerun [ numeric ] - Number of times the LaTeX compiler was run to compile the PDF.

## Options

- 'abstract=' [ char | empty ] - Abstract that will displayed on the title page.
- 'abstractWidth=' [ numeric | 1 ] - Width of the abstract on the page as a percentage of the full default width (between 0 and 1).
- 'author=' [ char | empty ] - List of authors on the title page separated with \and or \\.
- 'cd=' [ true | false ] - If true do not use the pdflatex option -include-directory and instead change the directory (cd) temporarily to the location of the input file; this is a workaround for systems where pdflatex does not support the option -include-directory.
- 'cleanup=' [ true | false ] - Delete all temporary files created when compiling the report.
- 'compile=' [ true | false ] - Compile the source files to an actual PDF; if false only the source files are created.
- 'date=' [ char | '\today' ] - Date on the title page.
- 'display=' [ true | false ] - Display the L<sup>A</sup>T<sub>E</sub>X compiler report on the final iteration.
- 'echo=' [ true | false ] - If true, the optional flag '-echo' will be used in the Matlab function system when compiling the PDF; this causes the screen output and all prompts to be displayed for each run of the compiler.
- 'epsToPdf=' [ char | Inf ] - Command line arguments for EPSTOPDF; Inf means OS-specific arguments are used.

## Report functions: section

- 'fontEnc=' [ char | 'T1' ] - L<sup>A</sup>T<sub>E</sub>X font encoding.
- 'makeTitle=' [ true | false ] - Produce title page (with title, author, date, and abstract).
- 'package=' [ char | cellstr | empty ] - Package or list of packages that will be imported in the preamble of the LaTeX file.
- 'paperSize=' [ 'a4paper' | 'letterpaper' ] - Paper size.
- 'orientation=' [ 'landscape' | 'portrait' ] - Paper orientation.
- 'preamble=' [ char | empty ] - L<sup>A</sup>T<sub>E</sub>X commands that will be placed in the L<sup>A</sup>T<sub>E</sub>X file preamble.
- 'timeStamp=' [ char | 'datestr(now())' ] - String printed in the top-left corner of each page.
- 'tempDir=' [ char | tempname(cd()) ] - Directory for storing temporary files; the directory is deleted at the end of the execution if it's empty.
- 'maxRerun=' [ numeric | 5 ] - Maximum number of times the L<sup>A</sup>T<sub>E</sub>X compiler will be run to resolve cross-references, etc.
- 'minRerun=' [ numeric | 1 ] - Minimum number of times the L<sup>A</sup>T<sub>E</sub>X compiler will be run to resolve cross-references, etc.
- 'textScale=' [ numeric | 0.8 ] - Percentage of the total page area that will be used.

### Description

—*Difference between 'display=' and 'echo='*

There are two differences between these otherwise similar options:

- When publishing the final PDF, the PDFLaTeX compiler may be called more than once to resolve cross-references, the table of contents, and so on. Setting 'display=' true only displays the screen output from the final iteration only, while 'echo=' true displays the screen outputs from all iterations.
- In the case of a compiler error unrelated to the L<sup>A</sup>T<sub>E</sub>X code, the compiler may stop and prompt the user to respond. The prompt only appears on the screen when 'echo=' true. Otherwise, Matlab may remain in a busy state with no on-screen information, and Ctrl+C may be needed to regain control.

### Example

---

## ■ section

Start new section in report

### Syntax

```
P.section(CAP,...)
```

### Input arguments

- P [ struct ] - Report object created by the [report.new](#) P398 function.
- CAP [ char ] - Section title.

### Options

- 'numbered=' [ true | false ] - (Inherited) Numbered section.
- 'separator=' [ char | empty ] - (Not inherited) L<sup>A</sup>T<sub>E</sub>X commands that will be inserted after the table.

### Generic options

See help on [generic options](#) P376 in report objects.

### Description

### Example

---

## ■ series

Add new data to graph or table

### Syntax

```
P.series(Cap,X,...)
```

### Input arguments

- `P` [ struct ] - Report object created by the `report.new` [P398](#) function.
- `Cap` [ char ] - Caption used as a default legend entry in a graph, or in the leading column in a table.
- `X` [ tseries ] - Input data that will be added to the current table or graph.

### Options for both table series and graph series

- `'marks='` [ cellstr | empty ] - (Inheritable from parent objects) Marks that will be added to the legend entries in graphs, or printed in a third column in tables, to distinguish the individual columns of possibly multivariate input tseries objects.
- `'showMarks='` [ true | false ] - (Inheritable from parent objects) Use the marks defined in the `'marks='` option to label the individual rows when input data is a multivariate tseries object.

