The additional effects of adaptive survey design beyond post-survey adjustment: An experimental evaluation

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Many thanks to my committee:

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Many thanks to the team of

Detroit Metro Area Communities Study:

Dr. Elisabeth Gerber

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Sharon Sand

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Adaptive survey design

Recruitment Stage

-- Change and tailor recruitment procedures and protocols for different sample cases

2 fundamental ideas:

- Leverage-salience theory
- Not all cases have the same value

Under budget constraints, 2 goals:

- Reduce **variance** of survey estimates
- Reduce **bias**

Not unique…

Groves, Singer, & Corning, 2000

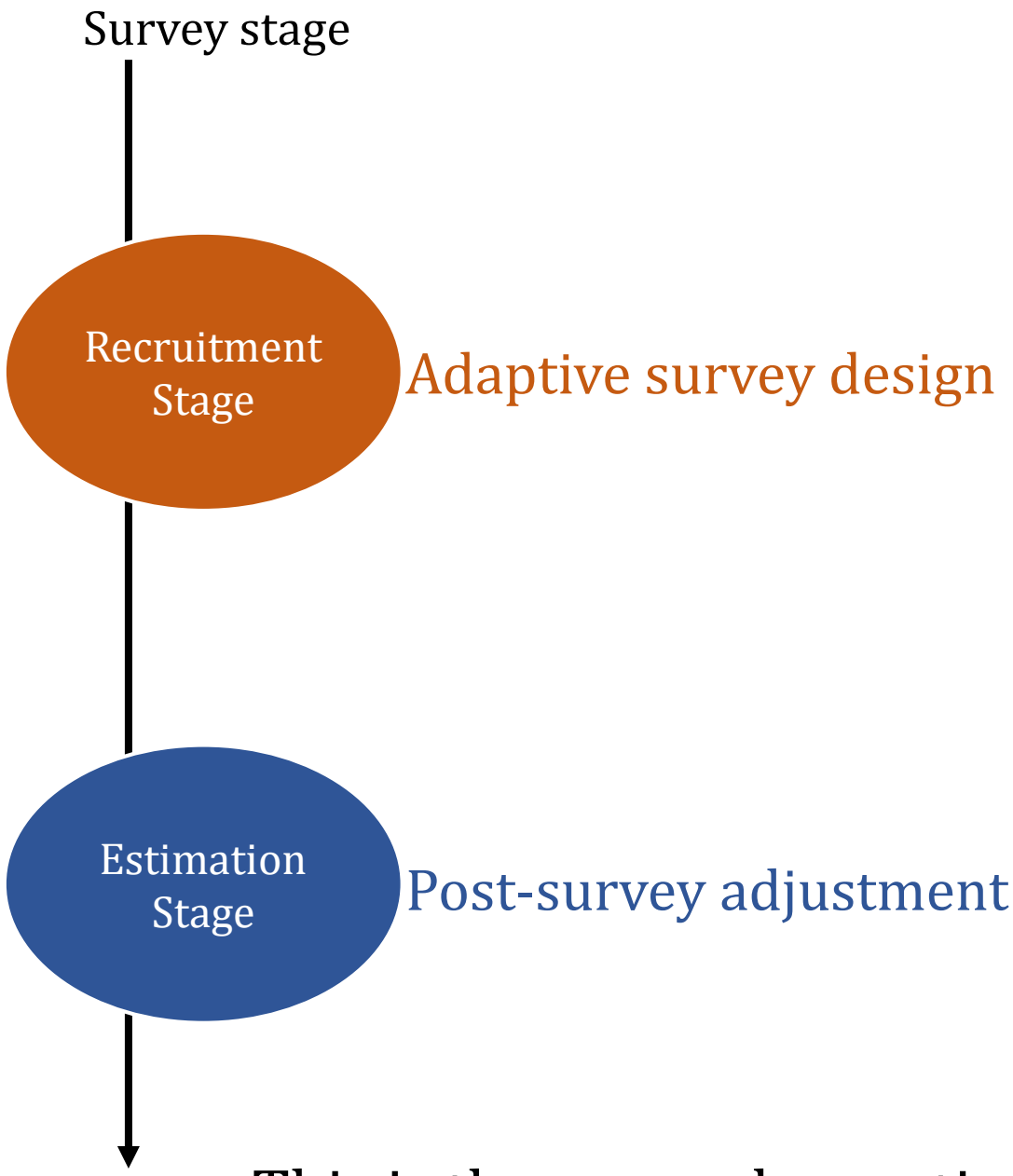
Post-survey adjustment

Estimation Stage

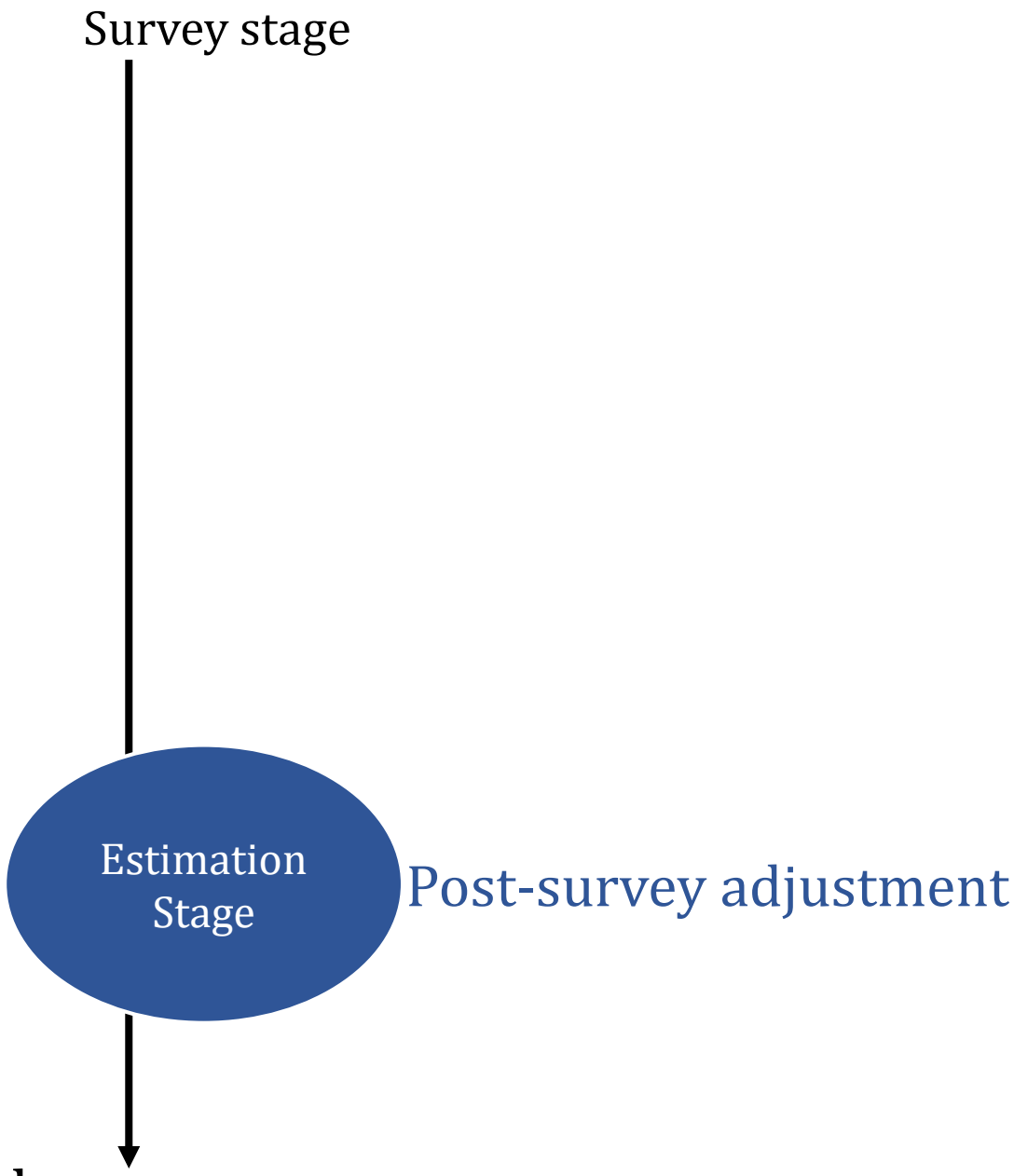
For example, **calibration:**

Matching respondent distributions to population distributions

- Reduce bias
- Reduce variance



VS.



This is the research question of this study.

Current literature

Theoretically:

adaptive design + post-survey adjustment—smaller bias and variance than— post-survey adjustment

