Title

wntestb — Bartlett's periodogram-based test for white noise

Description

`wntestb` performs Bartlett's periodogram-based test for white noise. The result is presented graphically by default but optionally may be presented as text in a table.

Quick start

Bartlett's periodogram-based test for white noise on series `y` using `tsset` data

```
wntestb y
```

As above, but report table instead of graph

```
wntestb y, table
```

As above, but specify 90%, instead of 95%, confidence interval

```
wntestb y, table level(90)
```

Menu

Statistics > Time series > Tests > Bartlett's periodogram-based white-noise test

Syntax

`wntestb` *varname* [*if*] [*in*] [, *options*]

options	Description
Main	
`table`	display a table instead of graphical output
`level(#)`	set confidence level; default is `level(95)`
Plot	
marker_options	change look of markers (color, size, etc.)
marker_label_options	add marker labels; change look or position
cline_options	add connecting lines; change look
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 `wntestb`; see [TS] **tsset**. In addition, the time series must be dense (nonmissing with no gaps in the time variable) in the specified sample.

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

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

Options

Main

`table` displays the test results as a table instead of as the default graph.

`level(#)` specifies the confidence level, as a percentage, for the confidence bands included on the graph. The default is `level(95)` or as set by `set level`; see [U] **20.8 Specifying the width of confidence intervals**.

Plot

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***.

cline_options specify if the points are to be connected with lines and the rendition of those lines; see [G-3] ***cline_options***.

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

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Bartlett's test is a test of the null hypothesis that the data come from a white-noise process of uncorrelated random variables having a constant mean and a constant variance.

For a discussion of this test, see Bartlett (1955, 92–94), Newton (1988, 172), or Newton (1996).

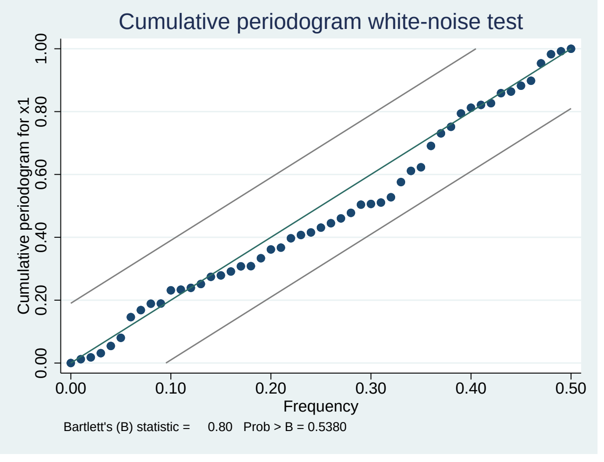
▷ Example 1

In this example, we generate two time series and show the graphical and statistical tests that can be obtained from this command. The first time series is a white-noise process, and the second is a white-noise process with an embedded deterministic cosine curve.

```
. drop _all
. set seed 12393
. set obs 100
Number of observations (_N) was 0, now 100.
. generate x1 = rnormal()
. generate x2 = rnormal() + cos(2*_pi*(_n-1)/10)
. generate time = _n
. tsset time
Time variable: time, 1 to 100
        Delta: 1 unit
```

We can then submit the white-noise data to the wntestb command by typing

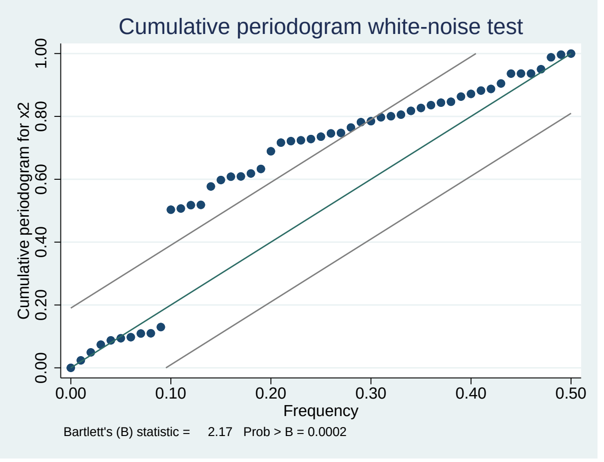
```
. wntestb x1
```



We can see in the graph that the values never appear outside the confidence bands. The test statistic has a p-value of 0.91, so we conclude that the process is not different from white noise. If we had wanted only the statistic without the plot, we could have used the table option.

Turning our attention to the other series (`x2`), we type

```
. wntestb x2
```



Here the process does appear outside of the bands. In fact, it steps out of the bands at a frequency of 0.1 (exactly as we synthesized this process). We also have confirmation from the test statistic, at a p-value of 0.001, that the process is significantly different from white noise.

◁

Stored results

`wntestb` stores the following in `r()`:

Scalars

`r(stat)`	Bartlett's statistic	`r(p)`	probability value

Methods and formulas

If $x(1),\dots,x(T)$ is a realization from a white-noise process with variance σ^2, the spectral distribution would be given by $F(\omega)=\sigma^2\omega$ for $\omega\in[0,1]$, and we would expect the cumulative periodogram (see [TS] **cumsp**) of the data to be close to the points $S_k=k/q$ for $q=\lfloor n/2\rfloor+1, k=1,\dots,q$. $\lfloor n/2\rfloor$ is the greatest integer less than or equal to $n/2$.

Except for $\omega=0$ and $\omega=.5$, the random variables $2\widehat{f}(\omega_k)/\sigma^2$ are asymptotically independent and identically distributed as χ^2_2. Because χ^2_2 is the same as twice a random variable distributed exponentially with mean 1, the cumulative periodogram has approximately the same distribution as the ordered values from a uniform (on the unit interval) distribution. Feller (1948) shows that this results in

$$\lim_{q\to\infty}\Pr\left(\max_{1\le k\le q}\sqrt{q}\left|U_k-\frac{k}{q}\right|\le a\right)=\sum_{j=-\infty}^{\infty}(-1)^j e^{-2a^2j^2}=G(a)$$

where U_k is the ordered uniform quantile. The Bartlett statistic is computed as

$$B=\max_{1\le k\le q}\sqrt{\frac{n}{2}}\left|\widehat{F}_k-\frac{k}{q}\right|$$

where $\widehat{F}_k$ is the cumulative periodogram defined in terms of the sample spectral density $\widehat{f}$ (see [TS] **pergram**) as

$$\widehat{F}_k = \frac{\sum_{j=1}^{k} \widehat{f}(\omega_j)}{\sum_{j=1}^{q} \widehat{f}(\omega_j)}$$

The associated p-value for the Bartlett statistic and the confidence bands on the graph are computed as $1 - G(B)$ using Feller's result.

Maurice Stevenson Bartlett (1910–2002) was a British statistician. Apart from a short period in industry, he spent his career teaching and researching at the universities of Cambridge, Manchester, London (University College), and Oxford. His many contributions include work on the statistical analysis of multivariate data (especially factor analysis) and time series and on stochastic models of population growth, epidemics, and spatial processes.

Acknowledgment

`wntestb` is based on the `wntestf` command by H. Joseph Newton (1996) of the Department of Statistics at Texas A&M University, College Station, TX, who is coeditor of the *Stata Journal*.

References

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Feller, W. 1948. On the Kolmogorov–Smirnov limit theorems for empirical distributions. *Annals of Mathematical Statistics* 19: 177–189. https://doi.org/10.1214/aoms/1177730243.

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Also see

[TS] **corrgram** — Tabulate and graph autocorrelations

[TS] **cumsp** — Graph cumulative spectral distribution

[TS] **pergram** — Periodogram

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

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