svy brr — Balanced repeated replication for survey data

Description

svy brr performs balanced repeated replication (BRR) estimation of specified statistics (or expressions) for a Stata command or a user-written program. The command is executed once for each replicate using sampling weights that are adjusted according to the BRR methodology. Any Stata estimation command listed in [SVY] svy estimation may be used with svy brr. User-written programs that meet the requirements in [P] program properties may also be used.

Quick start

Estimate population mean of v1 using BRR standard-error estimates with sampling weight wvar1 and replicate weights in variables with prefix rwvar

svyset [pweight = wvar1], brrweight(rwvar*)
svy brr _b: mean v1

BRR estimate of the standard error of the difference between the means of v2 and v3

svy brr (_b[v2]-_b[v3]): mean v2 v3

As above, but name the result diff and save results from each replication to mydata.dta

svy brr diff=(_b[v2]-_b[v3]), saving(mydata): mean v2 v3

Same as above

brr diff=(_b[v2]-_b[v3]), saving(mydata): mean v2 v3

Note: Any estimation command meeting the requirements specified in the Description may be substituted for mean in the examples above.

Menu

Statistics > Survey data analysis > Resampling > Balanced repeated replications estimation
Syntax

```
[svy] brr exp_list [, svy_options brr_options eform_option] : command
```

**svy**

**exp_list**

**svy_options**

**brr_options**

**eform_option**

**Description**

**if/in**

```
subpop( [ varname ] [ if ] )
```

identify a subpopulation

**Reporting**

```
level(#)
noheader
nolegend
noadjust
noconsreport
```

set confidence level; default is level(95)

suppress table header

suppress table legend

do not adjust model Wald statistic

do not display constraints

**display_options**

control columns and column formats, row spacing, line width, display of omitted variables and base and empty cells, and factor-variable labeling

**coeflegend**

display legend instead of statistics

**brr_options**

**Description**

**Main**

```
hadamard(matrix)
fay(#)
```

Hadamard matrix

Fay’s adjustment

**Options**

```
saving(filename[, ...])
mse
```

save results to filename; save statistics in double precision; save results to filename every # replications

use MSE formula for variance

**Reporting**

```
verbose
nodots
dots(#)
nosily
trace
title(text)
```

display the full table legend

suppress replication dots

display dots every # replications

display any output from command

trace command

use text as title for BRR results

**Advanced**

```
nodrop
reject(exp)
dof(#)
```

do not drop observations

identify invalid results

design degrees of freedom

**Warning:** Using **if** or **in** restrictions will often not produce correct variance estimates for subpopulations. To compute estimates for subpopulations, use the **subpop()** option.

**svy** requires that the survey design variables be identified using **svyset**; see [SVY] **svyset**.

**command** defines the statistical command to be executed. The **by** prefix cannot be part of **command**.

See [U] 20 Estimation and postestimation commands for more capabilities of estimation commands.
The `exp_list` specifies the statistics to be collected from the execution of `command`. `exp_list` is required unless `command` has the `svyb` program property, in which case `exp_list` defaults to `_b`; see `[P] program properties`. The expressions in `exp_list` are assumed to conform to the following:

- `exp_list` contains `(name: elist)
  elist  
  exp  

- `elist` contains `newvarname = (exp)`  
- `exp` is `specname`
  `[eqno]specname`

- `specname` is `_b`
  `_b[]`
  `_se`
  `_se[]`

- `eqno` is `##`
  `name`

`exp` is a standard Stata expression; see `[U] 13 Functions and expressions.`

Distinguish between `[]`, which are to be typed, and `[]`, which indicate optional arguments.

### Options

- `svy_options`; see `[SVY] svy`.

- **Main**
  
  - `hadamard(matrix)` specifies the Hadamard matrix to be used to determine which PSUs are chosen for each replicate.
  
  - `fay(#)` specifies Fay’s adjustment (Judkins 1990), where \(0 \leq # \leq 2\), but excluding 1. This option overrides the `fay(#)` option of `svyset`; see `[SVY] svyset`.

- **Saving**
  
  - `saving(filename[, suboptions])` creates a Stata data file (.dta file) consisting of (for each statistic in `exp_list`) a variable containing the replicates.
  
    - `double` specifies that the results for each replication be saved as doubles, meaning 8-byte reals.
      
      By default, they are saved as floats, meaning 4-byte reals. This option may be used without the `saving()` option to compute the variance estimates by using double precision.

    - `every(#)` specifies that results be written to disk every \(#\)th replication. `every()` should be specified in conjunction with `saving()` only when `command` takes a long time for each replication. This will allow recovery of partial results should some other software crash your computer. See `[P] postfile`.

    - `replace` specifies that `filename` be overwritten if it exists. This option does not appear in the dialog box.

