corrgram — Tabulate and graph autocorrelations

Description

corrgram produces a table of the autocorrelations, partial autocorrelations, and portmanteau (Q) statistics. It also displays a character-based plot of the autocorrelations and partial autocorrelations. See [TS] **wntestq** for more information on the Q statistic.

ac produces a correlogram (a graph of autocorrelations) with pointwise confidence intervals that is based on Bartlett's formula for MA(q) processes.

pac produces a partial correlogram (a graph of partial autocorrelations) with confidence intervals calculated using a standard error of $1/\sqrt{n}$. The residual variances for each lag may optionally be included on the graph.

Quick start

Produce correlogram for y using tsset data

```
corrgram y
```

Same as above, but limit the number of computed autocorrelations to 10

```
corrgram y, lags(10)
```

Plot the autocorrelation function for y

```
ac y
```

Same as above, and generate newv to hold the autocorrelations

```
ac y, generate(newv)
```

Plot partial autocorrelation function for y, and include standardized residual variances in the graph

```
pac y, srv
```

Menu

corrgram

Statistics > Time series > Graphs > Autocorrelations & partial autocorrelations

ac

Statistics > Time series > Graphs > Correlogram (ac)

pac

Statistics > Time series > Graphs > Partial correlogram (pac)

Syntax

Autocorrelations, partial autocorrelations, and portmanteau (Q) statistics

`corrgram` *varname* [*if*] [*in*] [, *corrgram_options*]

Graph autocorrelations with confidence intervals

`ac` *varname* [*if*] [*in*] [, *ac_options*]

Graph partial autocorrelations with confidence intervals

`pac` *varname* [*if*] [*in*] [, *pac_options*]

corrgram_options	Description
Main	
`lags(#)`	calculate # autocorrelations
`noplot`	suppress character-based plots
`yw`	calculate partial autocorrelations by using Yule–Walker equations

ac_options	Description
Main	
`lags(#)`	calculate # autocorrelations
`generate(`*newvar*`)`	generate a variable to hold the autocorrelations
`level(#)`	set confidence level; default is `level(95)`
`fft`	calculate autocorrelation by using Fourier transforms
Plot	
line_options	change look of dropped lines
marker_options	change look of markers (color, size, etc.)
marker_label_options	add marker labels; change look or position
CI plot	
`ciopts(`*area_options*`)`	affect rendition of the confidence bands
Add plots	
`addplot(`*plot*`)`	add other plots to the generated graph
Y axis, X axis, Titles, Legend, Overall	
twoway_options	any options other than `by()` documented in [G-3] ***twoway_options***

pac_options	Description
Main	
lags(#)	calculate # partial autocorrelations
generate(*newvar*)	generate a variable to hold the partial autocorrelations
yw	calculate partial autocorrelations by using Yule–Walker equations
level(#)	set confidence level; default is level(95)
Plot	
line_options	change look of dropped lines
marker_options	change look of markers (color, size, etc.)
marker_label_options	add marker labels; change look or position
CI plot	
ciopts(*area_options*)	affect rendition of the confidence bands
SRV plot	
srv	include standardized residual variances in graph
srvopts(*marker_options*)	affect rendition of the plotted standardized residual variances (SRVs)
Add plots	
addplot(*plot*)	add other plots to the generated graph
Y axis, X axis, Titles, Legend, Overall	
twoway_options	any options other than by() documented in [G-3] ***twoway_options***

You must tsset your data before using corrgram, ac, or pac; see [TS] **tsset**. Also, the time series must be dense (nonmissing and no gaps in the time variable) in the sample if you specify the fft option.

varname may contain time-series operators; see **[U] 11.4.4 Time-series varlists**.

collect is allowed with corrgram; see **[U] 11.1.10 Prefix commands**.

Options for corrgram

Main

lags(#) specifies the number of autocorrelations to calculate. The default is to use $\min(\lfloor n/2 \rfloor - 2, 40)$, where $\lfloor n/2 \rfloor$ is the greatest integer less than or equal to $n/2$.

noplot prevents the character-based plots from being in the listed table of autocorrelations and partial autocorrelations.

yw specifies that the partial autocorrelations be calculated using the Yule–Walker equations instead of using the default regression-based technique. yw cannot be used if srv is used.

