Title

> **pperron** — Phillips–Perron unit-root test

Description

pperron performs the Phillips–Perron (1988) test that a variable has a unit root. The null hypothesis is that the variable contains a unit root, and the alternative is that the variable was generated by a stationary process. pperron uses Newey–West (1987) standard errors to account for serial correlation, whereas the augmented Dickey–Fuller test implemented in dfuller (see [TS] **dfuller**) uses additional lags of the first-differenced variable.

Quick start

Phillips–Perron unit-root test for y using tsset data

 pperron y

Same as above, and include a trend in the specification

 pperron y, trend

Same as above, but use 10 lags when calculating Newey–West standard errors

 pperron y, trend lags(10)

Same as above, but without a trend or constant in the specification

 pperron y, lags(10) noconstant

Menu

Statistics > Time series > Tests > Phillips–Perron unit-root test

Syntax

> pperron *varname* [*if*] [*in*] [, *options*]

options	Description
Main	
<u>noc</u>onstant	suppress constant term
<u>tr</u>end	include trend term in regression
<u>regr</u>ess	display regression table
<u>lags</u>(#)	use # Newey–West lags

You must tsset your data before using pperron; see [TS] **tsset**.

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]

noconstant suppresses the constant term (intercept) in the model.

trend specifies that a trend term be included in the associated regression. This option may not be specified if noconstant is specified.

regress specifies that the associated regression table appear in the output. By default, the regression table is not produced.

lags(#) specifies the number of Newey–West lags to use in calculating the standard error. The default is to use $\text{int}\left\{4(T/100)^{2/9}\right\}$ lags.

Remarks and examples

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As noted in [TS] **dfuller**, the Dickey–Fuller test involves fitting the regression model

$$y_t = \alpha + \rho y_{t-1} + \delta t + u_t \tag{1}$$

by ordinary least squares (OLS), but serial correlation will present a problem. To account for this, the augmented Dickey–Fuller test's regression includes lags of the first differences of y_t.

The Phillips–Perron test involves fitting (1), and the results are used to calculate the test statistics. Phillips and Perron (1988) proposed two alternative statistics, which pperron presents. Phillips and Perron's test statistics can be viewed as Dickey–Fuller statistics that have been made robust to serial correlation by using the Newey–West (1987) heteroskedasticity- and autocorrelation-consistent covariance matrix estimator.

Hamilton (1994, chap. 17) and [TS] **dfuller** discuss four different cases into which unit-root tests can be classified. The Phillips–Perron test applies to cases one, two, and four but not to case three. Cases one and two assume that the variable has a unit root without drift under the null hypothesis, the only difference being whether the constant term α is included in regression (1). Case four assumes that the variable has a random walk, with or without drift, under the null hypothesis. Case three, which assumes that the variable has a random walk with drift under the null hypothesis, is just a special case of case four, so the fact that the Phillips–Perron test does not apply is not restrictive. The table below summarizes the relevant cases:

Case	Process under null hypothesis	Regression restrictions	dfuller option
1	Random walk without drift	$\alpha = 0$, $\delta = 0$	noconstant
2	Random walk without drift	$\delta = 0$	(default)
4	Random walk with or without drift	(none)	trend

The critical values for the Phillips–Perron test are the same as those for the augmented Dickey–Fuller test. See Hamilton (1994, chap. 17) for more information.

▷ Example 1

Here we use the international airline passengers dataset (Box et al. 2016, Series G). This dataset has 144 observations on the monthly number of international airline passengers from 1949 through 1960. Because the data exhibit a clear upward trend over time, we will use the trend option.

```
. use https://www.stata-press.com/data/r18/air2
(TIMESLAB: Airline passengers)

. pperron air, lags(4) trend regress

Phillips-Perron test for unit root          Number of obs   = 143
Variable: air                               Newey-West lags =   4

H0: Random walk with or without drift
```

	Test statistic	Dickey-Fuller critical value		
		1%	5%	10%
Z(rho)	-46.405	-27.687	-20.872	-17.643
Z(t)	-5.049	-4.026	-3.444	-3.144

```
MacKinnon approximate p-value for Z(t) = 0.0002.
Regression table
```

air	Coefficient	Std. err.	t	P>|t|	[95% conf. interval]	
air						
L1.	.7318116	.0578092	12.66	0.000	.6175196	.8461035
_trend	.7107559	.1670563	4.25	0.000	.3804767	1.041035
_cons	25.95168	7.325951	3.54	0.001	11.46788	40.43547

Just as in the example in [TS] **dfuller**, we reject the null hypothesis of a unit root at all common significance levels. The interpolated critical values for Z_t differ slightly from those shown in the example in [TS] **dfuller** because the sample sizes are different: with the augmented Dickey–Fuller regression we lose observations because of the inclusion of lagged difference terms as regressors.

