Can Estimated-Control Calibration Reduce Bias in Estimates from Nonprobability Samples?

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Motivation

Fit for Purpose (6 Criteria):

Relevance, Timeliness, Accessibility, Interpretability, Accuracy (Precision), and Coherence [1]

Climate

- Declining response rates
- Measurement errors
- Limited funds
- The need for speed

Motivation

Weights needed for public-/research-use data [2]

- *Propensity score adjustment* [3]

- *Calibration adjustment* [4]

- Composite estimation (multiple data sets)

- Meta-analysis

- Model-based analyses (no weights)

- Bayesian modeling

Two Flavors of Survey Sampling Designs

Probability sampling:

– Presence of a sampling frame linked to population

– Every unit has a known probability of being selected

– Design-based theory focuses on <u>random selection mechanism</u>

– Examples: address-based sampling, dual-frame RDD

Non-probability sampling:

– No population sampling frame available

– Underlying <u>population model</u> is important

– Some opinions on reported estimates of error

– Examples: focus groups, opt-in web panels, quota sampling

Propensity Score Adjustment

Logistic model with a reference survey to estimate probability of selection => weights

Adjust for *selection bias*:
- Covered population
- Catchment area
- Nonresponse (nonparticipation)

Input weights:
- NP weights = 1
- Reference survey weights [4]

Propensity Score Adjustment

Assumptions:

- – Surveys are disjoint
- – Nonparticipants are missing at random
- – Large reference survey from the target population
- – Overlap in the questionnaires

Research to date:

- – Only part of the bias was removed [5]
- – Mixed results [3,6]
- – Adjusted reference survey weights needed [4]

Calibration Adjustment

Traditional weight calibration [7]

$$\sum_{s_A} w_k \mathbf{x}_k = \mathbf{t}_{Ux}, \quad \text{where} \quad \mathbf{t}_{Ux} = \sum_U \mathbf{x}_k$$

$$\hat{t}_{yGR} = \hat{t}_{Ay} + \left(\mathbf{t}_{Ux} - \hat{\mathbf{t}}_{Ax} \right)' \hat{\mathbf{B}}_A$$

Adjust for: [8]

- Coverage
- Nonresponse
- Weight variability

Input weights adjusted for sampling, nonresponse (possibly)

Estimated Control (EC) Calibration [7]

$$\sum_{s_A} w_k \mathbf{x}_k = \hat{\mathbf{t}}_{Bx}, \quad \text{where} \quad \hat{\mathbf{t}}_{Bx} = \sum_{s_B} w_l \mathbf{x}_l$$

$$\hat{t}_{yEC} = \hat{t}_{Ay} + \left(\hat{\mathbf{t}}_{Bx} - \hat{\mathbf{t}}_{Ax} \right)' \hat{\mathbf{B}}_A$$

Adjust for:
- Coverage
- Nonresponse

Input weights adjusted for sampling, nonresponse (possibly)

Simulation Study

Research questions:

Can estimated-control calibration reduce bias in estimates from non-probability samples?

Is there a difference between EC PSA, PSA.avg and calibration?

Simulation parameters [4]

- 2003 Michigan Behavioral Risk Factor Surveillance Survey (enhanced), N = 50,000

- Volunteer sample selected via Poisson sampling with defined probabilities of participation, n_A = (250, 500, 1000)

- Reference sample selected via simple random sampling, n_B = (1000, 500, 250)

- R = 10,000

Simulation Study

Covariates	Propensity to Volunteer	PSA's	EC Calibration
Age (6)	✓	✓	✓
Race (3)	✓	✓	✓
Gender (2)	✓	✓	✓
Wireless phone (2)	✓	✓	✓
Education (4)	✓	✓	✓
Income (5)	✓	✓	✓
Diabetes (2)		✓	✓

Simulation Study — Result Highlights

Compare relative differences in relative bias with and without estimated control (Diabetes):

$$relbias\left(\hat{\theta}\right) = 100\left(\overline{\hat{\theta}} - \theta\right)\bigg/\theta$$

Propensity to Volunteer covariates:

- EC PSA = bias decrease for some (< 5%),
  linked to correlation and size of reference

- EC PSA.avg = higher returns on bias reduction (<5%),
  more volatile results than EC PSA

Health Variables (9 categorical, 2 continuous):

- EC PSA = bias decrease for a few and not for others,
  better when reference survey is larger than NP

- EC PSA.avg = higher returns on bias reduction,
  more volatile results than EC PSA

- EC Calibration = bigger bang for the buck,
  more volatile results than EC PSA

Simulation Study — Result Highlights

Relative Sample Size	Body Mass Index (*Pct Relative Difference*)		
	PSA	PSA.Avg	Calibration
0.25	0.0	0.0	25.0
1	1.3	0.0	22.7
4	2.5	2.0	19.4

* Reference divided by non-probability sample size

Questions for Future Research

- How "best" to use EC Calibration with Propensity Scores?

- What is the impact on measures of error in using estimated controls?

- How sensitive are the theoretical assumptions underlying the methodology (e.g., surveys must be disjoint)?

- What flavor of estimated control should one choose?

References

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More Information

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