    - `mse` specifies that `svy brr` compute the variance by using deviations of the replicates from the observed value of the statistics based on the entire dataset. By default, `svy brr` computes the variance by using deviations of the replicates from their mean.
Reporting

verbose requests that the full table legend be displayed.

to display replication dots. By default, one dot character is displayed for each successful replication. A red ‘x’ is displayed if command returns an error, and an ‘e’ is displayed if at least one value in exp_list is missing. You can also control whether dots are displayed using set dots; see [R] set.

nodots suppresses display of the replication dots.

dots(#) displays dots every # replications. dots(0) is a synonym for nodots.

noisily requests that any output from command be displayed. This option implies the nodots option.

trace causes a trace of the execution of command to be displayed. This option implies the noisily option.

title(text) specifies a title to be displayed above the table of BRR results; the default title is “BRR results”.

eform_option; see [R] eform_option. This option is ignored if exp_list is not _b.

Advanced

nodrop prevents observations outside e(sample) and the if and in qualifiers from being dropped before the data are resampled.

reject(exp) identifies an expression that indicates when results should be rejected. When exp is true, the resulting values are reset to missing values.

dof(#) specifies the design degrees of freedom, overriding the default calculation, df = N_{psu} - N_{strata}.

Remarks and examples

BRR was first introduced by McCarthy (1966, 1969a, 1969b) as a method of variance estimation for designs with two PSUs in every stratum. The BRR variance estimator tends to give more reasonable variance estimates for this design than the linearized variance estimator, which can result in large values and undesirably wide confidence intervals.

In BRR, the model is fit multiple times, once for each of a balanced set of combinations where one PSU is dropped from each stratum. The variance is estimated using the resulting replicated point estimates. Although the BRR method has since been generalized to include other designs, Stata’s implementation of BRR requires two PSUs per stratum.

To protect the privacy of survey participants, public survey datasets may contain replicate-weight variables instead of variables that identify the PSUs and strata. These replicate-weight variables are adjusted copies of the sampling weights. For BRR, the sampling weights are adjusted for dropping one PSU from each stratum; see [SVY] Variance estimation for more details.

Example 1: BRR replicate-weight variables

The survey design for the NHANES II data (McDowell et al. 1981) is specifically suited to BRR; there are two PSUs in every stratum.
Survey: Describing stage 1 sampling units

pweight: finalwgt
VCE: linearized
Single unit: missing
Strata 1: strata
SU 1: psu
FPC 1: <zero>

<table>
<thead>
<tr>
<th>Stratum</th>
<th>#Units</th>
<th>#Obs</th>
<th>min</th>
<th>mean</th>
<th>max</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>380</td>
<td>165</td>
<td>190.0</td>
<td>215</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>185</td>
<td>67</td>
<td>92.5</td>
<td>118</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>348</td>
<td>149</td>
<td>174.0</td>
<td>199</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td>460</td>
<td>229</td>
<td>230.0</td>
<td>231</td>
</tr>
<tr>
<td>5</td>
<td>2</td>
<td>252</td>
<td>105</td>
<td>126.0</td>
<td>147</td>
</tr>
<tr>
<td>(output omitted)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>2</td>
<td>503</td>
<td>215</td>
<td>251.5</td>
<td>288</td>
</tr>
<tr>
<td>30</td>
<td>2</td>
<td>365</td>
<td>166</td>
<td>182.5</td>
<td>199</td>
</tr>
<tr>
<td>31</td>
<td>2</td>
<td>308</td>
<td>143</td>
<td>154.0</td>
<td>165</td>
</tr>
<tr>
<td>32</td>
<td>2</td>
<td>450</td>
<td>211</td>
<td>225.0</td>
<td>239</td>
</tr>
<tr>
<td>31</td>
<td>62</td>
<td>10,351</td>
<td>67</td>
<td>167.0</td>
<td>288</td>
</tr>
</tbody>
</table>

Here is a privacy-conscious dataset equivalent to the one above; all the variables and values remain, except strata and psu are replaced with BRR replicate-weight variables. The BRR replicate-weight variables are already svyset, and the default method for variance estimation is vce(brr).

Suppose that we were interested in the population ratio of weight to height. Here we use total to estimate the population totals of weight and height and the svy brr prefix to estimate their ratio and variance; we use total instead of ratio (which is otherwise preferable here) to illustrate how to specify an exp_list.
\texttt{. svy brr WtoH = \_b[weight]/\_b[height]): total weight height}

\textit{running \texttt{total} on estimation sample}

\begin{verbatim}
BRR replications (32)
1 2 3 4 5
\end{verbatim}

\begin{verbatim}
BRR results
Number of obs = 10,351
Population size = 117,157,513
Replications = 32
Design df = 31
\end{verbatim}

\begin{verbatim}
command: total weight height
WtoH: \_b[weight]/\_b[height]
\end{verbatim}

\begin{verbatim}
| BRR | Coef. | Std. Err. | t   | P>|t| | [95% Conf. Interval] |
|-----|-------|-----------|-----|------|----------------------|
| WtoH| .4268116 | .0008904  | 479.36 | 0.000 | .4249957 | .4286276 |
\end{verbatim}