Särndal & Lundquist, 2014, 2017, 2019; Schouten, Cobben, Lundquist, & Wagner, 2016

Current literature

Why?

Supposed that men are less likely to participate than women under a standard protocol

Solution 1: post-survey adjustment

- Large weights → increase variance
- Small number of men → imbalance in unobserved dimensions → increase bias

Solution 2: + adaptive design

More male respondents

- → less need for large weights
- → more likely to balance in other unobserved dimensions

Current literature

Limitation:

Theories and simulations

- The adaptive design is assumed to work efficiently
- In reality, there are constraints

→In real surveys, can the adaptive design bring additional benefits?

Experimentally answer this question

Methods

Methods

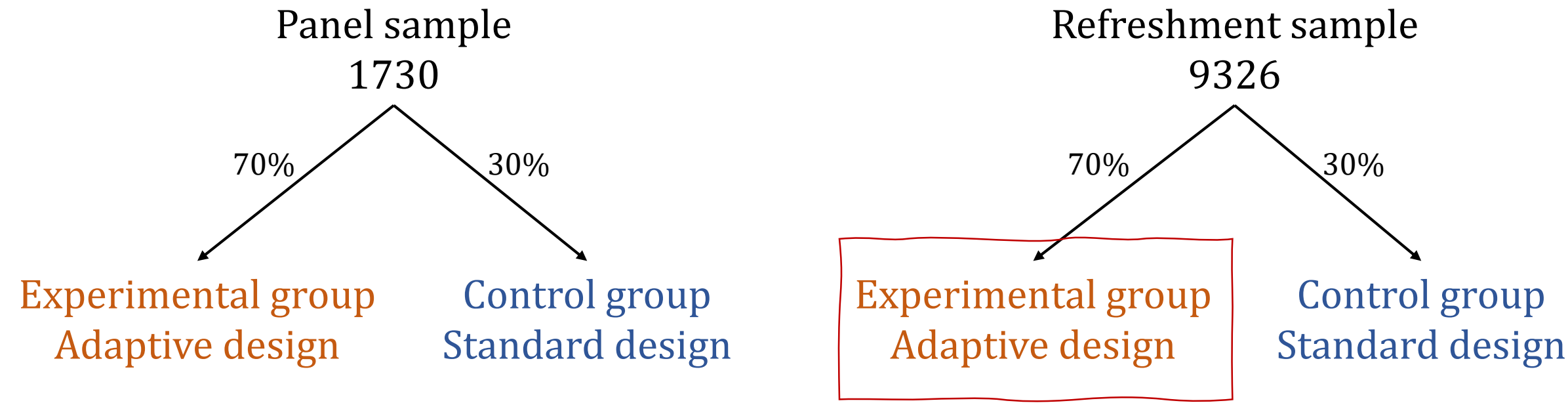
Experiment in Detroit Metro Area Communities Study (DMACS)

- Panel study of residents of city of Detroit
- Wave 12; January - March 2021
- Refreshment sample (n= 9329) + panel sample (n= 1730)

- Address-based sample
- Refreshment cases: mailings; panel cases: emails/ texts/ mailings
- Two ways to participate: Self-administered web interview (87%) + interviewer-administered telephone interview (13%)