Options for ac and pac

Main

lags(#) specifies the number of autocorrelations to calculate. The default is to use $\min(\lfloor n/2 \rfloor - 2, 40)$, where $\lfloor n/2 \rfloor$ is the greatest integer less than or equal to $n/2$.

generate(*newvar*) specifies a new variable to contain the autocorrelation (ac command) or partial autocorrelation (pac command) values. This option is required if the nograph option is used.

nograph (implied when using generate() in the dialog box) prevents ac and pac from constructing a graph. This option requires the generate() option.

yw (pac only) specifies that the partial autocorrelations be calculated using the Yule–Walker equations instead of using the default regression-based technique. yw cannot be used if srv is used.

level(#) specifies the confidence level, as a percentage, for the confidence bands in the ac or pac graph. The default is level(95) or as set by set level; see [R] **level**.

fft (ac only) specifies that the autocorrelations be calculated using two Fourier transforms. This technique can be faster than simply iterating over the requested number of lags.

Plot

line_options, *marker_options*, and *marker_label_options* affect the rendition of the plotted autocorrelations (with ac) or partial autocorrelations (with pac).

line_options specify the look of the dropped lines, including pattern, width, and color; see [G-3] ***line_options***.

marker_options specify the look of markers. This look includes the marker symbol, the marker size, and its color and outline; see [G-3] ***marker_options***.

marker_label_options specify if and how the markers are to be labeled; see [G-3] ***marker_label_options***.

CI plot

ciopts(*area_options*) affects the rendition of the confidence bands; see [G-3] ***area_options***.

SRV plot

srv (pac only) specifies that the standardized residual variances be plotted with the partial autocorrelations. srv cannot be used if yw is used.

srvopts(*marker_options*) (pac only) affects the rendition of the plotted standardized residual variances; see [G-3] ***marker_options***. This option implies the srv option.

Add plots

addplot(*plot*) adds specified plots to the generated graph; see [G-3] ***addplot_option***.

Y axis, X axis, Titles, Legend, Overall

twoway_options are any of the options documented in [G-3] ***twoway_options***, excluding by(). These include options for titling the graph (see [G-3] ***title_options***) and for saving the graph to disk (see [G-3] ***saving_option***).

Remarks and examples

Remarks are presented under the following headings:

Basic examples

`corrgram` tabulates autocorrelations, partial autocorrelations, and portmanteau (Q) statistics and plots the autocorrelations and partial autocorrelations. The Q statistics are the same as those produced by [TS] **wntestq**. `ac` produces graphs of the autocorrelations, and `pac` produces graphs of the partial autocorrelations. See Becketti (2020) for additional examples of how these commands are used in practice.

▷ Example 1

Here we use the international airline passengers dataset (Box et al. 2016). This dataset has 144 observations on the monthly number of international airline passengers from 1949 through 1960. We can list the autocorrelations and partial autocorrelations by using `corrgram`.

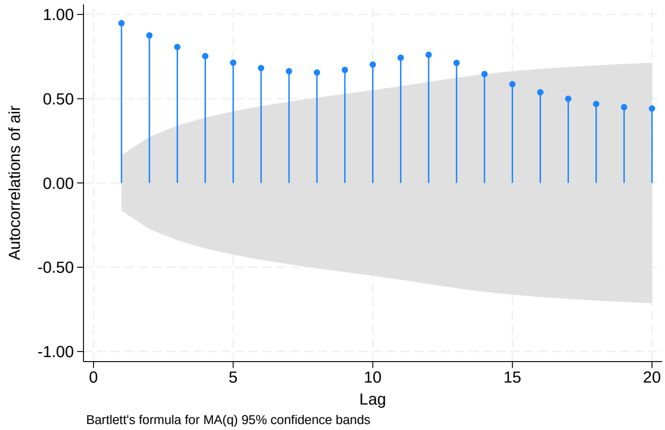
```
. use https://www.stata-press.com/data/r19/air2
(TIMESLAB: Airline passengers)

. corrgram air, lags(20)

                                          -1       0       1 -1       0       1
 LAG       AC       PAC      Q     Prob>Q  [Autocorrelation]  [Partial autocor]
-------------------------------------------------------------------------------
1        0.9480   0.9589   132.14  0.0000
2        0.8756  -0.3298   245.65  0.0000
3        0.8067   0.2018   342.67  0.0000
4        0.7526   0.1450   427.74  0.0000
5        0.7138   0.2585    504.8  0.0000
6        0.6817  -0.0269    575.6  0.0000
7        0.6629   0.2043   643.04  0.0000
8        0.6556   0.1561   709.48  0.0000
9        0.6709   0.5686   779.59  0.0000
10       0.7027   0.2926   857.07  0.0000
11       0.7432   0.8402   944.39  0.0000
12       0.7604   0.6127   1036.5  0.0000
13       0.7127  -0.6660     1118  0.0000
14       0.6463  -0.3846   1185.6  0.0000
15       0.5859   0.0787   1241.5  0.0000
16       0.5380  -0.0266     1289  0.0000
17       0.4997  -0.0581   1330.4  0.0000
18       0.4687  -0.0435     1367  0.0000
19       0.4499   0.2773   1401.1  0.0000
20       0.4416  -0.0405   1434.1  0.0000
```

