

Calibration of Weights in Surveys with Nonresponse and Frame Imperfections

A course presented at
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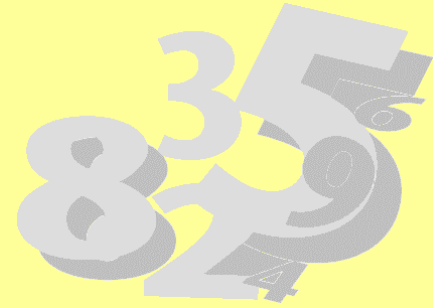
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1 Introduction



Welcome to this course

with the title :

*Calibration of Weights in Surveys
with Nonresponse
and Frame Imperfections*

The title of the course
suggests two objectives :

- To study *calibration* as a general method for estimation in surveys; this approach has attracted considerable attention in recent years
- To focus on problems caused by *nonresponse* : bias in the estimates, and how to reduce it

Key concepts

Finite population U :

N objects (elements) : persons,
or farms, or business firms, or ...

Sample s :

A subset of the elements in U : $s \subset U$

Sampling design :

How to select a sample s from U
or, more precisely, from the list
of the elements in U (the *frame population*)

Key concepts

Probability sampling :

Every element in the population has
a non-zero probability denoted π_k
of being selected for the sample

In this course we assume that
probability sampling is used
to draw the sample –
but not everyone in the sample responds

There is a well-defined survey objective .

For ex., information needed about employment :

How many unemployed persons are there
in the population?

Study variable : y

with value $y_k = 1$ if k unemployed

$y_k = 0$ if k not unemployed

‘Unemployed’ is a well-defined concept (ILO)

Number of unemployed to be estimated :

$$\sum_{k=1}^N y_k = \sum_{k \in U} y_k = \sum_U y_k$$

For a domain (a sub-population) U_q
we consider a domain specific y-variable, y_q

with value y_{qk} such that

$y_{qk} = y_k$ in the domain, $y_{qk} = 0$ outside

Domain total to estimate: $\sum_{U_q} y_k = \sum_U y_{qk}$

Example: total of **disposable income** (the y-variable)
in **single-member households** (the domain)

Key concepts

There may exist *other variables* whose values are known and can be used to improve the estimation. They are called *auxiliary variables*.

Calibration is a systematic approach to the use of auxiliary information.

Key concepts

Auxiliary variables play an important role

- in the sampling design (e.g., stratification)
- in the estimation (by calibration)

In this course we focus on how aux.
information is used in the estimation.

Key concepts

Ideal survey conditions :

- The only error is sampling error.
- All units selected for the sample provide the desired information
(no *nonresponse*)
- They respond correctly and truthfully
(no *measurement error*)
- The frame population agrees with the target population
(no *frame imperfections*)

Horwitz-Thompson estimator of $Y = \sum_U y_k$

$$\hat{Y}_{HT} = \sum_S d_k y_k \quad \text{unbiased}$$

Design weight of k : $d_k = 1 / \pi_k$

Requires complete response (ideal conditions)

GREG estimator of $Y = \sum_U y_k$

$$\hat{Y}_{GREG} = \sum_S d_k y_k + \left(\sum_U \hat{y}_k - \sum_S d_k \hat{y}_k \right)$$

HT est. of Y + regression adjustment

almost unbiased

also requires ideal conditions

This course

Nonresponse (abbreviated NR) :

All of those selected for the sample do not response, or they respond to part of the questionnaire only

A troubling feature of surveys today:

NR rates are very high.

‘Classical survey theory’ did not need to pay much attention to NR.

This course

Most of this course is devoted to the situation :
sampling error and NR error

Objective :

Describe approaches to estimation ;

Reduce as much as possible

both bias (due to NR) and variance

This course

In the concluding session we add another complication :

Frame imperfections : The target population is not identical to the frame population

Not discussed in the course:

Measurement error : Some of the answers provided are wrong

Research on NR in recent years

Two directions :

Preventing NR from occurring (methods from behavioural sciences) - We do not discuss this

Dealing with ('adjusting for') NR once it has occurred (mathematical and statistical sciences) ; the subject of this course.

Categories of NR

- *Item NR (or partial NR)*: The selected element responds to some but not all questions on the questionnaire
- *Unit NR* : The selected element does not respond at all ;
 - among the reasons :
 - refusal, not-at-home, and others

Basic considerations for this course

- NR is a *normal, but undesirable feature* of essentially all sample surveys today
- NR causes *bias* in the estimates
- We must still make the best possible estimates
- Bias is never completely eliminated, but we strive to reduce it as far as possible
- Small variance is no consolation, because $(\text{bias})^2$ can be the dominating part of MSE

Why is NR such a serious problem ?

The intuitive understanding : Those who happen to respond are often not '*representative*' for the population for which we wish to make inferences (estimates).

The result is *bias* : Data on the study variable(s) available only for those who respond. The estimates computed on these data are often systematically wrong (biased).

We cannot (completely) eliminate that bias.

The term “representative”

has been (and is) used with several different meanings .

Those who respond are often

“a skewed selection”

“a non-representative selection”

Consequences of NR

- $(\text{bias})^2$ can be the larger part of MSE
- NR increases **survey cost**; follow-up is expensive
- NR will **increase the variance**, because fewer than desired will respond. But this can be compensated by anticipating the NR rate and allowing 'extra sample size'
- Increased variance often a minor problem, compared with **the bias problem**.

Treatment of NR

- NR may be treated by *imputation*
primarily the *item NR* ;
not discussed in this course .
- NR may be treated by (adjustment) *weighting*
primarily the *unit NR* ;
it is the main topic in this course

Neither type of treatment will resolve the real problem, which is bias.

Starting points

- Adjustment methods never completely eliminate the NR bias for a given study variable. This holds for the methods in this course, and for any other method
- NR bias may be *small for some* of the usually many study variables, but *large for others*; unfortunately, we have no way of knowing

Comment

Different countries have very different conditions for *sampling design* and *estimation*. The Scandinavian countries have access to many kinds of registers, providing extensive sources of auxiliary data.

Literature on nonresponse

- little was said in early books on survey sampling (Cochran and other books from the 1950's)
- in recent years, a large body of literature , many conferences
- several statistical agencies have paid considerable attention to the problem

Our background and experience for work on NR methodology

- *S. Lundström*, Ph.D. Thesis, Stockholm Univ. (1997)
- *Lundström & Särndal* : Current Best Methods manual, Statistics Sweden (2002)

http://www.scb.se/statistik/_publikationer/OV9999_2000I02_BR_X97%c3%96P0103.pdf.

- *Särndal & Lundström*: **Estimation in Surveys with Nonresponse**. New York: Wiley (2005). The course is structured on this book.

Our background

Särndal & Lundström (2008): Assessing auxiliary vectors for control of nonresponse bias in the calibration estimator. *Journal of Official Statistics*, 24, 251-260

Särndal & Lundström (2009): Design for estimation: Identifying auxiliary vectors to reduce nonresponse bias. To appear in: *Survey Methodology Journal*.

Important earlier works

Olkin, Madow and Rubin (editors):

Incomplete data in sample surveys.

New York: Academic Press (1983) (3 volumes)

Groves, Dillman, Eltinge and Little (editors):

Survey Nonresponse.

New York: Wiley (2001)

These books examine NR from many different perspectives.

Survey response in your organization

Trends in survey response rates ? Increasing ?

What are typical response rates ? In the Labour Force Survey for ex.? Is it a reason for concern ?

Have measures been introduced to increase survey response ?

Have measures been introduced to improve estimation ? By more efficient use of auxiliary information, or by other means ?