### Options for table series

- `'autoData='` [ function\_handle | cell | empty ] - Function, or a cell array of functions, that will be used to produce new columns in the input tseries object (i.e. new rows of output in the report).
- `'condFormat='` [ struct | empty ] - (Inheritable from parent objects) Structure with `.test` and `.format` fields describing conditional formatting of individual table entries.
- `'decimal='` [ numeric | NaN ] - (Inheritable from parent objects) Number of decimals that will be displayed; if NaN the `'format='` option is used instead.
- `'format='` [ char | `'%.2f'` ] - (Inheritable from parent objects) Numeric format string; see help on the built-in `sprintf` function.
- `'footnote='` [ char | empty ] - Footnote at the series text.
- `'highlight='` [ numeric | empty ] - (Inheritable from parent objects) Periods that will get highlighted in tables; to highlight date ranges in graphs, use the `'highlight='` option in the parent graph object.
- `'inf='` [ char | `'\ensuremath{\infty}'` ] - (Inheritable from parent objects) LaTeX string that will be used to typeset Inf entries.
- `'nan='` [ char | `'\ensuremath{\cdot}` ] - (Inheritable from parent objects) LaTeX string that will be used to typeset NaN entries.

## Report functions: series

- 'pureZero=' [ char | empty ] - (Inheritable from parent objects) LaTeX string that will be used to typeset pure zero entries; if empty the zeros will be printed using the current numeric format.
- 'printedZero=' [ char | empty ] - (Inheritable from parent objects) LaTeX string that will be used to typeset the entries that would appear as zero under the current numeric format used; if empty these numbers will be printed using the current numeric format.
- 'separator=' [ char | empty ] - (Not inheritable from parent objects) LaTeX commands that will be inserted immediately after the end of the table row, i.e. appended to `\`, within a tabular mode.
- 'units=' [ char ] - (Inheritable from parent objects) Description of input data units that will be displayed in the second column of tables.

### Options for graph series

- 'legend=' [ char | cellstr | NaN | Inf ] - (Not inheritable from parent objects) Legend entries used instead of the series caption and marks; Inf means the caption and marks will be used to construct legend entries; NaN means the series will be excluded from legend.
- 'plotFunc=' [ @area | @bar | @barcon | @plot | @plotcmp | @plotpred | @stem ] - (Inheritable from parent objects) Plot function that will be used to create graphs.
- 'plotOptions=' [ cell | empty ] - Options passed as the last input arguments to the plot function.
- yAxis=' [ 'left' | \*'right' ] - Choose the LHS or RHS axis to plot this series; see also comments on LHS-RHS plots in Description.

### Generic options

See help on [generic options](#) P376 in report objects.

### Description

—Using the 'nan=', 'inf=', 'pureZero=' and 'printedZero=' options

When specifying the LaTeX string for these options, bear in mind that the table entries are printed in the math mode. This means that whenever you wish to print a normal text, you need to use an appropriate text formatting command allowed within a math mode. Most frequently, it would be '`\textnormal{...}`'.

*—Using the 'plotFunc=' option*

When you set the option to 'plotpred', the input data X (second input argument) must be a multicolumn tseries object where the first column is the time series observations, and the second and further columns are its Kalman filter predictions as returned by the filter function.

*—Conditional formatting*

The conditional format struct (or an array of structs) specified through the 'condFormat=' option must have two fields, .test and .format.

The .test field is a text string with a Matlab expression. The expression must evaluate to a scalar true or false, and can refer to the following attributes associated with each entry in the data part of the table:

- value - the numerical value of the entry,
- date - the date under which the entry appears,
- year - the year under which the entry appears,
- period - the period within the year (e.g. month or quarter) under which the entry appears,
- freq - the frequency of the date under which the entry appears,
- text - the text label on the left,
- mark - the text mark on the left used to describe the individual rows reported for multivariate series,
- row - the row number within a multivariate series.
- rowvalues - a row vector of all values on the current row.

If the table is based on user-defined structure of columns (option 'colstruct=' in [table P407](#)), the following additional attributes are available

- colname - descriptor of the column (text in the headline).

You can combine a number of attributes within one test, using the logical operators, e.g.

```
'value > 0 && year > 2010'
```

The `.format` fields of the conditional format structure consist of LaTeX commands that will be used to typeset the corresponding entry. The reference to the entry itself is through a question mark. The entries are typeset in math mode; this for instance means that for bold or italic typface, you must use the `\mathbf{...}` and `\mathit{...}` commands.

In addition to standard LaTeX commands, you can use the following IRIS-specific commands in the format strings:

- `\sprintf{FFFF}` - to modify the way each numeric entry that passes the test is printed by the `sprintf` function; FFFF is one of the standard `sprintf` formatting strings.
- `\hide{?}` - to hide the actual entry when it is supposed to be replaced with something else.

You can combine multiple tests and their corresponding formats in one structure; they will be all applied to each entry in the specified order.

#### —LHS-RHS plots

The LHS-RHS report graphs are still an experimental feature.

When the option `'yAxis='` is used to plot on both the LHS and the RHS y-axis, the plot functions are restricted to `@plot`, `@bar`, `@area` and `@stem`. Also, because of a bug in Matlab, always control the color of the lines, bars and areas in all LHS-RHS graphs: use either the option `'plotOptions='` in this command, or `'style='` in the respective `graph` [P389](#) command.

#### Example of a conditional format structure

```
cf = struct();
cf(1).test = 'value < 0';
cf(1).format = '\mathit{?}';
cf(2).test = 'date < qq(2010,1)';
cf(2).format = '\color{blue}';
```

## ■ subheading

Enter subheading in table

### Syntax

```
P.subheading(CAP,...)
```

### Input arguments

- `P [ struct ]` - Report object created by the `report.new` [P398](#) function.
- `CAP [ char ]` - Text displayed as a subheading on a separate line in the table.