Methods

Experimental Randomization



Adaptive design

Three strategies

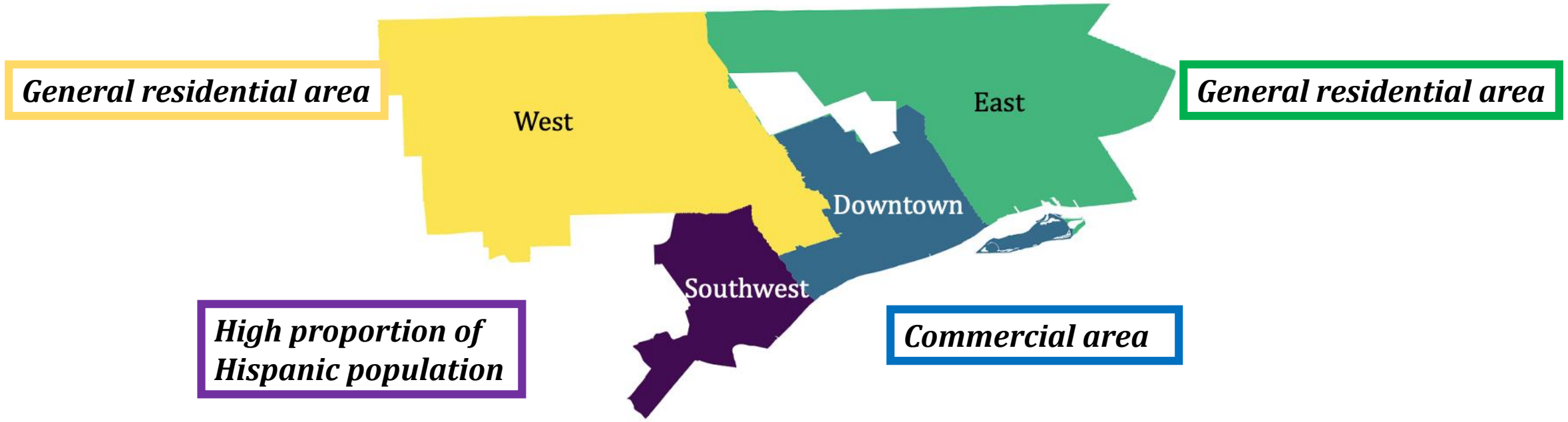
1. Higher incentives to lower-response propensity cases
2. Invitation materials, highlight different aspects of the survey
3. Invitation letter, region-specific fact about COVID-19

Bundled together → combined effect

Adaptive design

Categorize sample into subgroups

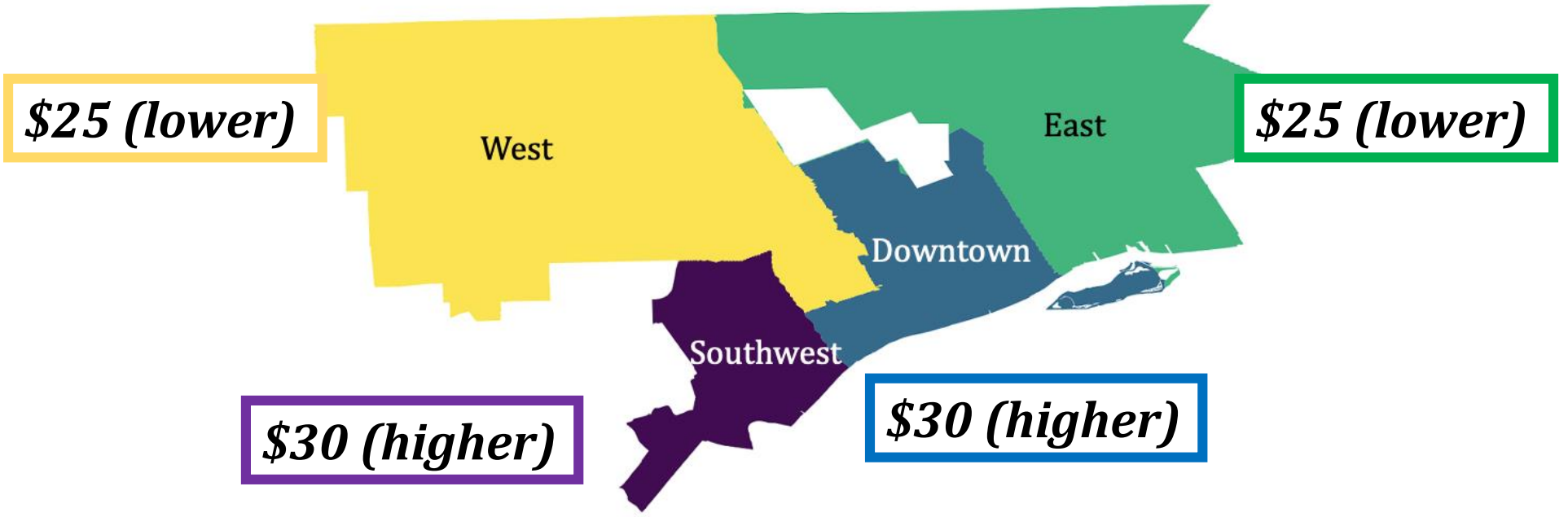
- Cluster analysis on block groups
  Input: Census planning database (PDB) + National neighborhood data archive (NaNDA)
- Smooth into geographically contiguous areas



Adaptive design

Operationalizing adaptive strategies for the four regions

#1: Differential incentive

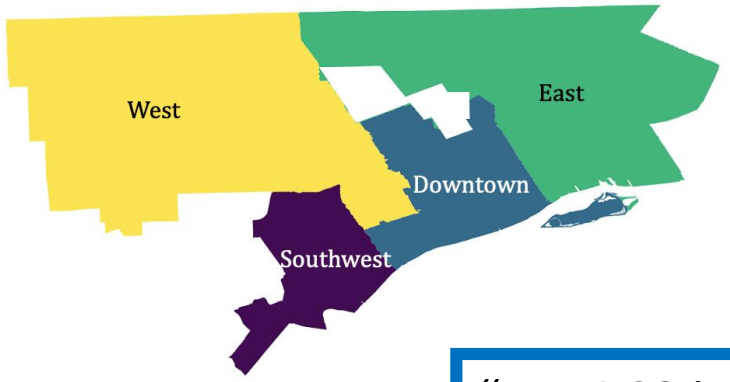


Adaptive design

Operationalizing adaptive strategies for the four regions

#2: Tailored invitation materials

Same as East



"DMACS is an ongoing survey that asks residents ***about neighborhoods, quality of life, and other topics important to Detroiters and their families."***

"DMACS is an ongoing survey that asks residents how the city can ***best meet the needs of people of many races and ethnicities who live in Detroit***."

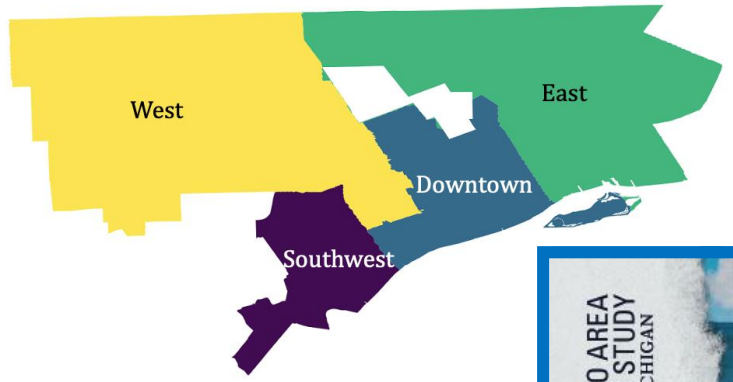
"DMACS is an ongoing survey that asks residents ***what they feel are the important issues related to residential and commercial growth in Detroit***."

