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prtest — Tests of proportions

Description

`prtest` performs tests on the equality of proportions using large-sample statistics. The test can be performed for one sample against a hypothesized population value or for no difference in population proportions estimated from two samples. Clustered data are supported.

`prtesti` is the immediate form of `prtest`; see **[U] 19 Immediate commands**.

Quick start

One-sample test that the proportion of 1s in `v` is equal to 0.1

```
prtest v == 0.1
```

As above, but using the 90% confidence level and adjusting for clustering with clusters defined by `cvar` and an intraclass correlation of 0.5

```
prtest v == 0.1, level(90) cluster(cvar) rho(0.5)
```

Test that the proportion of 1s in `v` is equal between two groups defined by `catvar`

```
prtest v, by(catvar)
```

As above, and adjust for clustering with clusters defined by `cvar` and an intraclass correlation of 0.5 in the two groups

```
prtest v, by(catvar) cluster(cvar) rho(0.5)
```

Test equality of proportions between `v1` and `v2`

```
prtest v1 == v2
```

Test $p_1 = p_2$ if $\widehat{p}_1 = 0.10$, $\widehat{p}_2 = 0.17$, $n_1 = 29$, and $n_2 = 36$

```
prtesti 29 0.10 36 0.17
```

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prtesti

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Syntax

One-sample test of proportion

prtest *varname* == $\#_p$ [*if*] [*in*] [, *onesampleopts*]

Two-sample test of proportions using groups

prtest *varname* [*if*] [*in*] , by(*groupvar*) [*twosamplegropts*]

Two-sample test of proportions using variables

prtest $varname_1$ == $varname_2$ [*if*] [*in*] [, level(#)]

Immediate form of one-sample test of proportion

prtesti $\#_{\mathrm{obs1}}$ $\#_{p1}$ $\#_{p2}$ [, level(#) count]

Immediate form of two-sample test of proportions

prtesti $\#_{\mathrm{obs1}}$ $\#_{p1}$ $\#_{\mathrm{obs2}}$ $\#_{p2}$ [, level(#) count]

onesampleopts	Description
Main	
level(#)	confidence level; default is level(95)
cluster(*varname*)	variable defining the clusters
rho(#)	intraclass correlation

twosamplegropts	Description
Main	
* by(*groupvar*)	variable defining the groups
level(#)	confidence level; default is level(95)
cluster(*varname*)	variable defining the clusters
rho(#)	common intraclass correlation
rho1(#)	intraclass correlation for group 1
rho2(#)	intraclass correlation for group 2

* by(*groupvar*) is required.

by is allowed with prtest; see [D] **by**.

Options for prtest

Main

by(*groupvar*) specifies a numeric variable that contains the group information for a given observation. This variable must have only two values. Do not confuse the by() option with the by prefix; both may be specified.

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

cluster(*varname*) specifies the variable that identifies clusters. The cluster() option is required to adjust the computation for clustering.

rho(#) specifies the intraclass correlation for a one-sample test or the common intraclass correlation for a two-sample test. The rho() option is required to adjust the computation for clustering for a one-sample test.

rho1(#) specifies the intraclass correlation of the first group for a two-sample test using groups. The rho() option or both rho1() and rho2() options are required to adjust the computation for clustering.

rho2(#) specifies the intraclass correlation of the second group for a two-sample test using groups. The rho() option or both rho1() and rho2() options are required to adjust the computation for clustering.

Options for prtesti

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

count specifies that integer counts instead of proportions be used in the immediate forms of prtest. In the first syntax, prtesti expects that $\#_{\text{obs1}}$ and $\#_{p1}$ are counts—$\#_{p1} \leq \#_{\text{obs1}}$—and $\#_{p2}$ is a proportion. In the second syntax, prtesti expects that all four numbers are integer counts, that $\#_{\text{obs1}} \geq \#_{p1}$, and that $\#_{\text{obs2}} \geq \#_{p2}$.

Remarks and examples

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Remarks are presented under the following headings:

Tests of proportions
Adjust for clustering
Immediate form

Tests of proportions

The prtest output follows the output of ttest in providing a lot of information. Each proportion is presented along with a confidence interval. The appropriate one- or two-sample test is performed, and the two-sided and both one-sided results are included at the bottom of the output. For a two-sample test, the calculated difference is also presented with its confidence interval. This command may be used for both large-sample testing and large-sample interval estimation. For one-sample tests of proportions with small-sample sizes and to obtain exact p-values, researchers should use bitest; see [R] bitest.