The \texttt{mse} option causes \texttt{svy brr} to use the MSE form of the BRR variance estimator. This variance estimator will tend to be larger than the previous because of the addition of the familiar squared bias term in the MSE; see \textit{[SVY] Variance estimation} for more details. The header for the column of standard errors in the table of results is \texttt{BRR *} for the BRR variance estimator using the MSE formula.

\begin{verbatim}
. svy brr WtoH = \_b[weight]/\_b[height]), mse: total weight height
\end{verbatim}

\begin{verbatim}
BRR replications (32)
1 2 3 4 5
\end{verbatim}

\begin{verbatim}
BRR results
Number of obs = 10,351
Population size = 117,157,513
Replications = 32
Design df = 31
\end{verbatim}

\begin{verbatim}
command: total weight height
WtoH: \_b[weight]/\_b[height]
\end{verbatim}

\begin{verbatim}
| BRR | Coef. | Std. Err. | t   | P>|t| | [95% Conf. Interval] |
|-----|-------|-----------|-----|------|----------------------|
| WtoH| .4268116 | .0008904  | 479.36 | 0.000 | .4249957 | .4286276 |
\end{verbatim}

The bias term here is too small to see any difference in the standard errors.

\textbf{Example 2: Survey data without replicate-weight variables}

For survey data with the PSU and strata variables but no replication weights, \texttt{svy brr} can compute adjusted sampling weights within its replication loop. Here the \texttt{hadamard()} option must be supplied with the name of a Stata matrix that is a Hadamard matrix of appropriate order for the number of strata in your dataset (see the following technical note for a quick introduction to Hadamard matrices).

There are 31 strata in \texttt{nhanes2.dta}, so we need a Hadamard matrix of order 32 (or more) to use \texttt{svy brr} with this dataset. Here we use \texttt{h32} (from the following technical note) to estimate the population ratio of weight to height by using the BRR variance estimator.
. use https://www.stata-press.com/data/r16/nhanes2
. svy brr, hadamard(h32): ratio (WtoH: weight/height)
(running ratio on estimation sample)

BRR replications (32)
1 2 3 4 5
................................

Survey: Ratio estimation
Number of strata = 31 Number of obs = 10,351
Number of PSUs = 62 Population size = 117,157,513
Replications = 32 Design df = 31

WtoH: weight/height

| BRR Ratio Std. Err. [95% Conf. Interval] |
|----------------|-----------------|------------------|
| WtoH | .4268116 | .0008904 | .4249957 .4286276 |

Technical note

A Hadamard matrix is a square matrix with \( r \) rows and columns that has the property

\[
H_r' H_r = r I_r
\]

where \( I_r \) is the identity matrix of order \( r \). Generating a Hadamard matrix with order \( r = 2^p \) is easily accomplished. Start with a Hadamard matrix of order 2 (\( H_2 \)), and build your \( H_r \) by repeatedly applying Kronecker products with \( H_2 \). Here is the Stata code to generate the Hadamard matrix for the previous example.

```stata
matrix h2 = (-1, 1 \\ 1, 1)
matrix h32 = h2
forvalues i = 1/4 {
    matrix h32 = h2 # h32
}
svy brr consumes Hadamard matrices from left to right, so it is best to make sure that \( r \) is greater than the number of strata and that the last column is the one consisting of all 1s. This will ensure full orthogonal balance according to Wolter (2007).
Stored results

In addition to the results documented in [SVY] svy, svy brr stores the following in e():

Scalars

- `e(N_reps)` number of replications
- `e(N_misreps)` number of replications with missing values
- `e(k_exp)` number of standard expressions
- `e(k_eexp)` number of `_b/_se` expressions
- `e(k_extra)` number of extra estimates added to `_b`
- `e(fay)` Fay’s adjustment

Macros

- `e(cmdname)` command name from `command`
- `e(cmd)` same as `e(cmdname)` or brr
- `e(vce)` `brr`
- `e(brrweight)` `brrweight()` variable list

Matrices

- `e(b_brr)` BRR means
- `e(V)` BRR variance estimates

When `exp_list` is `_b`, svy brr will also carry forward most of the results already in e() from `command`.

Methods and formulas

See [SVY] Variance estimation for details regarding BRR variance estimation.

References


Also see

[SVY] svy postestimation — Postestimation tools for svy

[SVY] svy bootstrap — Bootstrap for survey data

[SVY] svy jackknife — Jackknife estimation for survey data

[SVY] svy sdr — Successive difference replication for survey data

[SVY] Calibration — Calibration for survey data

[SVY] Poststratification — Poststratification for survey data

[SVY] Subpopulation estimation — Subpopulation estimation for survey data

[SVY] Variance estimation — Variance estimation for survey data

[U] 20 Estimation and postestimation commands