### Options

- `'justify=' [ 'c' | 'l' | 'r' ]` - (Inheritable from parent objects) Horizontal alignment of the subheading (centre, left, right).
- `'separator=' [ char | empty ]` - (Not inheritable from parent objects) LaTeX commands that will be inserted immediately after the end of the table row, i.e. appended to `\`, within a tabular mode.
- `'stretch=' [ true | false ]` - (Inheritable from parent objects) Stretch the subheading text also across the data part of the table; if not the text will be contained within the initial descriptive columns.
- `'typeface=' [ char | '\itshape\bfseries' ]` - (Not inheritable from parent objects) LaTeX code specifying the typeface for the subheading; it must use the declarative forms (such as `\itshape`) and not the command forms (such as `\textit{...}`).

### Generic options

See help on [generic options](#) [P376](#) in report objects.

### Description

### Example

---

## ■ table

Start new table

## Syntax

P.table(Caption,...)

## Input arguments

- P [ report ] - Report object created by the `report.new` [P398](#) function.
- Caption [ char | cellstr ] - Title or a cell array with title and subtitle displayed at the top of the table; see Description for splitting the title or subtitle into multiple lines.

## Options

- 'arrayStretch=' [ numeric | 1.15 ] - (Inheritable from parent objects) Stretch between lines in the table (in pts).
- 'captionTypeface=' [ cell | '\large\bfseries' ] - LaTeX format commands for typesetting the table caption and subcaption; you can use Inf for either to indicate the default format.
- 'colStruct=' [ struct | empty ] - (Not inheritable from parent objects) User-defined structure of the table columns; use of this option disables 'range='.
- 'colWidth=' [ numeric | NaN ] - (Inheritable from parent objects) Width, or a vector of widths, of the table columns in emunits; NaN means the width of the column will adjust automatically.
- 'headlineJustify=' [ 'c' | 'l' | 'r' ] - Horizontal alignment of the headline entries (individual dates or user-defined text): Centre, Left, Right.
- 'dateFormat=' [ char | cellstr | irisget('dateFormat') ] - (Inheritable from parent objects) Format string for the date row.
- 'footnote=' [ char | empty ] - Footnote at the table title; only shows if the title is non-empty.
- 'long=' [ true | false ] - (Inheritable from parent objects) If true, the table may stretch over more than one page.
- 'longFoot=' [ char | empty ] - (Inheritable from parent objects) Works only with 'long'=true: Footnote that appears at the bottom of the table (if it is longer than one page) on each page except the last one.
- 'longFootPosition=' [ 'centre' | 'left' | 'right' ] - (Inheritable from parent objects) Works only with 'long=' true: Horizontal alignment of the footnote in long tables.
- 'range=' [ numeric | empty ] - (Inheritable from parent objects) Date range or vector of dates that will appear as columns of the table.

## Report functions: table

- `'separator='` [ char | `'\medskip\par'` ] - (Inheritable from parent objects) L<sup>A</sup>T<sub>E</sub>X commands that will be inserted after the table.
- `'sideways='` [ true | `false` ] - (Inheritable from parent objects) Print the table rotated by 90 degrees.
- `'tabcolsep='` [ NaN | numeric ] - (Inheritable from parent objects) Space between columns in the table, measured in em units; NaN means the L<sup>A</sup>T<sub>E</sub>X default.
- `'typeface='` [ char | `empty` ] - (Not inheritable from parent objects) L<sup>A</sup>T<sub>E</sub>X code specifying the typeface for the table as a whole; it must use the declarative forms (such as `\itshape`) and not the command forms (such as `\textit{...}`).
- `'vline='` [ numeric | `empty` ] - (Inheritable from parent objects) Vector of dates after which a vertical line (divider) will be placed.

### Generic options

See help on [generic options](#) P376 in report objects.

### Description

Tables are top-level report objects and cannot be nested within other report objects, except [align](#) P378. Table objects can have the following children:

- [series](#) P402;
- [subheading](#) P406.

By default, the date row is printed as a leading row with dates formatted using the option `'dateFormat='`. Alternatively, you can specify this option as a cell array of two strings. In that case, the dates will be printed in two rows. The first row will have a date string displayed and centred for every year, and the first cell of the `'dateFormat='` option will be used for formatting. The second row will have a date displayed for every period (i.e. every column), and the second cell of the `'dateFormat='` option will be used for formatting.

—*User-defined structure of the table columns*

Use can use the `'columnStruct='` option to define your own table columns. This gives you more flexibility than when using the `'range='` option in defining the content of the table.

The option `'columnStruct='` must be a 1-by-N struct, where N is the number of columns you want in the table, with the following fields:

- 'name=' - specifies the descriptor of the column that will be displayed in the headline;
- 'func=' - specifies a function that will be applied to the input series; if 'func=' is empty, no function will be applied. The function must evaluate to a tseries or a numeric scalar.
- 'date=' - specifies the date at which a number will be taken from the series unless the function 'func=' applied before resulted in a numeric scalar.