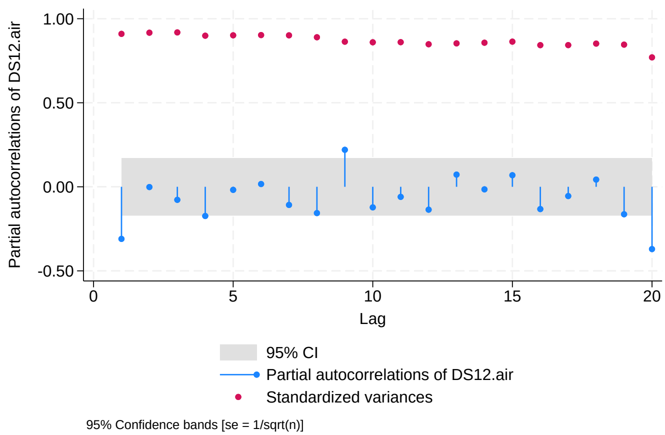
We can use ac to produce a graph of the autocorrelations.

```
. ac air, lags(20)
```



The data probably have a trend component as well as a seasonal component. First-differencing will mitigate the effects of the trend, and seasonal differencing will help control for seasonality. To accomplish this goal, we can use Stata's time-series operators. Here we graph the partial autocorrelations after controlling for trends and seasonality. We also use srv to include the standardized residual variances.

```
. pac DS12.air, lags(20) srv
```



See [U] 11.4.4 Time-series varlists for more information about time-series operators.

◁

Video example

Correlograms and partial correlograms

Stored results

corrgram stores the following in r():

Scalars	
r(lags)	number of lags
r(ac#)	AC for lag #
r(pac#)	PAC for lag #
r(q#)	Q for lag #
r(p#)	p-value for lag #
Matrices	
r(AC)	vector of autocorrelations
r(PAC)	vector of partial autocorrelations
r(Q)	vector of Q statistics
r(P)	vector of p-values

Scalars r(ac#), r(pac#), r(q#), and r(p#) are stored for lag # 1 to 10. Matrices r(AC), r(PAC), r(Q), and r(P) are stored for all lags.

Methods and formulas

Box et al. (2016, sec. 2.1.4); Newton (1988); Chatfield (2004); and Hamilton (1994) provide excellent descriptions of correlograms. Newton (1988) also discusses the calculation of the various quantities.

The autocovariance function for a time series $x_1, x_2, \ldots, x_n$ is defined for $|v| < n$ as

$$\widehat{R}(v) = \frac{1}{n} \sum_{i=1}^{n-|v|} (x_i - \overline{x})(x_{i+v} - \overline{x})$$

where $\overline{x}$ is the sample mean, and the autocorrelation function is then defined as

$$\hat{\rho}_v = \frac{\widehat{R}(v)}{\widehat{R}(0)}$$

The variance of $\hat{\rho}_v$ is given by Bartlett's formula for MA(q) processes. From Brockwell and Davis (2016, 92), we have

$$\mathrm{Var}(\hat{\rho}_v) = \begin{cases} 1/n & v = 1 \\ \frac{1}{n}\left\{1 + 2\sum_{i=1}^{v-1} \hat{\rho}^2(i)\right\} & v > 1 \end{cases}$$

