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
svy brr — Balanced repeated replication for survey data

Syntax

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

svy_options

Description

```
if/in
   subpop([ varname ] [ if ] ) identify a subpopulation
```

Reporting

```
level(#) set confidence level; default is level(95)
noheader suppress table header
nolegend suppress table legend
noadjust do not adjust model Wald statistic
ncnsreport 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
```

coeplegend display legend instead of statistics

coeplegend is not shown in the dialog boxes for estimation commands.

brr_options

Description

```
Main
   hadamard(matrix) Hadamard matrix
   fay(#) Fay’s adjustment

Options
   saving(filename[, ...]) save results to filename; save statistics in double precision; save results to filename every # replications
   mse use MSE formula for variance

Reporting
   verbose display the full table legend
   nodots suppress replication dots
   dots(#) display dots every # replications
   noisy display any output from command
   trace trace command
   title(text) use text as title for BRR results

Advanced
   nodrop do not drop observations
   reject(exp) identify invalid results
   dof(#) design degrees of freedom
```

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.

Warning: Using if or in restrictions will often not produce correct variance estimates for subpopulations. To compute estimates for subpopulations, use the subpop() option.
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)
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 ≤ # ≤ 2, but excluding 1. This option overrides the fay(#) option of svyset; see [SVY] svyset.

Options

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.
`svy brr` — Balanced repeated replication for survey data

### Reporting

- `verbose` requests that the full table legend be displayed.
- `nodots` and `dots(#)` specify whether 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.
. use https://www.stata-press.com/data/r16/nhanes2brr

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>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).

. use https://www.stata-press.com/data/r16/nhanes2brr

svyset
  pweight: finalwgt
  VCE: brr
  MSE: off
  brrweight: brr_1 .. brr_32
  Single unit: missing
  Strata 1: <one>
  SU 1: <observations>
  FPC 1: <zero>

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.
. svy brr WtoH = (_b[weight]/_b[height]): total weight height
(running total on estimation sample)
BRR replications (32)

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
</table>

BRR results

<p>| command: total weight height  |</p>
<table>
<thead>
<tr>
<th>WtoH: _b[weight]/_b[height]</th>
</tr>
</thead>
<tbody>
<tr>
<td>BRR * Coef. Std. Err. t P&gt;</td>
</tr>
<tr>
<td>WtoH .4268116 .0008904 479.36 0.000 .4249957 .4286276</td>
</tr>
</tbody>
</table>

The mse option causes 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 [SVY] Variance estimation for more details. The header for the column of standard errors in the table of results is BRR * for the BRR variance estimator using the MSE formula.

. svy brr WtoH = (_b[weight]/_b[height]), mse: total weight height
(running total on estimation sample)
BRR replications (32)

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
</table>

BRR results

<p>| command: total weight height  |</p>
<table>
<thead>
<tr>
<th>WtoH: _b[weight]/_b[height]</th>
</tr>
</thead>
<tbody>
<tr>
<td>BRR * Coef. Std. Err. t P&gt;</td>
</tr>
<tr>
<td>WtoH .4268116 .0008904 479.36 0.000 .4249957 .4286276</td>
</tr>
</tbody>
</table>

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

Example 2: Survey data without replicate-weight variables

For survey data with the PSU and strata variables but no replication weights, svy brr can compute adjusted sampling weights within its replication loop. Here the 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 nhanes2.dta, so we need a Hadamard matrix of order 32 (or more) to use svy brr with this dataset. Here we use 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)
.............................
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

<table>
<thead>
<tr>
<th>BRR Ratio Std. Err. [95% Conf. Interval]</th>
</tr>
</thead>
<tbody>
<tr>
<td>WtoH .4268116 .0008904 .4249957 .4286276</td>
</tr>
</tbody>
</table>

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 \[SVY\] \texttt{svy}, \texttt{svy brr} stores the following in \texttt{e()}:  

Scalars 
\begin{itemize}
  \item \texttt{e(N_reps)} \hspace{1cm} \text{number of replications}
  \item \texttt{e(N_misreps)} \hspace{1cm} \text{number of replications with missing values}
  \item \texttt{e(k_exp)} \hspace{1cm} \text{number of standard expressions}
  \item \texttt{e(k_eexp)} \hspace{1cm} \text{number of } _b/_se \text{ expressions}
  \item \texttt{e(k_extra)} \hspace{1cm} \text{number of extra estimates added to } _b
  \item \texttt{e(fay)} \hspace{1cm} \text{Fay’s adjustment}
\end{itemize}

Macros 
\begin{itemize}
  \item \texttt{e(cmdname)} \hspace{1cm} \text{command name from } \texttt{command}
  \item \texttt{e(cmd)} \hspace{1cm} \text{same as } \texttt{e(cmdname)} \text{ or } \texttt{brr}
  \item \texttt{e(vce)} \hspace{1cm} \texttt{brr}
  \item \texttt{e(brrweight)} \hspace{1cm} \texttt{brrweight()} \text{ variable list}
\end{itemize}

Matrices 
\begin{itemize}
  \item \texttt{e(b_brr)} \hspace{1cm} \text{BRR means}
  \item \texttt{e(V)} \hspace{1cm} \text{BRR variance estimates}
\end{itemize}

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

Methods and formulas

See \[SVY\] \textbf{Variance estimation} for details regarding BRR variance estimation.

References


Also see

\texttt{[SVY]} \texttt{svy postestimation} — Postestimation tools for \texttt{svy}

\texttt{[SVY]} \texttt{svy bootstrap} — Bootstrap for survey data

\texttt{[SVY]} \texttt{svy jackknife} — Jackknife estimation for survey data

\texttt{[SVY]} \texttt{svy sdr} — Successive difference replication for survey data

\texttt{[SVY]} \texttt{Calibration} — Calibration for survey data

\texttt{[SVY]} \texttt{Poststratification} — Poststratification for survey data

\texttt{[SVY]} \texttt{Subpopulation estimation} — Subpopulation estimation for survey data

\texttt{[SVY]} \texttt{Variance estimation} — Variance estimation for survey data

\texttt{[U]} \texttt{20 Estimation and postestimation commands}