—*Titles and subtitles*

The input argument Caption can be either a text string, or a 1-by-2 cell array of strings. In the latter case, the first cell will be printed as a title, and the second cell will be printed as a subtitle.

To split the title or subtitle into multiple lines, use the following LaTeX commands wrapped in curly brackets: `{\}` or `{\}[Xpt]}`, where X is the width of an extra vertical space (in points) added between the respective lines.

### Example

Compare the headers of these two tables:

```
x = report.new();

x.table('First table', ...
    'range',qq(2010,1):qq(2012,4), ...
    'dateformat','YYYYFP');
% You can add series or subheadings here.

x.table('Second table', ...
    'range',qq(2010,1):qq(2012,4), ...
    'dateformat',{'YYYY','FP'});
% You can add series or subheadings here.

x.publish('myreport.pdf');
```

---

## ■ tex

Include  $\LaTeX$  code or verbatim text input in report

### Syntax with input specified in comment block

```
P.tex(Cap,...)

%{
Write text or \LaTeX\ code as a block comment
right after the P.tex(...) command.
%}
```

### Syntax with input specified as char argument

```
P.tex(Cap,Code,...)
```

### Input arguments

- P [ struct ] - Report object created by the [report.new](#) P398 function.
- Cap [ char ] - Caption displayed at the top of the text.
- Code [ char ] -  $\LaTeX$  code or text input that will be included in the report.

### Options

- 'centering=' [ true | false ] - (Inheritable from parent objects) Centre the  $\LaTeX$  code or text input on the page.
- 'footnote=' [ char | empty ] - Footnote at the tex block title; only shows if the title is non-empty.
- 'separator=' [ char | '\medskip\par' ] - (Inheritable from parent objects)  $\LaTeX$  commands that will be inserted after the text.
- 'verbatim=' [ true | false ] - If true the text will be typeset verbatim in monospaced font; if false the text will be treated as  $\LaTeX$  code included in the report.

### Generic options

See help on [generic options](#) P376 in report objects.

## Description

## Example

---

## ■ userfigure

Insert existing figure window

## Syntax

```
P.userfigure(Caption,H,...)
```

## Input arguments

- P [ struct ] - Report object created by the [report.new](#) P398 function.
- Caption [ char | cellstr ] - Title or a cell array with title and subtitle displayed at the top of the figure; see Description for splitting the title or subtitle into multiple lines.
- H [ numeric ] - Handle to a graphics figure created by the user that will be captured and inserted in the report.

## Options

See help on [report/figure](#) P386 for options available.

## Generic options

See help on [generic options](#) P376 in report objects.

## Description

The function `report/userfigure` inserts an existing figure window (created by the user by standard Matlab commands, and referenced by its handle, H) into a report:

- The figure and the graphs in it must be created before you call `report/figure`: any changes or additions to the figure or its graphs made after you call the function will not show in the report.

- The report figure cannot have any children; in other words, you cannot call `report/graph` [P389](#) after a call to `report/figure` with a graphics handle, H.

—*Titles and subtitles*

The input argument `Caption` can be either a text string, or a 1-by-2 cell array of strings. In the latter case, the first cell will be printed as a title, and the second cell will be printed as a subtitle.

To split the title or subtitle into multiple lines, use the following LaTeX commands wrapped in curly brackets: `{\}` or `{\}[Xpt]}`, where X is the width of an extra vertical space (in points) added between the respective lines.

### Example

## ■ vline

Add vertical line to graph

### Syntax

```
P.vline(Caption,Date,...)
```

### Input arguments

- `P [ struct ]` - Report object created by the `report.new` [P398](#) function.
- `Caption [ char ]` - Caption used to annotate the vertical line.
- `Date [ numeric ]` - Date at which the vertical line will be plotted.

### Options

- `'hPosition=' [ 'bottom' | 'middle' | 'top' ]` - (Inheritable from parent objects) Horizontal position of the caption.
- `'vPosition=' [ 'centre' | 'left' | 'right' ]` - (Inheritable from parent objects) Vertical position of the caption relative to the line.

## Report functions: vline

- 'timePosition=' [ 'after' | 'before' | 'middle' ] - Placement of the vertical line on the time axis: in the middle of the specified period, immediately before it (between the specified period and the previous one), or immediately after it (between the specified period and the next one).

### Generic options

See help on [generic options](#) P376 in report objects.

### Description

### Example

## 21 Quick-report file language

### Figures

- `!++` P415 - Create new figure window.
- `#MxN` P418 - Specify the subplot division of the figure windows. figure windows.

### Graphs

- `!--` P416 - Create new line graph.
- `!::` P416 - Create new bar graph.
- `!ii` P418 - Create new stem graph.
- `!II` P417 - Create new errorbar graph.
- `!^^` P417 - Create new histogram.
- `!..` P416 - Skip the current subplot position leaving it blank.

### Formatting graph titles

- `//` P419 - Line break in graph title.
- `--` P419 - Subtitle in graph title.

### Getting on-line help on qreport file language

```
help qreportlang  
help qreportlang/keyword
```

---

### ■ !+++

Create new figure window

### Syntax

```
!++ figure_caption
```

**Description**

**Example**

---

■ !-

Create new line graph

**Syntax**

```
!-- graph_caption  
    expression1, expression2, ...
```

**Description**

**Example**

---

■ !..

