Minimizing errors in multi-mode surveys through Adaptive Survey Designs

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Survey data collection

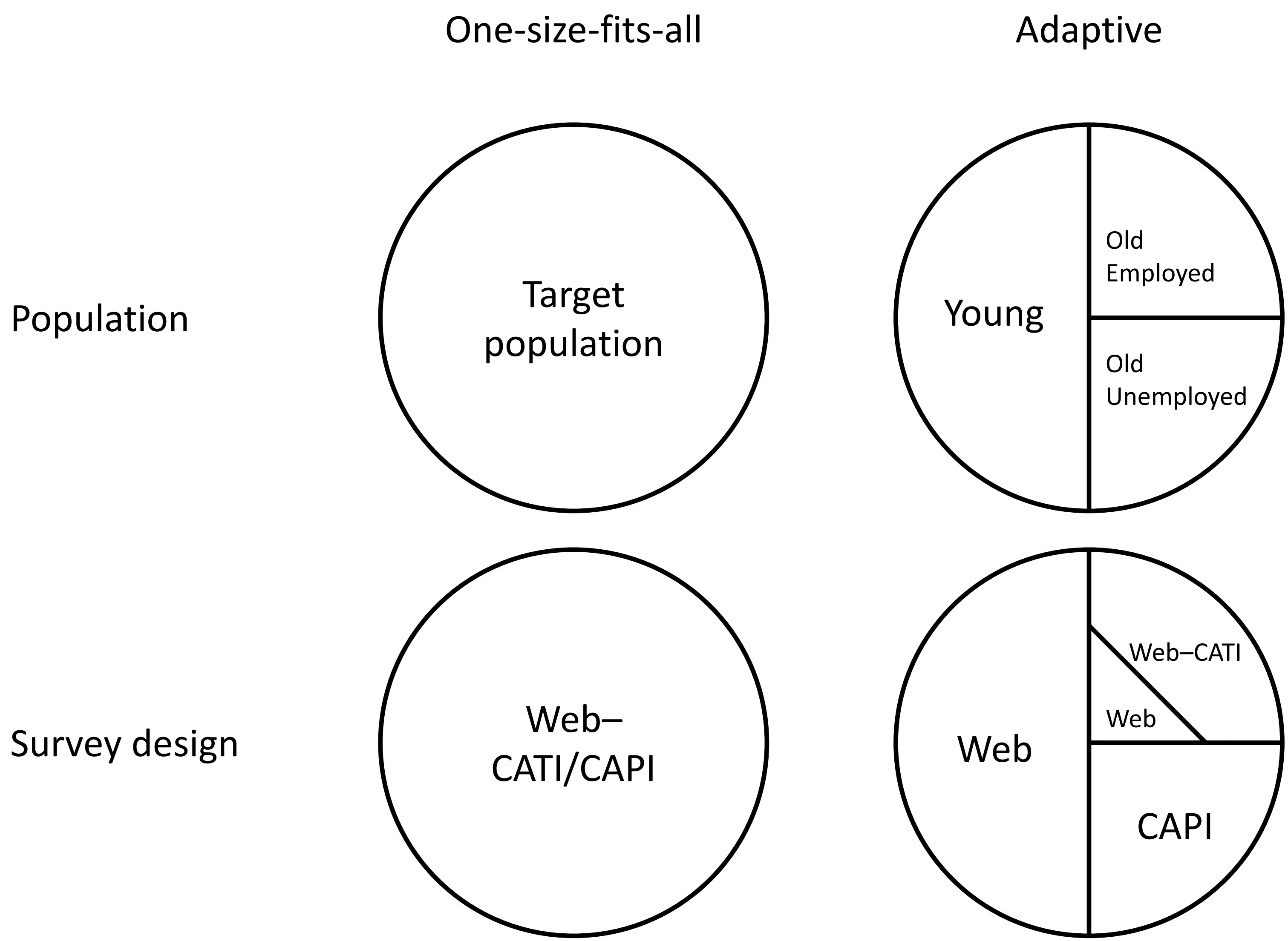
- Trends
  - Declining response rates
  - Budget cuts
- Multi-mode (e.g. web–CATI/CAPI)
  - Cheaper ☺
  - Mode effects ☹
- Accuracy under pressure

Mode effects

- Selection
  - Coverage
  - Nonresponse
- Measurement

Problem if mode mix changes over time

→ Adaptive survey design (ASD)