▷ Example 1: One-sample test of proportion

In the first form, prtest tests whether the mean of the sample is equal to a known constant. Assume that we have a sample of 74 automobiles. We wish to test whether the proportion of automobiles that are foreign is different from 40%.

```
. use http://www.stata-press.com/data/r15/auto
(1978 Automobile Data)
```

```
. prtest foreign == .4

One-sample test of proportion                    foreign: Number of obs =        74

    Variable |       Mean   Std. Err.                      [95% Conf. Interval]
-------------+------------------------------------------------------------------
     foreign |   .2972973   .0531331                      .1931583    .4014363
--------------------------------------------------------------------------------
    p = proportion(foreign)                                       z =  -1.8034
Ho: p = 0.4

     Ha: p < 0.4                 Ha: p != 0.4                 Ha: p > 0.4
 Pr(Z < z) = 0.0357         Pr(|Z| > |z|) = 0.0713          Pr(Z > z) = 0.9643
```

The test indicates that we cannot reject the hypothesis that the proportion of foreign automobiles is 0.40 at the 5% significance level.

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▷ Example 2: Two-sample test of proportions

We have two headache remedies that we give to patients. Each remedy's effect is recorded as 0 for failing to relieve the headache and 1 for relieving the headache. We wish to test the equality of the proportion of people relieved by the two treatments.

```
. use http://www.stata-press.com/data/r15/cure

. prtest cure1 == cure2

Two-sample test of proportions                     cure1: Number of obs =        50
                                                   cure2: Number of obs =        59

    Variable |       Mean   Std. Err.       z    P>|z|     [95% Conf. Interval]
-------------+------------------------------------------------------------------
       cure1 |        .52   .0706541                      .3815205    .6584795
       cure2 |   .7118644   .0589618                      .5963013    .8274275
-------------+------------------------------------------------------------------
        diff |  -.1918644   .0920245                      -.372229   -.0114998
             |  under Ho:   .0931155   -2.06   0.039
--------------------------------------------------------------------------------
        diff = prop(cure1) - prop(cure2)                          z =  -2.0605
    Ho: diff = 0

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(Z < z) = 0.0197         Pr(|Z| > |z|) = 0.0394          Pr(Z > z) = 0.9803
```

We find that the proportions are statistically different from each other at any level greater than 3.9%.

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Adjust for clustering

When observations are not independent and can be grouped into clusters, we need to adjust for clustering in a proportion test. For example, in a cluster randomized design, groups of individuals are randomized instead of individuals. To adjust for clustering, we need to specify the cluster identifier variable in the `cluster()` option. In the case of a one-sample proportion test, we need to also specify the intraclass correlation in the `rho()` option. In the case of a two sample proportions test, we need to also specify the common population intraclass correlation in the `rho()` option or group-specific population intraclass correlations in the `rho1()` and `rho2()` options.

▷ Example 3: One-sample test of proportion, adjusting for clusters

Consider data from Hujoel, Moulton, and Loesche (1990) on the accuracy of an enzymatic diagnostic test (EDT) of bacterial infections for 29 patients with multiple sites. The EDT was conducted on each site, a specific area in a patient's mouth, to determine infection by two strings of bacteria. A separate reference test was also conducted on each site with an antibody assay against the two strings of bacteria. The data record whether there was a positive EDT result at each infected site, a true positive result.

We want to test whether the proportion of infected sites that were correctly diagnosed by the EDT is different from 0.6. Because we have multiple infections per patient, we cluster by the patient-identifier `subject` and use a value of 0.2 from Ahn, Heo, and Zhang (2015, 33) for the intrapatient correlation.

To perform the test, we specify the `cluster(subject)` and `rho(0.2)` options:

```
. use http://www.stata-press.com/data/r15/infection
(Target infections detected by EDT (Hujoel, Moulton, and Loesche, 1990))

. prtest infect == 0.6, cluster(subject) rho(0.2)

One-sample test of proportion                    Number of obs      =        142
Cluster variable: subject                        Number of clusters =         29
                                                 Avg. cluster size  =       4.90
                                                 CV cluster size    =     0.2419
                                                 Intraclass corr.   =     0.2000

------------------------------------------------------------------------------
    Variable |       Mean   Std. Err.                     [95% Conf. Interval]
-------------+----------------------------------------------------------------
   infection |   .6619718   .0537974                      .5565308    .7674129
------------------------------------------------------------------------------
    p = proportion(infection)                                     z =   1.1123
Ho: p = 0.6

     Ha: p < 0.6                 Ha: p != 0.6                 Ha: p > 0.6
 Pr(Z < z) = 0.8670         Pr(|Z| > |z|) = 0.2660          Pr(Z > z) = 0.1330
```

We do not find statistical evidence to reject the null hypothesis of H_0: $P_{\text{infection}} = 0.6$ versus the two-sided alternative H_a: $P_{\text{infection}} \neq 0.6$ at the 5% significance level; the p-value $= 0.2660 > 0.05$.