Skip the current subplot position leaving it blank

**Syntax**

```
!..
```

**Description**

**Example**

---

■ !::

Create new bar graph

### Syntax

```
!:: graph_caption  
    expression1, expression2, ...
```

### Description

### Example

---

#### ■ !^ ^

Create new histogram

### Syntax

```
!^^ graph_caption  
    expression1, expression2, ...
```

### Description

### Example

---

#### ■ !II

Create new errorbar graph

### Syntax

```
!II TITLE  
    EXPRESSION1, EXPRESSION2, ...
```

### Description

### Example

---

#### ■ !ii

Create new stem graph

### Syntax

```
!ii TITLE  
    EXPRESSION1, EXPRESSION2, ...
```

### Description

### Example

---

#### ■ #MxN

Specify the subplot division of the figure windows

### Syntax with user-supplied subdivision

```
#MxN
```

### Syntax for automatic subdivision

```
#auto
```

### Input arguments

- M [ numeric ] - Number of rows of graphs in each figure window from this point on.

Quick-report file language: \_\_

- N [ numeric ] - Number of columns of graphs in each figure window from this point on.

### Description

### Example

This command produces figure windows with 3x2 graphs in each.

```
#3x2
```

---

■ //

Line break in graph title

### Syntax

```
!-- FIRST LINE // SECOND LINE // ...
```

### Description

### Example

■ \_ \_

Subtitle in graph title

### Syntax

```
!-- TITLE __ SUBTITLE
```

Quick-report file language: \_\_

**Description**

**Example**

## 22 Quick-report functions

### Quick-report functions

- `qplot` [P421](#) - Quick report.
- `qstyle` [P423](#) - Apply styles to graphics object and its descendants.

### Getting on-line help on qreport functions

```
help qreport  
help qreport/function_name
```

---

## ■ qplot

Quick report

### Syntax

```
[FF,AA,PDb] = qplot(QFile,D,Range,...)
```

### Input arguments

- `QFile` [ char ] - Name of the q-file that defines the contents of the individual graphs.
- `D` [ struct ] - Database with input data.
- `Range` [ numeric ] - Date range.

### Output arguments

- `FF` [ numeric ] - Handles to figures created by `qplot`.
- `AA` [ cell ] - Handles to axes created by `qplot`.
- `PDb` [ struct ] - Database with actually plotted series.

## Options

- 'addClick=' [ true | false ] - Make axes expand in a new graphics figure upon mouse click.
- 'caption=' [ cellstr | @comment | empty ] - Strings that will be used for titles in the graphs that have no title in the q-file.
- 'clear=' [ numeric | empty ] - Serial numbers of graphs (axes objects) that will not be displayed.
- 'dbsave=' [ cellstr | empty ] - Options passed to dbsave when 'saveAs=' is used.
- 'drawNow=' [ true | false ] - Call Matlab drawnow function upon completion of all figures.
- 'grid=' [ true | false ] - Add grid lines to all graphs.
- 'highlight=' [ numeric | cell | empty ] - Date range or ranges that will be highlighted.
- 'interpreter=' [ 'latex' | 'none' ] - Interpreter used in graph titles.
- 'mark=' [ cellstr | empty ] - Marks that will be added to each legend entry to distinguish individual columns of multivariated tseries objects plotted.
- 'overflow=' [ true | false ] - Open automatically a new figure window if the number of subplots exceeds the available total; 'overflow' = false means an error will occur instead.
- 'prefix=' [ char | 'P%g\_' ] - Prefix (a sprintf format string) that will be used to precede the name of each entry in the PDb database.
- 'round=' [ numeric | Inf ] - Round the input data to this number of decimals before plotting.
- 'saveAs=' [ char | empty ] - File name under which the plotted data will be saved either in a CSV data file or a PDF; you can use the 'dbsave=' option to control the options used when saving CSV.
- 'style=' [ struct | empty ] - Style structure that will be applied to all figures and their children created by the qplot function.
- 'subplot=' [ 'auto' | numeric ] - Default subplot division of figures, can be modified in the q-file.
- 'sstate=' [ struct | model | empty ] - Database or model object from which the steady-state values referenced to in the quick-report file will be taken.
- 'style=' [ struct | empty ] - Style structure that will be applied to all created figures upon completion.
- 'transform=' [ function\_handle | empty ] - Function that will be used to transform the data.
- 'tight=' [ true | false ] - Make the y-axis in each graph tight.

## Quick-report functions: qstyle

- 'vLine=' [ numeric | empty ] - Dates at which vertical lines will be plotted.
- 'zeroLine=' [ true | false ] - Add a horizontal zero line to graphs whose y-axis includes zero.

### Description

### Example

---

## ■ qstyle

Apply styles to graphics object and its descendants

### Syntax

```
qstyle(H,S,...)
```

### Input arguments

- H [ numeric ] - Handle to a figure or axes object that will be styled together with its descendants (unless 'cascade=' is false).
- S [ struct ] - Struct each field of which refers to an object-dot-property; the value of the field will be applied to the the respective property of the respective object; see below the list of graphics objects allowed.