One-size-fits-all
Adaptive
Population
Target population
Young
Old Employed
Old Unemployed
Survey design
Web–CATI/CAPI
Web
Web–CATI
Web
CAPI

Adaptive Survey Design

- Avoid mode-specific effects
- Maintain budget
- Assign different strategies to different groups
  - Exploit difference between groups

Optimization problem

- Minimize overall mode effect, $\bar{D}$
- By optimally assigning strategies s to groups g

$$\min_{p_{s,g}} \bar{D} = \left| \sum_{s,g} \frac{N_g}{N} \frac{p_{s,g}\rho_{s,g}}{\sum_{s'} p_{s',g}\rho_{s',g}} D_{s,g} \right|$$

Constraints

- Budget

$$\sum_{s,g} N_g p_{s,g} c_{s,g} \leq B$$

- Minimum number of respondents per group

$$r_g = N_g \sum_{s} p_{s,g} \rho_{s,g} \geq R_g$$

- Minimum response rate

$$\frac{r}{n} = \frac{\sum_g r_g}{\sum_{s,g} N_g p_{s,g}} \geq \Gamma$$

Robustness

- ASDs require strategy- and group-specific input parameters
  - Response propensity, $\rho_{s,g}$
  - Sampling cost, $c_{s,g}$
  - Mode effect, $D_{s,g}$
- How sensitive are ASDs to
  - uncertainty about parameter estimates?
  - temporal changes in parameters?

Quantifying robustness

- Compare designs between bootstrap samples
- Compare designs between years
- Effect of old design on subsequent years

Comparing designs

Three distance measures

- relative difference in sample size; $[-1, \infty)$

$$d_1(1,2) = \frac{n_2 - n_1}{n_1}$$

- normalized Euclidean distance between group sampling probabilities; [0,1]

$$d_2(1,2) = \sqrt{\frac{1}{2}\sum_g \left(w_{1,g} - w_{2,g}\right)^2}$$

$$w_{j,g} = \mathbb{P}\{\text{group}|\text{sample}\} = \frac{w_g\left(1-p_{j,\emptyset,g}\right)}{\sum_g w_g\left(1-p_{j,\emptyset,g}\right)};\ w_g = \frac{N_g}{N}$$

- probability that a unit sampled under both designs is not allocated to the same strategy; [0,1]

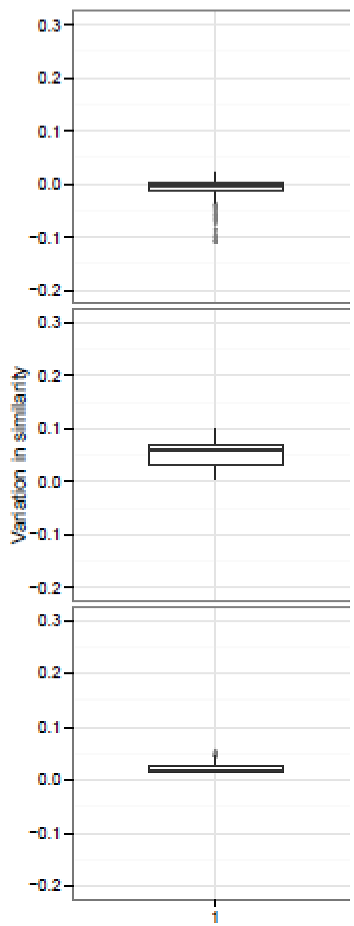
$$d_3(1,2) = 1 - \mathbb{P}\{\text{same strategy}|\text{group}, \text{sample}\}$$
$$= 1 - \sum_{s,g} \frac{w_g\left(1 - p_{1,\emptyset,g}\right)\left(1 - p_{2,\emptyset,g}\right)}{\sum_g w_g\left(1 - p_{1,\emptyset,g}\right)\left(1 - p_{2,\emptyset,g}\right)} P_{1,s,g} P_{2,s,g}$$

$$P_{j,s,g} = \mathbb{P}\{\text{strategy}|\text{group}, \text{sample}\} = \frac{p_{j,s,g}}{1 - p_{j,\emptyset,g}}$$

Case study

- Dutch Travel Survey
  - Travel behavior
- 8 groups: see paper
- 3 strategies
  - Web
  - Web–CATI
  - Web–CATI/CAPI (regular design)
- Parameter estimates: see paper

