What is Survey Weighting?

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Outline

1. Introduction
2. (Unresolved) Issues
3. Further reading etc.
Sampling
Representation

4 out of 8

1 out of 10
Weights

\[
\frac{8}{4} = 2
\]

\[
\frac{10}{1} = 10
\]
## Data

<table>
<thead>
<tr>
<th>Sample unit</th>
<th>Weight</th>
<th>Survey variable</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>10</td>
<td>4</td>
</tr>
</tbody>
</table>
## Estimation of Mean of Survey Variable

<table>
<thead>
<tr>
<th>Respondent $i$</th>
<th>Weight $w_i$</th>
<th>Survey variable $y_i$</th>
<th>$w_i y_i$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>10</td>
<td>4</td>
<td>40</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>18</strong></td>
<td><strong>8</strong></td>
<td><strong>48</strong></td>
</tr>
</tbody>
</table>

Unweighted mean = $8/5 = 1.60$

Weighted mean = $48/18 = 2.67$
Weighted Estimation as Replication

Weighting equivalent to

(i) replicating each respondent $w_i$ times (provided $w_i$ is integer)
(ii) using unweighted estimation with replicated dataset

respondent $i$ represents $w_i$ population units
**Why Weight?**

Want to estimate statistical characteristics of population.

If don’t weight will estimate characteristics of sample, which may not be representative of population.

Difference between two → **bias** of unweighted estimator.
### Example: Workplace Employee Relations Survey 1997

(Purdon, 2004)

<table>
<thead>
<tr>
<th>Population</th>
<th>Sample</th>
<th>Sampling fraction (1 in ..)</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>10-24</td>
<td>197358</td>
<td>362</td>
<td>545</td>
</tr>
<tr>
<td>25-49</td>
<td>76087</td>
<td>603</td>
<td>126</td>
</tr>
<tr>
<td>50-99</td>
<td>36004</td>
<td>566</td>
<td>64</td>
</tr>
<tr>
<td>100-199</td>
<td>18701</td>
<td>562</td>
<td>33</td>
</tr>
<tr>
<td>200-499</td>
<td>9832</td>
<td>626</td>
<td>16</td>
</tr>
<tr>
<td>500+</td>
<td>3249</td>
<td>473</td>
<td>7</td>
</tr>
</tbody>
</table>
Example of Bias in WERS

Unweighted employee-level estimates will overrepresent characteristics of employees in larger workplaces (when population of all employees is of interest).

Weighting needed to avoid bias.
Circumstances when Weighting may be useful

• unequal probability sampling

• non-probability sampling

• nonresponse (usually unit)

• other selection e.g. undercoverage
Construction vs. Use of weights

**Construction** of weights and incorporation into data files by survey agency
- may use detailed information, technical expertise and evaluations not available to standard data user.

**Use** of weights by researchers / survey data users
Construction of weights
Weights

\[ \frac{8}{4} = 2 \]

\[ \frac{10}{1} = 10 \]
### Alternative Weights

<table>
<thead>
<tr>
<th>Calculation</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>$5/3$</td>
<td>$1.67$</td>
</tr>
<tr>
<td>$3/1$</td>
<td>$3$</td>
</tr>
<tr>
<td>$10/1$</td>
<td>$10$</td>
</tr>
</tbody>
</table>
Approaches to Constructing Weights

*Inverse probability weights*  
(Hansen and Hurvitz, 1943; Horvitz and Thompson, 1952)

Weight = $1 / \text{Probability that unit is selected}$

For probability sampling, assume probabilities of selection ‘measurable’

For nonprobability sampling or nonresponse, need to model probability of selection e.g. using logistic regression. Sometimes called *propensity weights*
Auxiliary Information

Weights use information on *auxiliary variables = weighting variables* in *population*, e.g. national age-sex population estimates

or (in case of non-response) on *sample*, e.g. characteristics of area in which respondent or nonresponsive lives.

Techniques include *post-stratification, (generalized) regression estimation, raking, calibration estimation*. 
Use of Weights

Different kinds of weights:

- *sampling weights* to compensate for unequal sampling probabilities
- *nonresponse weights* to compensate for nonresponse
  - may have alternative weights corresponding to different responding subsamples, e.g. in surveys combining interview & diary
- *final/combined weights* (e.g. combining sampling and nonresponse weights)
• *scaled (standardised) weights*, which sum to 1 or 100 across sample (may be easier to interpret, but not suitable for estimating totals)

• *weights for different units of analysis*, e.g. household vs. individual weights

• *weights for different survey variables*, but usually try to avoid this, weights are multipurpose unlike e.g. imputation
Dependence on assumptions for bias adjustment

*Probability sampling* – sampling weights can correct for bias without further assumptions

*Non-probability sampling and nonresponse* – weights only correct for bias under **strong assumption** that selection is unrelated to survey variable, conditional on auxiliary weighting variables
Weighting and Variance

Weighting affects variance as well as bias. Can inflate variance or can reduce it. Variance inflation can offset advantage of bias-correction.

Unless, effect is allowed for, standard errors, confidence intervals, significant tests etc. produced by standard statistical software can be misleading.

Other features of complex sampling (stratification and multistage sampling) also affect variance.
Using weighted data

Want software which allows for weighting, stratification and multistage sampling in analysis.

Usually require data file which includes fields for: weight, stratum and primary sampling unit

Software includes:
STATA (version 10+) - svy procedures
SAS (SAS/STAT)
SPSS (version 12+) – Complex sample module
R (Lumley, 2010)
Issues: construction of weights

• which weighting variables to use in particular applications e.g. use of past vote in election polling (Curtice, 2010)
• how many weighting variables to use (and with what detail)?
• whether & how to incorporate social science theory of survey participation in nonresponse weights (Groves and Couper, 1995)
Issues: construction of weights (new methods)

- weighting for multilevel modelling (Pfeffermann, Skinner…, 1998)
- links with biostatistical and econometric literatures on inverse probability and double robust weighting (Kang and Schafer, 2005)
Issues: alternative approaches

- whether (and when) to weight (Fienberg, 2008)
- regression models to control for selection variables as alternative (Gelman, 2007)
- ‘efficient’ statistical modelling approaches (Bayesian, likelihood) (Chambers and Skinner, 2003)
- multiple imputation as alternative, even for unit nonresponse
Future Short Course

Introduction to Survey Sampling and Estimation
Pedro Silva
4th - 6th October 2010
Southampton

Courses in Applied Social Surveys
http://www.s3ri.soton.ac.uk/cass/
Further Reading


Practical Exemplars on the Analysis of Surveys (PEAS) http://www.restore.ac.uk/PEAS/ (website last updated May 2009)


Additional References