### Options

- 'cascade=' [ true | false ] - Cascade through all descendants of the object H; if false only the object H itself will be styled.
- 'warning=' [ true | false ] - Display warnings produced by this function.

### Description

The style structure, S, is constructed of any number of nested object-property fields:

```
S.object.property = value;
```

## Quick-report functions: qstyle

The following is the list of standard Matlab graphics objects the top-level fields can refer to:

- figure;
- axes;
- title;
- xlabel;
- ylabel;
- zlabel;
- line;
- bar;
- patch;
- text.

In addition, you can also refer to the following special instances of objects created by IRIS functions:

- rhsaxes (an RHS axes object created by plotyy)
- legend (represented by an axes object);
- plotpred (line objects with prediction data created by plotpred);
- highlight (a patch object created by highlight);
- highlightcaption (a text object created by highlight);
- vline (a line object created by vline);
- vlinecaption (a text object created by vline);
- zeroline (a line object created by zeroline).

The property used as the second-level field is simply any regular Matlab property of the respective object (see Matlab help on graphics).

The value assigned to a particular property can be either of the following:

- a single proper valid value (i.e. a value you would be able to assign using the standard Matlab set function);

## Quick-report functions: qstyle

- a cell array of multiple different values that will be assigned to the objects of the same type in order of their creation;
- a text string starting with a double exclamation point, `!!`, followed by Matlab commands. The commands are expected to eventually create a variable named `SET` whose value will then be assigned to the respective property. The commands have access to variable `H`, a handle to the current object.

### Example

## 23 Graphics functions

### Graphics functions

- [bottomlegend](#) P426 - Horizontal graph legend displayed at the bottom of the figure window.
- [ftitle](#) P427 - Add title to figure window.
- [highlight](#) P428 - Highlight specified range or date range in a graph.
- [hline](#) P438 - Add vertical line with text caption at the specified position.
- [maxfigure](#) P429 - Create graphics window maximised across the entire screen.
- [movetobkg](#) P429 - Move graphics objects to the background.
- [movetosubplot](#) P430 - Move an existing axes object or legend to specified subplot position.
- [plotcircle](#) P431 - Draw a circle or disc.
- [plotpp](#) P434 - Plot prior and/or posterior distributions and/or posterior mode.
- [plotmat](#) P431 - Visualise 2D matrix.
- [plotneigh](#) P433 - Plot local behaviour of objective function after estimation.
- [vline](#) P436 - Add vertical line with text caption at the specified position.
- [zeroline](#) P437 - Add zero line if Y-axis limits include zero.

### Getting on-line help on qreport functions

```
help grfun  
help grfun/function_name
```

---

### ■ bottomlegend

Horizontal graph legend displayed at the bottom of the figure window

#### Syntax

```
Le = grfun.bottomlegend(Entry,Entry,...)
```

### Input arguments

- Entry [ char | cellstr ] - Legend entries; same as in the standard legend function.

### Output arguments

- AX [ numeric ] - Handle to the legend axes object created.

### Description

### Example

---

## ■ ftitle

Add title to figure window

### Syntax

```
AA = grfun.ftitle(Titles,...)
AA = grfun.ftitle(FF,Titles,...)
```

### Input arguments

- FF [ numeric | struct ] - Handle to a figure window or windows; or a struct that includes a field name figure.
- Titles [ cellstr | char ] - Text string to be centred, or cell array of strings to be placed on the LHS, centred, and on the RHS of the figure.

### Output arguments

- AA [ numeric ] - Handle or handles to annotation objects.

### Options

- 'location=' [ 'north' | 'west' | 'east' | 'south' ] - Location of the figure title: top, left edge sideways, right edge sideways, bottom.

## Description

## Example

---

## ■ highlight

Highlight specified range or date range in a graph

## Syntax

```
[Pt,Cp] = highlight(Range,...)
[Pt,Cp] = highlight(Ax,Range,...)
```

## Input arguments

- Range [ numeric ] - X-axis range or date range that will be highlighted.
- Ax [ numeric ] - Handle(s) to axes object(s) in which the highlight will be made.

## Output arguments

- Pt [ numeric ] - Handle to the highlighted area (patch object).
- Cp [ numeric ] - Handle to the caption (text object).

## Options

- 'caption=' [ char ] - Annotate the highlighted area with this text string.
- 'color=' [ numeric | [0.9,0.9,0.9] ] - An RGB color code or a Matlab color name.
- 'excludeFromLegend=' [ true | false ] - Exclude the highlighted area from legend.
- 'hPosition=' [ 'center' | 'left' | 'right' ] - Horizontal position of the caption.
- 'vPosition=' [ 'bottom' | 'middle' | 'top' | numeric ] - Vertical position of the caption.

## Description

## Example

---

### ■ maxfigure

Create graphics window maximised across the entire screen

## Syntax

```
Fig = maxfigure(...)
```

## Output arguments

- Fig [ numeric ] - Handle to the figure created.

## Options

See help on standar figure for the options available.

## Description

The function maxfigure uses get(0,'screenSize') to determine the size of the screen, and sets the figure property 'outerPosition' accordingly.