Adaptive design

Operationalizing adaptive strategies for the fou

#2: Tailored invitation materials

Same as East

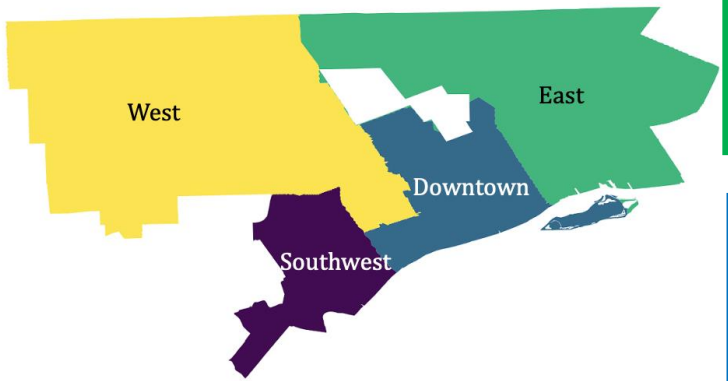


Adaptive design

Operationalizing adaptive strategies for the four regions

#3: Region-specific fact about COVID-19

According to our most recent survey from the end of October 2020, **42%** of Detroiters on the west side reported having friends or family members who died from COVID-19, compared to only 30% in the rest of Detroit



According to our most recent survey from the end of October 2020, **10%** of Detroiters on the Eastside considered **getting medication a major challenge**, compared to only 5% in the rest of Detroit

According to our most recent survey from the end of October 2020, a substantially higher percentage of Detroiters in Southwest Detroit (**31%**) are **not covered by any insurance or health care plan** compared to the rest of Detroit (14%).

According to our most recent survey from the end of October 2020, a substantially higher percentage of Detroiters in Downtown and Midtown (**80%**) considered COVID-19 to be **a very serious problem** for their communities, compared to 67% in the rest of Detroit.

Standard design in control group

1. Incentive: $25
2. Same invitation materials
3. No COVID fact was included

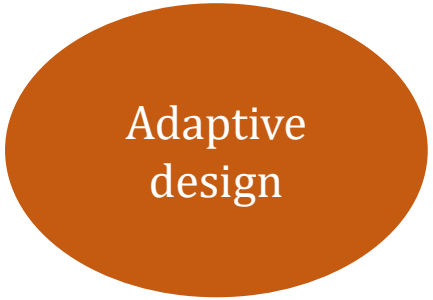
Refreshment & Panel sample

Same design with minor modifications

- Just accommodate the different contacts: emails/texts vs. mailings

Analysis

Experimental group

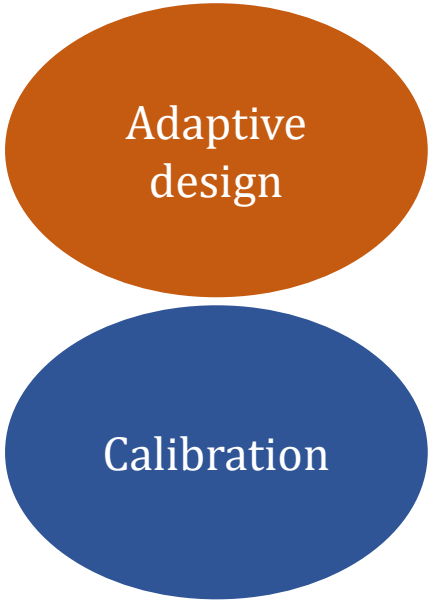


Control group

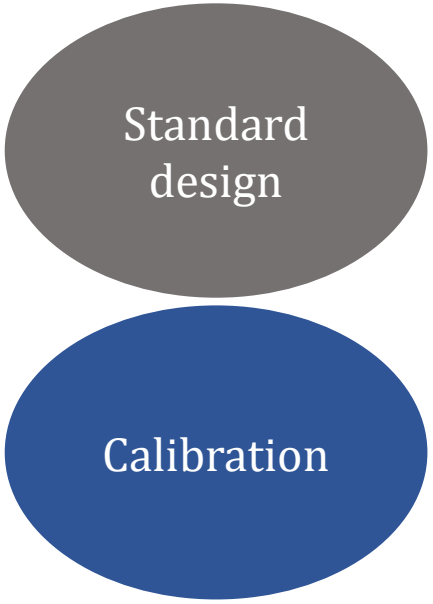
Compare **response rates** and respondents' demographic **representativeness**

Analysis

Experimental group



Control group



On gender and age, education, race and ethnicity, and household income

Compare **bias and variance of univariate estimates** and conclusions drawn from **multivariate analysis**