The partial autocorrelation at lag v measures the correlation between x_t and x_{t+v} after the effects of $x_{t+1}, \ldots, x_{t+v-1}$ have been removed. By default, corrgram and pac use a regression-based method to estimate it. We run an OLS regression of x_t on $x_{t-1}, \ldots, x_{t-v}$ and a constant term. The estimated coefficient on x_{t-v} is our estimate of the vth partial autocorrelation. The residual variance is the estimated variance of that regression, which we then standardize by dividing by $\widehat{R}(0)$.

If the yw option is specified, corrgram and pac use the Yule–Walker equations to estimate the partial autocorrelations. Per Enders (2015, 64–65), let ϕ_{vv} denote the vth partial autocorrelation coefficient. We then have

$$\hat{\phi}_{11} = \hat{\rho}_1$$

and for $v > 1$

$$\widehat{\phi}_{vv} = \frac{\widehat{\rho}_v - \sum_{j=1}^{v-1} \widehat{\phi}_{v-1,j}\widehat{\rho}_{v-j}}{1 - \sum_{j=1}^{v-1} \widehat{\phi}_{v-1,j}\widehat{\rho}_j}$$

and

$$\widehat{\phi}_{vj} = \widehat{\phi}_{v-1,j} - \widehat{\phi}_{vv}\widehat{\phi}_{v-1,v-j} \qquad j = 1, 2, \ldots, v-1$$

Unlike the regression-based method, the Yule–Walker equations-based method ensures that the first-sample partial autocorrelation equal the first-sample autocorrelation coefficient, as must be true in the population; see Greene (2008, 725).

McCullough (1998) discusses other methods of estimating ϕ_{vv}; he finds that relative to other methods, such as linear regression, the Yule–Walker equations-based method performs poorly, in part because it is susceptible to numerical error. Box et al. (2016, 66) also caution against using the Yule–Walker equations-based method, especially with data that are nearly nonstationary.

Acknowledgment

The ac and pac commands are based on the ac and pac commands written by Sean Becketti (1992), a past editor of the *Stata Technical Bulletin* and author of the Stata Press book *Introduction to Time Series Using Stata, Revised Edition*.

References

Becketti, S. 1992. sts1: Autocorrelation and partial autocorrelation graphs. *Stata Technical Bulletin* 5: 27–28. Reprinted in *Stata Technical Bulletin Reprints*, vol. 1, pp. 221–223. College Station, TX: Stata Press.

———. 2020. *Introduction to Time Series Using Stata*. Rev. ed. College Station, TX: Stata Press.

Box, G. E. P., G. M. Jenkins, G. C. Reinsel, and G. M. Ljung. 2016. *Time Series Analysis: Forecasting and Control*. 5th ed. Hoboken, NJ: Wiley.

Brockwell, P. J., and R. A. Davis. 2016. *Introduction to Time Series and Forecasting*. 3rd ed. Cham, Switzerland: Springer.

Chatfield, C. 2004. *The Analysis of Time Series: An Introduction*. 6th ed. Boca Raton, FL: Chapman and Hall/CRC.

Enders, W. 2015. *Applied Econometric Time Series*. 4th ed. Hoboken, NJ: Wiley.

Greene, W. H. 2008. *Econometric Analysis*. 6th ed. Upper Saddle River, NJ: Prentice Hall.

Hamilton, J. D. 1994. *Time Series Analysis*. Princeton, NJ: Princeton University Press. https://doi.org/10.2307/j.ctv14jx6sm.

McCullough, B. D. 1998. Algorithm choice for (partial) autocorrelation functions. *Journal of Economic and Social Measurement* 24: 265–278. https://doi.org/10.3233/JEM-1998-0151.

Newton, H. J. 1988. *TIMESLAB: A Time Series Analysis Laboratory*. Belmont, CA: Wadsworth.

Also see

[TS] **pergram** — Periodogram

[TS] **tsset** — Declare data to be time-series data

[TS] **wntestq** — Portmanteau (Q) test for white noise

For suggested citations, see the FAQ on citing Stata documentation.