## Example

---

### ■ movetobkg

Move graphics objects to the background

### Syntax

```
grfun.movetobkg(Parent,Children)
```

### Input arguments

- Parent [ numeric ] - Graphics handle to a parent object.
- Children [ numeric ] - Graphics handle to children that will be moved to the background.

### Description

### Example

---

## ■ movetosubplot

Move an existing axes object or legend to specified subplot position

### Syntax

```
Ax = movetosubplot(Ax,M,N,P)
```

### Input arguments

- Ax [ numeric ] - Handle to an existing axes object or legend.
- M, N, P [ numeric ] - Specification of the new position; see help on standard subplot.

### Output arguments

- AX [ numeric ] - Handle to the axes or legend moved to the new position.

### Description

### Example

---

## ■ plotcircle

Draw a circle or disc

### Syntax

```
H = grfun.plotcircle(X,Y,RAD,...)
```

### Input arguments

- X [ numeric ] - X-axis location of the centre of the circle.
- Y [ numeric ] - Y-axis location of the centre of the circle.
- RAD [ numeric ] - Radius of the circle.

### Output arguments

- H [ numeric ] - Handle to the line or the filled area.

### Options

- 'fill=' [ true | false ] - Switch between a circle ('fill=' false) and a disc ('fill=' true).

Any property name-value pair valid for line graphs.

### Description

### Example

---

## ■ plotmat

Visualise 2D matrix

### Syntax

```
[HPos,HNeg,HNaNInf,HMax] = grfun.plotmat(X,...)
```

### Short-cut syntax

```
[HPos,HNeg,HNanInf,HMax] = plotmat(X,...)
```

### Input arguments

- `X` [ numeric ] - 2D matrix that will be visualised; ND matrices will be unfolded in 2nd dimension before plotting.

### Output arguments

- `HPos` [ numeric ] - Handles to discs displaying non-negative entries.
- `HNeg` [ numeric ] - Handles to discs displaying negative entries.
- `HNanInf` [ numeric ] - Handles to NaN or Inf marks.
- `HMax` [ numeric ] - Handles to circles displaying maximum value.

### Options

- `'colNames='` [ char | cellstr | empty | 'auto' ] - Names that will be given to the columns of the matrix.
- `'rowNames='` [ char | cellstr | empty | 'auto' ] - Names that will be give to the row of the matrix.
- `'maxCircle='` [ true | false ] - If true,display a circle denoting the maximum value around each entry.
- `'nanInf='` [ char | `X` ] - Appearance of NaN and Inf entries.
- `'showDiag='` [ true | false ] - If false, hide the entries on the main diagonal by setting them to NaN.
- `'scale='` [ numeric | 'auto' ] - Maximum value (positive) relative to which all matrix entries will be scaled; by default the scale is the maximum entry in the input matrix, `max(max(abs(X(isfinite(X)))))`.

### Description

### Example

## ■ plotneigh

Plot local behaviour of objective function after estimation

### Syntax

```
H = grfun.plotneigh(D,...)
```

### Input arguments

- D [ struct ] - Structure describing the local behaviour of the objective function returned by the [neighbourhood](#) P122 function.

### Output arguments

- H [ struct ] - Struct with handles to the graphics objects plotted by plotpp; the struct has the following fields with vectors of handles: figure, axes, obj, est, lik, bounds.

### Options

- 'caption=' [ empty | cellstr ] - User-supplied graph titles; if empty, default captions will be automatically created.
- 'model=' [ model | empty ] - Model object used to create graph captions if the option 'caption=' is 'descript' or 'alias'.
- 'plotObj=' [ true | false ] - Plot the local behaviour of the overall objective function; a cell array can be specified to control graphics options.
- 'plotLik=' [ true | false | cell ] - Plot the local behaviour of the data likelihood component; a cell array can be specified to control graphics options.
- 'plotEst=' [ true | false | cell ] - Mark the actual parameter estimate; a cell array can be specified to control graphics options.
- 'plotBounds=' [ true | false | cell ] - Draw the lower and/or upper bounds if they fall within the graph range; a cell array can be specified to control graphics options.
- 'subplot=' [ 'auto' | numeric ] - Subplot division of the figure when plotting the results.
- 'title=' [ { 'interpreter=', 'none' } | cell ] - Display graph titles, and specify graphics options for the titles.
- 'linkAxes=' [ true | false ] - Make the vertical axes identical for all graphs.

## Description

The data log-likelihood curves are shifted up or down by an arbitrary constant to make them fit in the graph; their curvature is preserved.

## Example

---

## ■ plotpp

Plot prior and/or posterior distributions and/or posterior mode

### Syntax

```
[PrG,PoG,H] = grfun.plotpp(E,[],[],...)  
[PrG,PoG,H] = grfun.plotpp(E,Est,[],...)  
[PrG,PoG,H] = grfun.plotpp(E,[],Theta,...)  
[PrG,PoG,H] = grfun.plotpp(E,[],Stats,...)  
[PrG,PoG,H] = grfun.plotpp(E,Est,Theta,...)  
[PrG,PoG,H] = grfun.plotpp(E,Est,Stats,...)
```

### Input arguments

- E [ struct ] - Estimation input struct, see [estimate](#) [P82], with prior function handles from the [logdist](#) [P176] package.
- Est [ struct | empty ] - Output struct returned by the [model/estimate](#) [P82] function; Est will be used to plot the maximised posterior modes.
- Theta [ numeric | empty ] - Array with the chain of draws from the posterior simulator [arwm](#) [P169].
- Stats [ struct | empty ] - Output struct returned by the posterior simulator statistics function [stats](#) [P173].