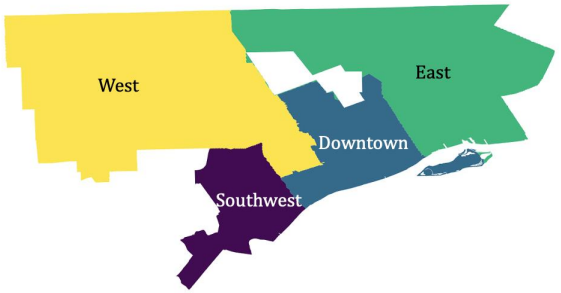
Costs

Results

Response rate

Panel
Con. vs. Exp.: 0.69 vs. 0.72

Refreshment
Con. vs. Exp.: 0.10 vs. 0.09



Panel
Con. vs. Exp.: 0.72 vs. 0.78

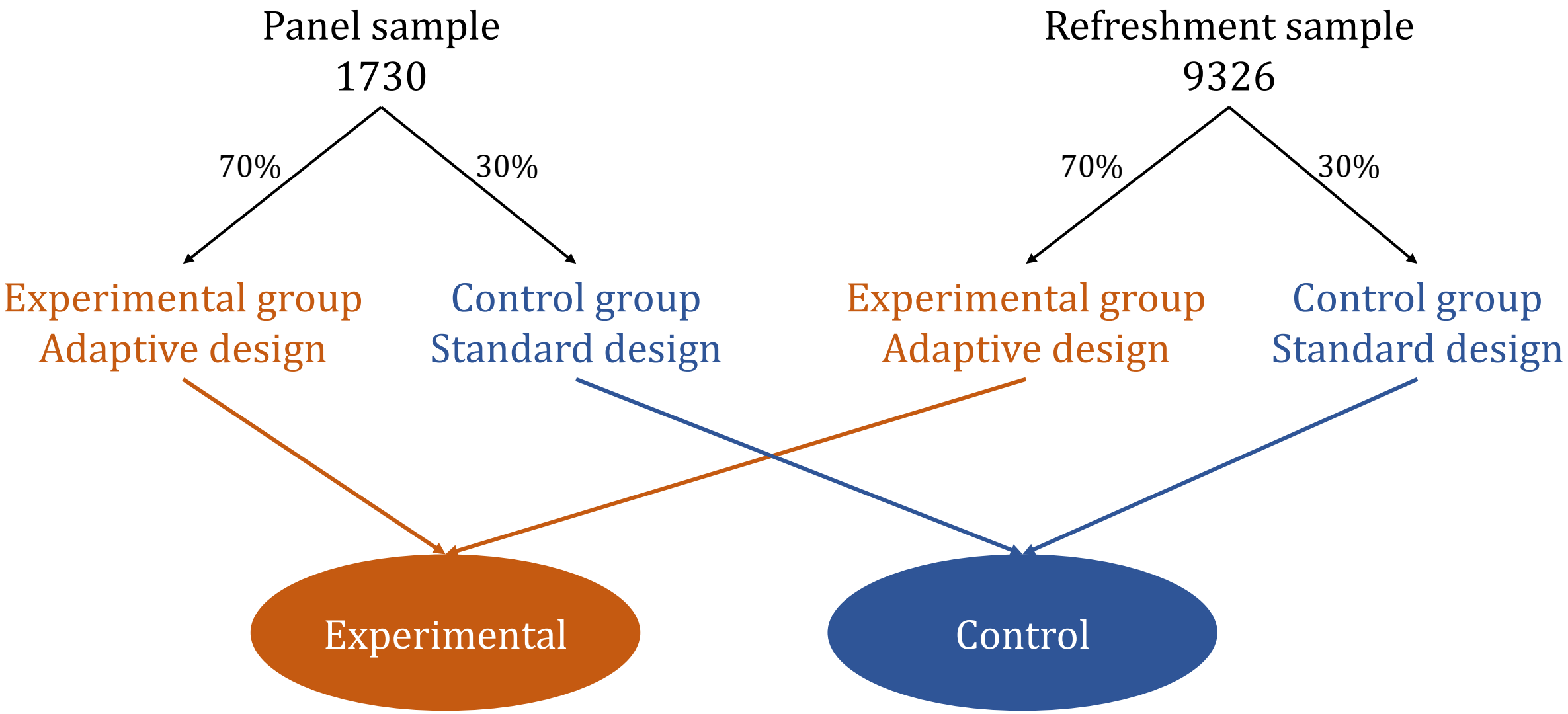
Refreshment
Con. vs. Exp.: 0.11 vs. 0.11

Panel
Con. vs. Exp.: 0.66 vs. 0.74

Refreshment
Con. vs. Exp.: 0.08 vs. 0.11

Panel
Con. vs. Exp.: 0.78 vs. 0.70

Refreshment
Con. vs. Exp.: 0.13 vs. 0.13


Panel sample
1730
70%
30%
Experimental group
Adaptive design
Control group
Standard design
Refreshment sample
9326
70%
30%
Experimental group
Adaptive design
Control group
Standard design
Experimental
Control

Representativeness

Imbalance score (IMB)

$$= \sum_{c=1}^{C} \frac{(\text{Population}_c - \text{Sample}_c)^2}{\text{Sample}_c}$$

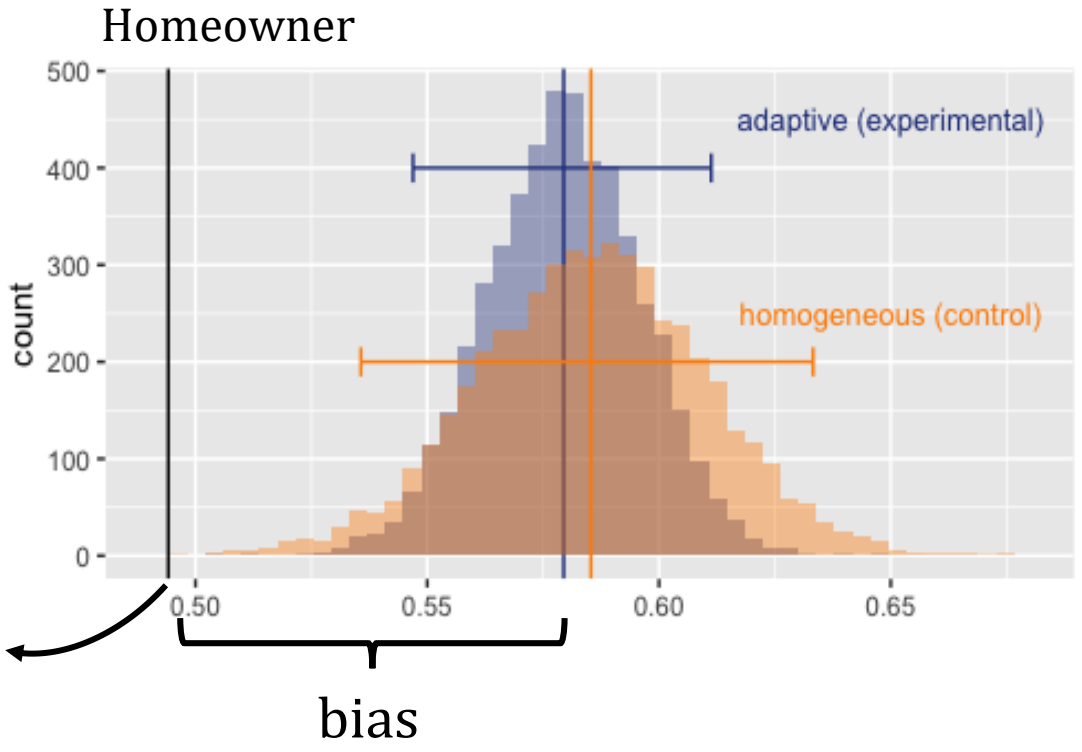
	Adaptive design (experimental)	Standard design (control)
Gender * Age (8 categories)	21.5	19.1
Education (4 categories)	24.2	33.4
Race and ethnicity (5 categories)	5.0	5.2
Income (5 categories)	4.1	2.3