◁

Stored results

pperron stores the following in r():

Scalars
r(N)	number of observations
r(lags)	number of lagged differences used
r(pval)	MacKinnon approximate p-value (not included if noconstant specified)
r(Zt)	Phillips–Perron τ test statistic
r(Zrho)	Phillips–Perron ρ test statistic
r(level)	confidence level

Matrices
r(table)	matrix of regression results
r(cvalues)	test statistic and critical values

Methods and formulas

In the OLS estimation of an AR(1) process with Gaussian errors,

$$y_i = \rho y_{i-1} + \epsilon_i$$

where ϵ_i are independent and identically distributed as $N(0, \sigma^2)$ and $y_0 = 0$, the OLS estimate (based on an n-observation time series) of the autocorrelation parameter ρ is given by

$$\widehat{\rho}_n = \frac{\sum_{i=1}^{n} y_{i-1} y_i}{\sum_{i=1}^{n} y_i^2}$$

If $|\rho| < 1$, then $\sqrt{n}(\widehat{\rho}_n - \rho) \to N(0, 1 - \rho^2)$. If this result were valid for when $\rho = 1$, then the resulting distribution would have a variance of zero. When $\rho = 1$, the OLS estimate $\widehat{\rho}$ still converges to one, though we need to find a nondegenerate distribution so that we can test $H_0: \rho = 1$. See Hamilton (1994, chap. 17).

The Phillips–Perron test involves fitting the regression

$$y_i = \alpha + \rho y_{i-1} + \epsilon_i$$

where we may exclude the constant or include a trend term. There are two statistics, Z_ρ and Z_τ, calculated as

$$Z_\rho = n(\widehat{\rho}_n - 1) - \frac{1}{2} \frac{n^2 \widehat{\sigma}^2}{s_n^2} \left(\widehat{\lambda}_n^2 - \widehat{\gamma}_{0,n} \right)$$

$$Z_\tau = \sqrt{\frac{\widehat{\gamma}_{0,n}}{\widehat{\lambda}_n^2}} \frac{\widehat{\rho}_n - 1}{\widehat{\sigma}} - \frac{1}{2} \left(\widehat{\lambda}_n^2 - \widehat{\gamma}_{0,n} \right) \frac{1}{\widehat{\lambda}_n} \frac{n \widehat{\sigma}}{s_n}$$

$$\widehat{\gamma}_{j,n} = \frac{1}{n} \sum_{i=j+1}^{n} \widehat{u}_i \widehat{u}_{i-j}$$

$$\widehat{\lambda}_n^2 = \widehat{\gamma}_{0,n} + 2 \sum_{j=1}^{q} \left(1 - \frac{j}{q+1} \right) \widehat{\gamma}_{j,n}$$

$$s_n^2 = \frac{1}{n-k} \sum_{i=1}^{n} \widehat{u}_i^2$$

where u_i is the OLS residual, k is the number of covariates in the regression, q is the number of Newey–West lags to use in calculating $\widehat{\lambda}_n^2$, and $\widehat{\sigma}$ is the OLS standard error of $\widehat{\rho}$.

The critical values, which have the same distribution as the Dickey–Fuller statistic (see Dickey and Fuller 1979) included in the output, are linearly interpolated from the table of values that appear in Fuller (1996), and the MacKinnon approximate p-values use the regression surface published in MacKinnon (1994).

Peter Charles Bonest Phillips (1948–) was born in Weymouth, England, and earned degrees in economics at the University of Auckland in New Zealand, and the London School of Economics. After periods at the Universities of Essex and Birmingham, Phillips moved to Yale in 1979. He also holds appointments at the University of Auckland and the University of York. His main research interests are in econometric theory, financial econometrics, time-series and panel-data econometrics, and applied macroeconomics.

Pierre Perron (1959–) was born in Québec, Canada, and earned degrees at McGill, Queen's, and Yale in economics. After posts at Princeton and the Université de Montréal, he joined Boston University in 1997. His research interests include time-series analysis, econometrics, and applied macroeconomics.

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Also see