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▷ Example 4: Two-sample test of proportions using groups, adjusting for clusters

Consider a dataset provided by Hayes and Moulton (2017), which contains a random subsample of the original participants in a cluster randomized trial of a pneumococcal conjugate vaccine in American Indian populations in the southwestern United States. There are two groups of infants with 18 clusters in each group. The control group received a meningococcal C conjugate vaccine (MnCC), and the experimental group received the seven-valent pneumococcal conjugate vaccine (PnCRM7). The two groups are identified by the `vaccine` variable, and the `pneumonia` variable records 1 if an infant had at least one bacterial pneumonia episode and 0 otherwise. These data are originally from O'Brien et al. (2003).

We want to test the equality of the proportion of cases of `pneumonia` in the two vaccine groups. We assume a common known intraclass correlation of 0.02. To perform the test, we type

```
. use http://www.stata-press.com/data/r15/pneumoniacrt
(Bacterial pneumonia episodes data from CRT (Hayes and Moulton, 2017))
. prtest pneumonia, by(vaccine) cluster(cluster) rho(0.02)
Two-sample test of proportions
Cluster variable: cluster

Group: MnCC                              Group: PnCRM7
  Number of obs       =        238         Number of obs       =        211
  Number of clusters =         18         Number of clusters =         18
  Avg. cluster size  =      13.22         Avg. cluster size  =      11.72
  CV cluster size    =     0.9605         CV cluster size    =     0.7976
  Intraclass corr.   =     0.0200         Intraclass corr.   =     0.0200

------------------------------------------------------------------------------
       Group |       Mean   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        MnCC |   .2226891   .0329017                      .1582029    .2871753
      PnCRM7 |   .1658768   .0299027                      .1072686     .224485
-------------+----------------------------------------------------------------
        diff |   .0568123     .04446                     -.0303278    .1439524
             |  under Ho:   .0447641     1.27   0.204
------------------------------------------------------------------------------
        diff = prop(MnCC) - prop(PnCRM7)                          z =   1.2691
    Ho: diff = 0

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(Z < z) = 0.8978         Pr(|Z| > |z|) = 0.2044          Pr(Z > z) = 0.1022
```

We do not find statistical evidence to reject the null hypothesis of H_0: $P_{\text{diff}} = 0$ versus the two-sided alternative H_a: $P_{\text{diff}} \neq 0$ at the 5% significance level; the p-value $= 0.2044 > 0.05$.

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Immediate form

▷ Example 5: Immediate form of one-sample test of proportion

prtesti is like prtest, except that you specify summary statistics rather than variables as arguments. For instance, we are reading an article that reports the proportion of registered voters among 50 randomly selected eligible voters as 0.52. We wish to test whether the proportion is 0.7:

```
. prtesti 50 0.52 0.70
One-sample test of proportion                   x: Number of obs =        50
------------------------------------------------------------------------------
             |       Mean   Std. Err.                     [95% Conf. Interval]
-------------+----------------------------------------------------------------
           x |        .52   .0706541                      .3815205    .6584795
------------------------------------------------------------------------------
    p = proportion(x)                                             z =  -2.7775
Ho: p = 0.7

     Ha: p < 0.7                 Ha: p != 0.7                 Ha: p > 0.7
 Pr(Z < z) = 0.0027         Pr(|Z| > |z|) = 0.0055          Pr(Z > z) = 0.9973
```

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▷ Example 6: Immediate form of two-sample test of proportions

To judge teacher effectiveness, we wish to test whether the same proportion of people from two classes will answer an advanced question correctly. In the first classroom of 30 students, 40% answered the question correctly, whereas in the second classroom of 45 students, 67% answered the question correctly.

```
. prtesti 30 0.4 45 0.67
Two-sample test of proportions                    x: Number of obs =       30
                                                  y: Number of obs =       45

             |       Mean   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
           x |         .4   .0894427                      .2246955    .5753045
           y |        .67   .0700952                       .532616     .807384
-------------+----------------------------------------------------------------
        diff |       -.27   .1136368                     -.4927241   -.0472759
             |  under Ho:   .1169416    -2.31   0.021
------------------------------------------------------------------------------
        diff = prop(x) - prop(y)                                  z =  -2.3088
    Ho: diff = 0

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(Z < z) = 0.0105         Pr(|Z| > |z|) = 0.0210          Pr(Z > z) = 0.9895
```