Robustness against uncertainty



d_1 (sample size)

d_2 (group sampling probabilities)

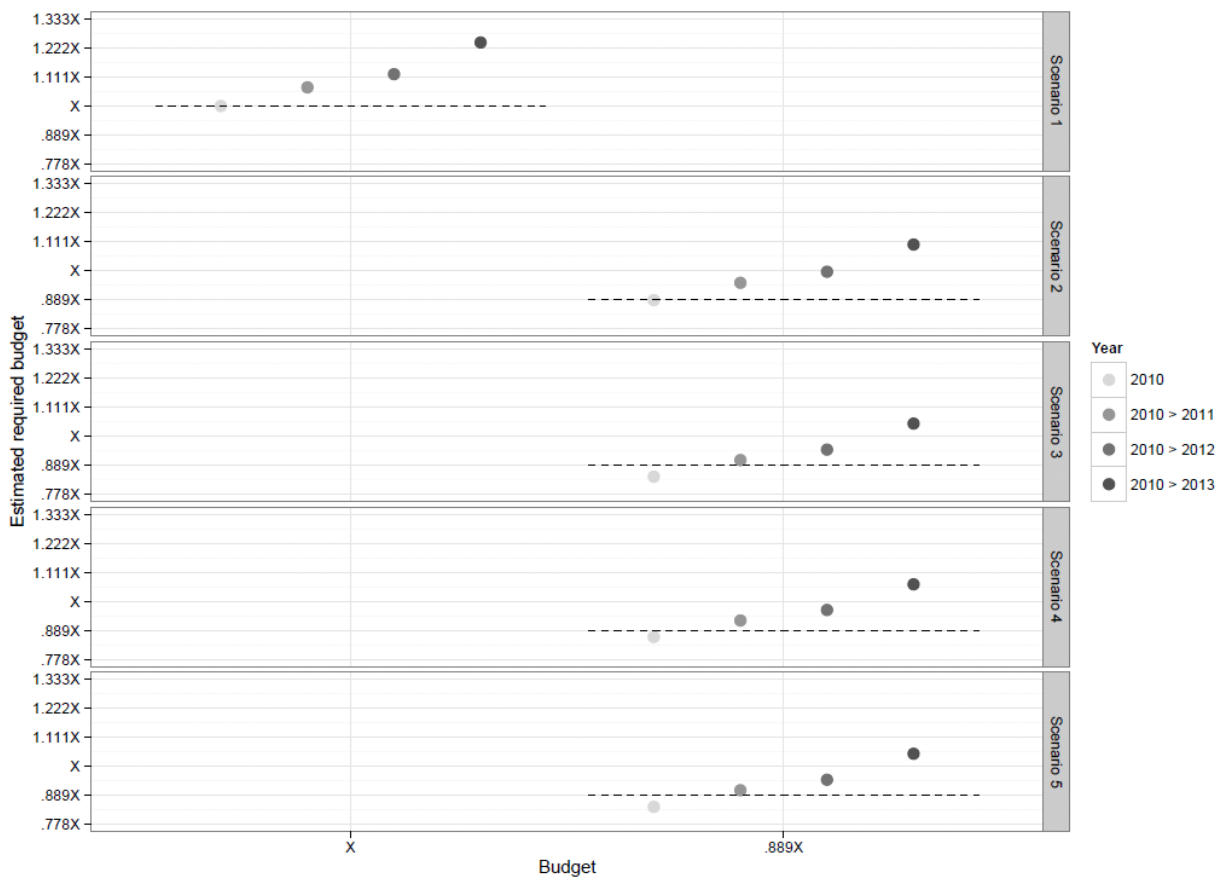
d_3 (conditional allocation probabilities)

Robustness against dynamics

Measure	Scenario	2010–2011	2010–2012	2010–2013
d_1	1	−0.098		
	2			
	3	−0.019		
	4	0.005		
	5	−0.019	0.027	
d_2	1	0.041		
	2			
	3	0.007		
	4	0.013		
	5	0.007		
d_3	1	0.087		
	2			
	3	0.018		
	4	0.158		
	5	0.018	0.145	

No solutions

Continue ASD 2010



Summary

- ASDs can avoid bias-inducing mode effects
  – in contrast to one-size-fits-all MMDs
- Proposed
  – ways to measure robustness
  – measures to compare designs
- Case study
  – robust against uncertainty
  – sensitive to dynamics