### Output arguments

- PrG [ struct ] - Struct with x- and y-axis coordinates to plot the prior distribution for each parameter.

## Graphics functions: plotpp

- PoG [ struct ] - Struct with x- and y-axis coordinates to plot the posterior distribution for each parameter.
- H [ struct ] - Struct with handles to the graphics objects plotted by plotpp; the struct has the following fields with vectors of handles: figure, axes, prior, poster, bounds, init, mode, title.

### Options

- 'caption=' [ empty | cellstr ] - User-supplied graph titles; if empty, default captions will be automatically created.
- 'describe=' [ 'auto' | true | false ] - Include information on prior distributions, starting values, and maximised posterior modes in the graph titles; 'auto' means the descriptions will be shown only if 'plotPrior=' is true.
- 'ksdensity=' [ numeric | empty ] - Number of points over which the density will be calculated; if empty, default number will be used depending on the backend function available.
- 'plotInit=' [ true | false | cell ] - Plot starting values (initial condition used in posterior mode maximisation) as vertical stems.
- 'plotPrior=' [ true | false | cell ] - Plot prior distributions.
- 'plotMode=' [ true | false | cell ] - Plot maximised posterior modes as vertical stems; the modes are taken from Est (and not from Stats or Theta).
- 'plotPoster=' [ true | false | cell ] - Plot posterior distributions.
- 'plotBounds=' [ true | false | cell ] - Plot lower and/or upper bounds as vertical lines; if false, the bounds will be plotted only added if within the graph x-limits.
- 'sigma=' [ numeric | 3 ] - Number of std devs from the mean or the mode (whichever covers a larger area) to the left and to right that will be plotted unless running out of bounds.
- 'tight=' [ true | false ] - Make graph axes tight.
- 'title=' [ true | false | cell ] - Display graph titles, and specify graphics options for the titles.
- 'xLims=' [ struct | empty ] - Control the x-limits of the prior and posterior graphs.

## Description

The options that control what will be plotted in the graphs (i.e. 'plotInit=', 'plotPrior=', 'plotMode=', 'plotPoster=', 'plotBounds=', 'title=') can be set to one of the following three values:

- true,
- false,
- a cell array with sub-options to control the appearance of the respective line; these will be passed into the respective plotting function.

## Example

---

### ■ vline

Add vertical line with text caption at the specified position

## Syntax

```
[Ln,Cp] = grfun.vline(Xpos,...)
[Ln,Cp] = grfun.vline(H,XPos,...)
```

## Input arguments

- 'XPos' [ numeric ] - Horizontal position or vector of positions at which the vertical line or lines will be drawn.
- H [ numeric ] - Handle to an axes object (graph) or to a figure window in which the the line will be added; if not specified the line will be added to the current axes.

## Output arguments

- Ln [ numeric ] - Handle to the vline(s) plotted (line objects).
- Cp [ numeric ] - Handle to the caption(s) created (text objects).

## Options

- 'caption=' [ char ] - Annotate the vline with this text string.
- 'excludeFromLegend=' [ true | false ] - Exclude the line from legend.
- 'hPosition=' [ 'center' | 'left' | 'right' ] - Horizontal position of the caption.
- 'vPosition=' [ 'bottom' | 'middle' | 'top' | numeric ] - Vertical position of the caption.
- 'timePosition=' [ 'after' | 'before' | 'middle' ] - Placement of the vertical line on the time axis: in the middle of the specified period, immediately before it (between the specified period and the previous one), or immediately after it (between the specified period and the next one).

## Description

### Example

---

## ■ zeroline

Add zero line if Y-axis limits include zero

### Syntax

```
Ln = zeroline(...)  
Ln = zeroline(H,...)
```

### Input arguments

- H [ numeric ] - Handle to an axes object (graph) or to a figure window in which the line will be added; if not specified the line will be added to the current axes.

### Output arguments

- Ln [ numeric ] - Handle to the line plotted (line object).

## Options

Any options valid for the standard plot function.

## Description

## Example

---

## ■ zeroline

Add vertical line with text caption at the specified position

## Syntax

```
Ln = hline(YPos,...)
Ln = hline(H,YPos,...)
```

## Input arguments

- 'YPos' [ numeric ] - Vertical position or vector of positions at which the horizontal line or lines will be drawn.
- H [ numeric ] - Handle to an axes object (graph) or to a figure window in which the the horizontal line will be added; if not specified the line will be added to the current axes.

## Output arguments

- Ln [ numeric ] - Handle to the line plotted (line object).

## Options

- 'excludeFromLegend=' [ true | false ] - Exclude the line from legend.

Any options valid for the standard plot function.

**Description**

**Example**