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Stored results

One-sample `prtest` and `prtesti` store the following in `r()`:

Scalars

`r(N)`	sample size
`r(P)`	sample proportion
`r(se)`	standard error of sample proportion
`r(lb)`	lower confidence bound of sample proportion
`r(ub)`	upper confidence bound of sample proportion
`r(z)`	z statistic
`r(p_l)`	lower one-sided p-value
`r(p)`	two-sided p-value
`r(p_u)`	upper one-sided p-value
`r(level)`	confidence level

Cluster-adjusted one-sample `prtest` also stores the following in `r()`:

Scalars

`r(K)`	number of clusters K
`r(M)`	cluster size M
`r(rho)`	intraclass correlation
`r(CV_cluster)`	coefficient of variation for cluster sizes

Two-sample `prtest` and two-sample `prtesti` store the following in `r()`:

Scalars

`r(N1)`	sample size of population one
`r(N2)`	sample size of population two
`r(P1)`	sample proportion for population one
`r(P2)`	sample proportion for population two
`r(P_diff)`	difference of proportions
`r(se1)`	standard error of population-one sample proportion
`r(se2)`	standard error of population-two sample proportion

r(se_diff)	standard error of the difference of proportions
r(se_diff0)	standard error of the difference of proportions under H_0
r(lb1)	lower confidence bound of population-one sample proportion
r(ub1)	upper confidence bound of population-one sample proportion
r(lb2)	lower confidence bound of population-two sample proportion
r(ub2)	upper confidence bound of population-two sample proportion
r(lb_diff)	lower confidence bound of the difference of proportions
r(ub_diff)	upper confidence bound of the difference of proportions
r(z)	z statistic
r(p_l)	lower one-sided p-value
r(p)	two-sided p-value
r(p_u)	upper one-sided p-value
r(level)	confidence level

Cluster-adjusted two-sample `prtest` using the `by()` option also stores the following in `r()`:

Scalars

r(K1)	population-one number of clusters K_1
r(K2)	population-two number of clusters K_2
r(M1)	population-one cluster size M_1
r(M2)	population-two cluster size M_2
r(rho)	common intraclass correlation
r(rho1)	population-one intraclass correlation
r(rho2)	population-two intraclass correlation
r(CV_cluster1)	population-one coefficient of variation for cluster sizes
r(CV_cluster2)	population-two coefficient of variation for cluster sizes

Methods and formulas

Remarks are presented under the following headings:

One-sample test
Two-sample test

For all the tests below, the test statistic z has an asymptotic standard normal distribution, and the p-value is computed as

$$p = \begin{cases} 1 - \Phi(z) & \text{for an upper one-sided test} \\ \Phi(z) & \text{for a lower one-sided test} \\ 2\{1 - \Phi(|z|)\} & \text{for a two-sided test} \end{cases}$$

where $\Phi(\cdot)$ is the cdf of a standard normal distribution and $|z|$ is an absolute value of z.

See Acock (2018, 157–163) for additional examples of tests of proportions using Stata.

One-sample test

Let n be the number of observations, $\widehat{p}$ be the observed proportion, and $\widehat{q} = 1 - \widehat{p}$.

The one-tailed and two-tailed tests of a population proportion use an asymptotically normally distributed test statistic calculated as

$$z = \frac{\widehat{p} - p_0}{s_0}$$

where p_0 is the hypothesized proportion, $q_0 = 1 - p_0$, and $s_0 = \sqrt{p_0 q_0 / n}$ is the standard error of $\widehat{p}$ under the null hypothesis of $p = p_0$.

A large-sample $100(1-\alpha)\%$ confidence interval for a proportion p is

$$\widehat{p} \pm z_{1-\alpha/2}s$$

where $s = \sqrt{\widehat{p}\,\widehat{q}/n}$ and $z_{1-\alpha/2}$ is the $(1-\alpha/2)$th quantile of the standard normal distribution.

With clustered data, suppose that there are K clusters, each of size M_i such that $n = \sum_{i=1}^{K} M_i$. Let ρ be the intraclass correlation. Following Ahn, Heo, and Zhang (2015), we assume that the cluster sizes M_i are independent and identically distributed. Let C_{adj} be the adjustment to the standard error for clustered data,

$$C_{\mathrm{adj}} = \sqrt{\sum_{i=1}^{K} M_i\{1+\rho(M_i-1)\}/n}$$

such that $s_{0,\mathrm{cl}} = C_{\mathrm{adj}}s_0$ and $s_{\mathrm{cl}} = C_{\mathrm{adj}}s$.