Brick, Kennedy, Flores Cervantes, & Mercer, 2021; Särndal & Lundquist, 2019

Univariate estimates – bias

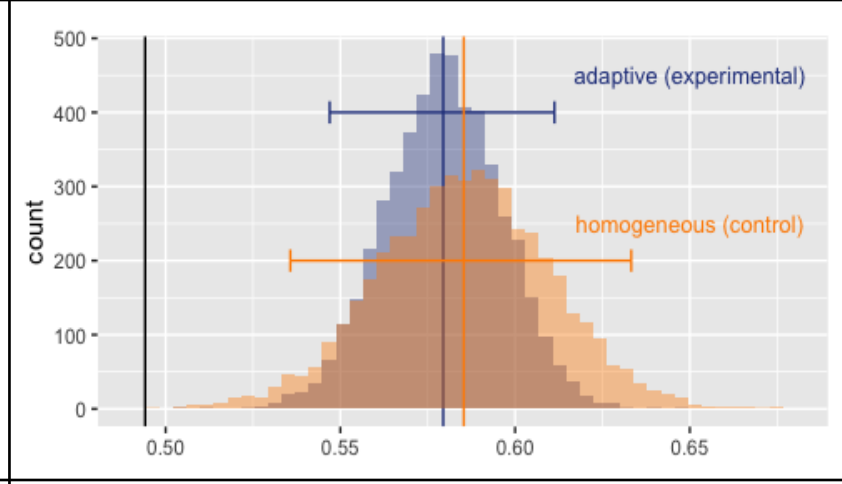
Separately for the experimental and control data:

- 5000 bootstrap samples
- On each sample:
  - Calibration
  - Weighted mean estimate