C_{adj} can be equivalently written as

$$C_{\mathrm{adj}} = \sqrt{1+\rho(\overline{M}-1)+\rho\overline{M}\,\mathrm{CV}_{\mathrm{cl}}^2}$$

where $\overline{M} = \sum_{i=1}^{K} M_i/K$ is the average cluster size and $\mathrm{CV}_{\mathrm{cl}}$ is the coefficient of variation for cluster sizes:

$$\mathrm{CV}_{\mathrm{cl}} = \frac{\sqrt{\sum_{i=1}^{K}(M_i-\overline{M})^2/K}}{\overline{M}}$$

To adjust the test statistic z and the confidence interval for clustering, replace s_0 with $s_{0,\mathrm{cl}}$ and s with s_{cl} in the corresponding formulas. In the presence of clustering, the test statistic z is asymptotically normally distributed conditional on the empirical distribution of M_i's.

Two-sample test

Let n_1 be the number of observations in population one and n_2 be the number of observations in population two, $\widehat{p}_1$ be the observed proportion in population one and $\widehat{p}_2$ be the observed proportion in population two, and $\widehat{q}_1 = 1-\widehat{p}_1$ and $\widehat{q}_2 = 1-\widehat{p}_2$. Let x_1 and x_2 be the total number of successes in the two populations.

A test of the difference of two proportions uses an asymptotically normally distributed test statistic calculated as

$$z = \frac{\widehat{p}_1-\widehat{p}_2}{s_{d0}}$$

where $s_{d0} = \sqrt{\widehat{p}_p\,\widehat{q}_p(1/n_1+1/n_2)}$ is the standard error of $\widehat{p}_1-\widehat{p}_2$ under the null hypothesis of $p_1 = p_2$, with $\widehat{p}_p = (x_1+x_2)/(n_1+n_2)$ and $\widehat{q}_p = 1-\widehat{p}_p$.

The $100(1-\alpha)\%$ confidence interval for the difference of two proportions is given by

$$(\widehat{p}_1-\widehat{p}_2) \pm z_{1-\alpha/2}\sqrt{s_1^2+s_2^2}$$

where $s_1 = \sqrt{\widehat{p}_1\,\widehat{q}_1/n_1}$ and $s_2 = \sqrt{\widehat{p}_2\,\widehat{q}_2/n_2}$ are the standard errors of the two sample proportions and $z_{1-\alpha/2}$ is the $(1-\alpha/2)$th quantile of the standard normal distribution.

With clustered data, suppose that there are K_1 and K_2 clusters in population one and population two with the corresponding average cluster sizes of $\overline{M}_1$ and $\overline{M}_2$. Let ρ_1 and ρ_2 be the intraclass correlations and $\text{CV}_{\text{cl},1}$ and $\text{CV}_{\text{cl},2}$ be the coefficients of variation for cluster sizes for population one and population two. Let $C_{\text{adj},1}$ and $C_{\text{adj},2}$ be the adjustments to standard errors of the two sample proportions for clustered data, defined analogously to C_{adj} in *One-sample test* for each population.

Let $s_{d0,\text{cl}} = \sqrt{\widehat{p}_p\,\widehat{q}_p\left(C^2_{\text{adj},1}/n_1 + C^2_{\text{adj},2}/n_2\right)}$ be the standard error of $\widehat{p}_1 - \widehat{p}_2$ under the null hypothesis of $p_1 = p_2$ adjusted for clustered data. Also, let $s_{1,\text{cl}} = C_{\text{adj},1}s_1$ and $s_{2,\text{cl}} = C_{\text{adj},2}s_2$ be the standard errors of $\widehat{p}_1$ and $\widehat{p}_2$ adjusted for clustered data. To adjust the two-sample test statistic and the confidence interval for clustering, replace s_{d0} with $s_{d0,\text{cl}}$, s_1 with $s_{1,\text{cl}}$, and s_2 with $s_{2,\text{cl}}$ in the corresponding formulas.

References

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Also see

[R] **bitest** — Binomial probability test

[R] **proportion** — Estimate proportions

[R] **ttest** — t tests (mean-comparison tests)

[MV] **hotelling** — Hotelling's T-squared generalized means test

[PSS] **power oneproportion** — Power analysis for a one-sample proportion test

[PSS] **power oneproportion, cluster** — Power analysis for a one-sample proportion test, CRD

[PSS] **power twoproportions** — Power analysis for a two-sample proportions test

[PSS] **power twoproportions, cluster** — Power analysis for a two-sample proportions test, CRD