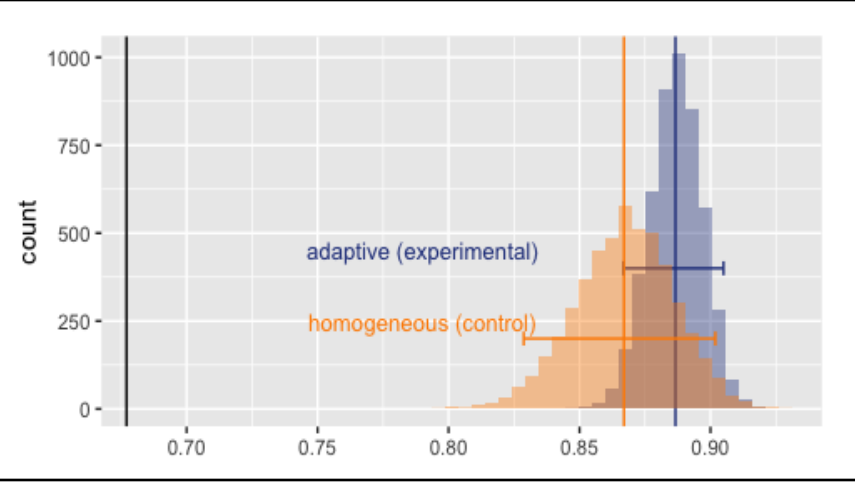


Benchmark:
2015-2019 ACS estimate

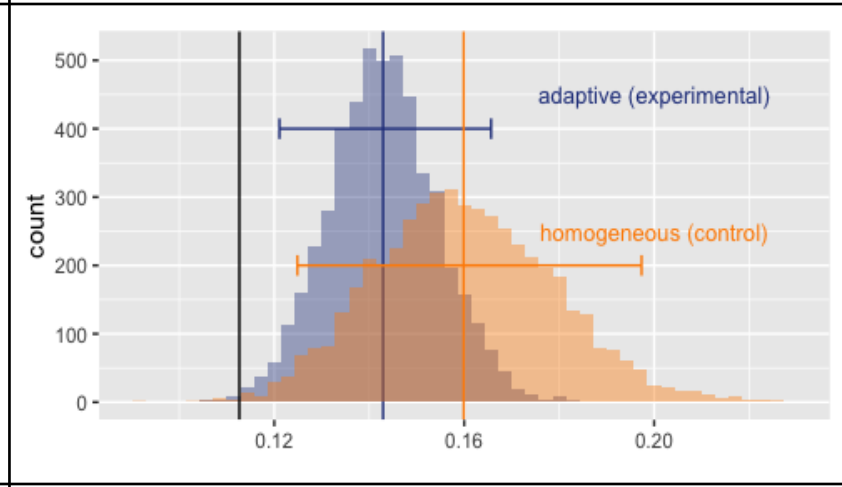
Homeowner



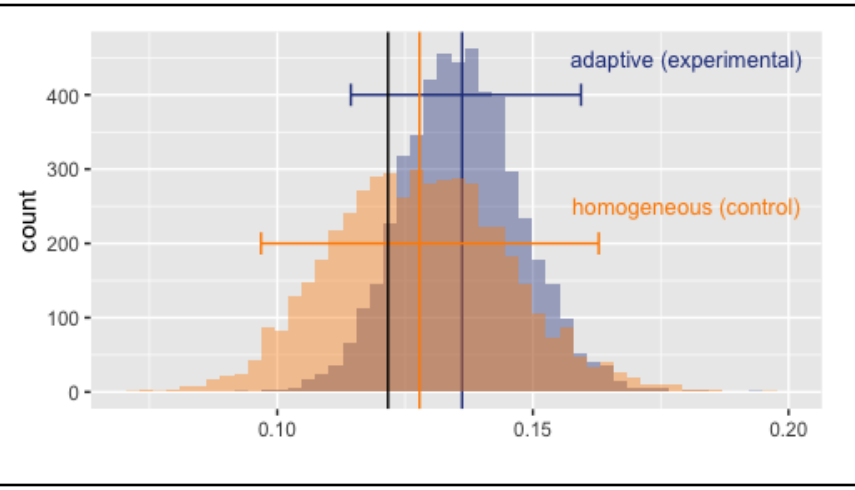
Access to internet



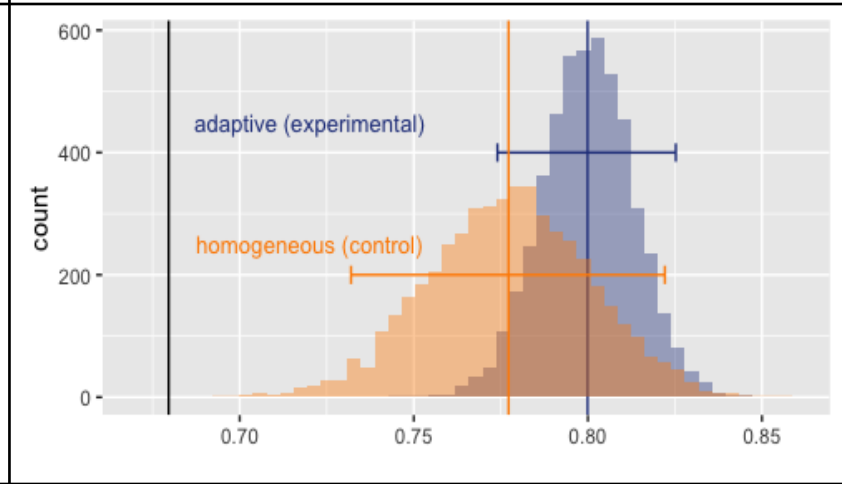
Other language



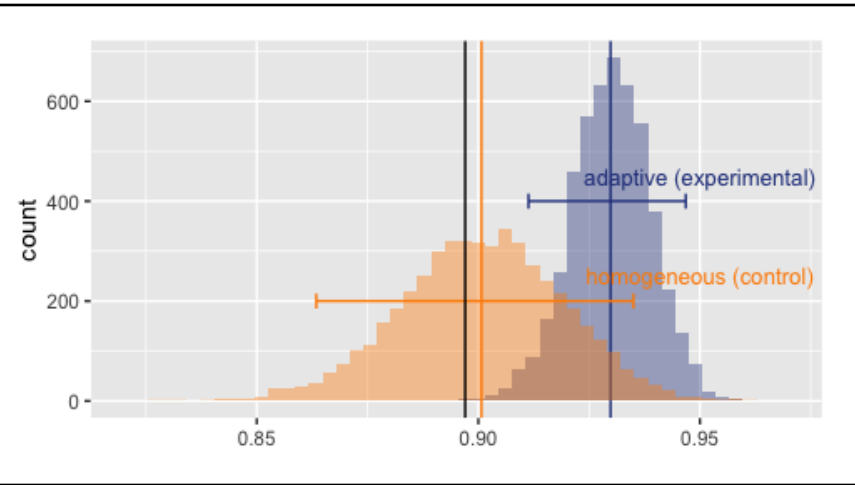
Divorced



Access to computer



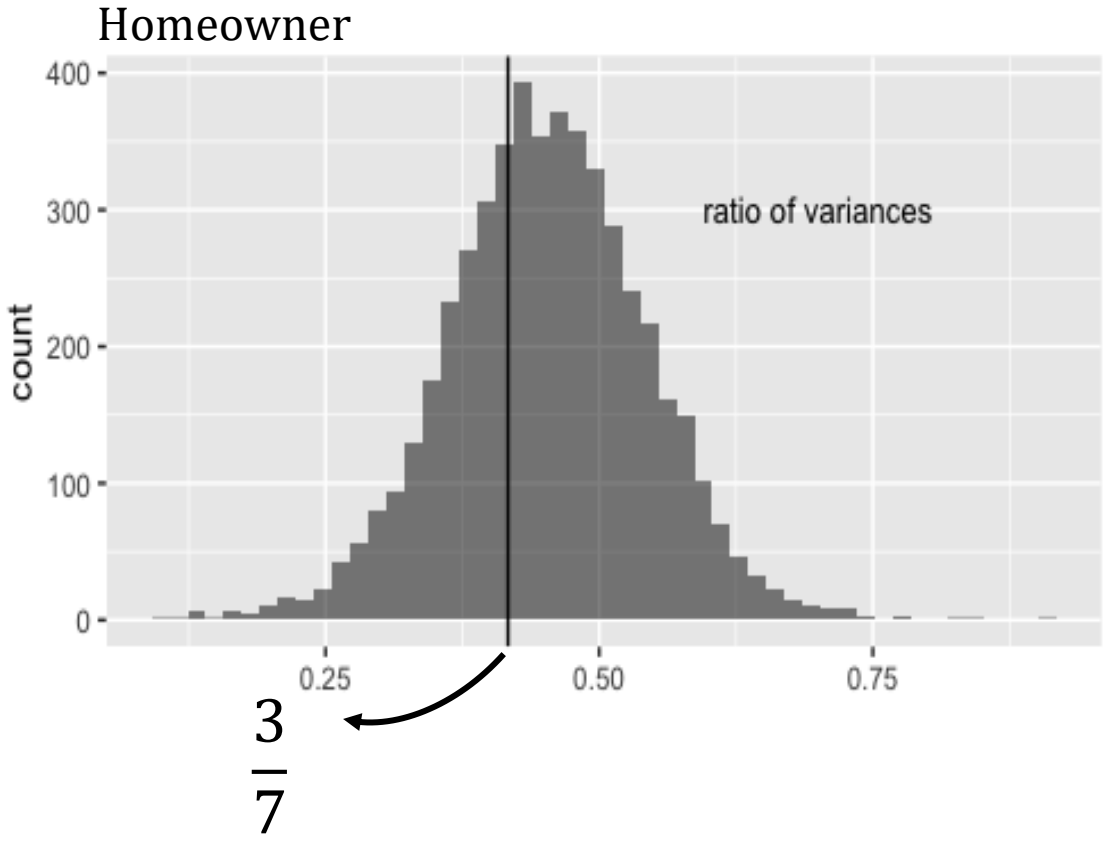
Insurance



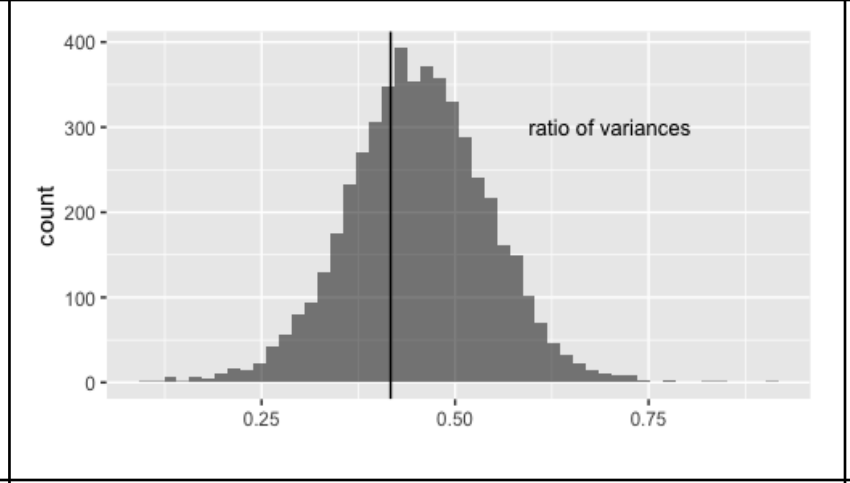
Univariate estimates – variance

Separately for the experimental and control data:

- 5000 bootstrap samples
- On each sample:
  - Calibration
  - Sampling variance estimate (VAR)
- Take a ratio $\frac{VAR_{exp}}{VAR_{con}}$, if $< \frac{3}{7}$



Homeowner



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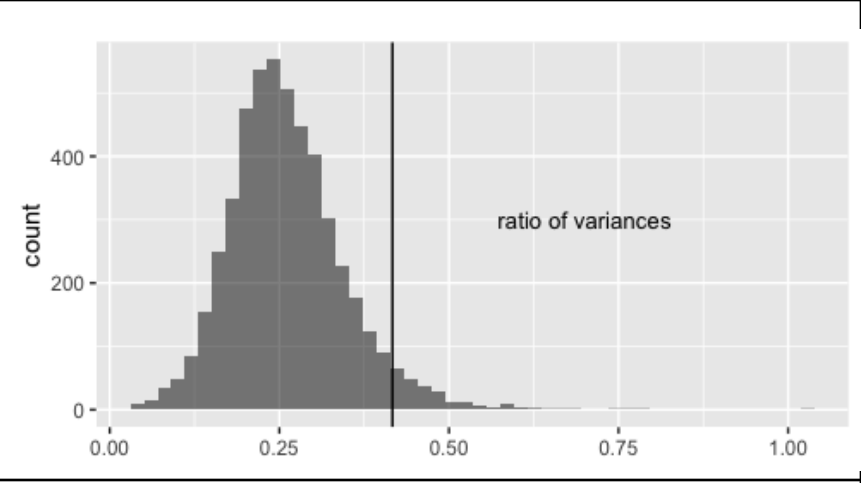

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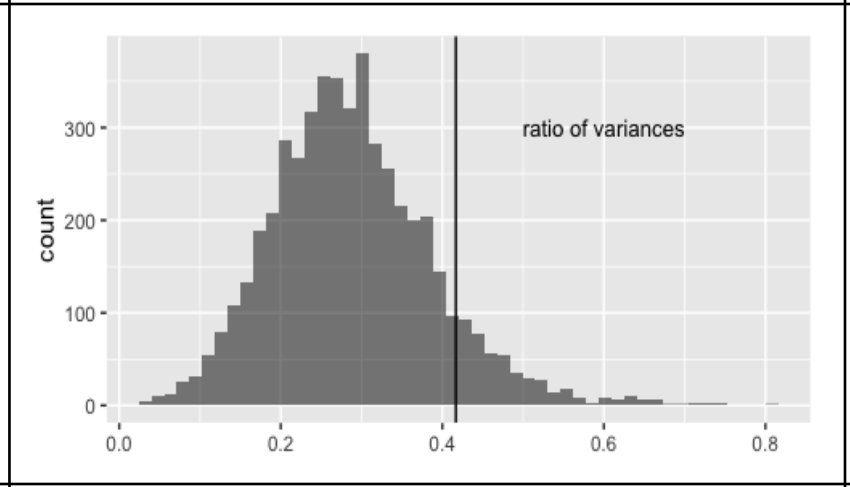

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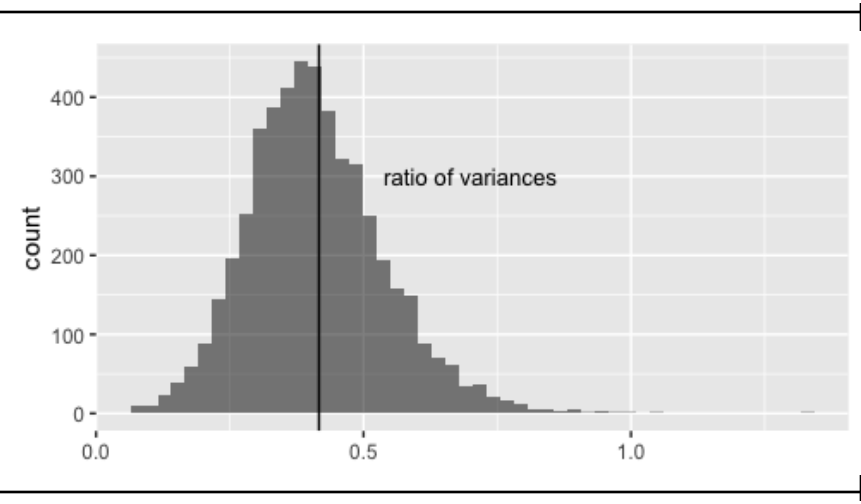
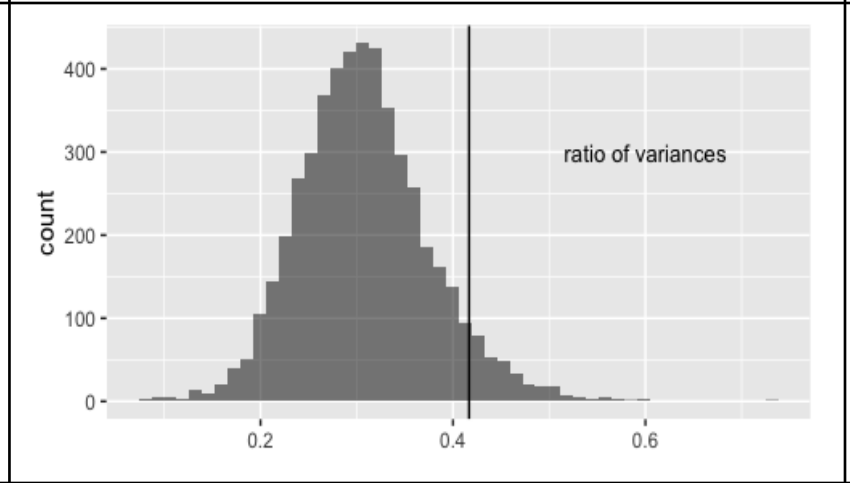


Access to computer



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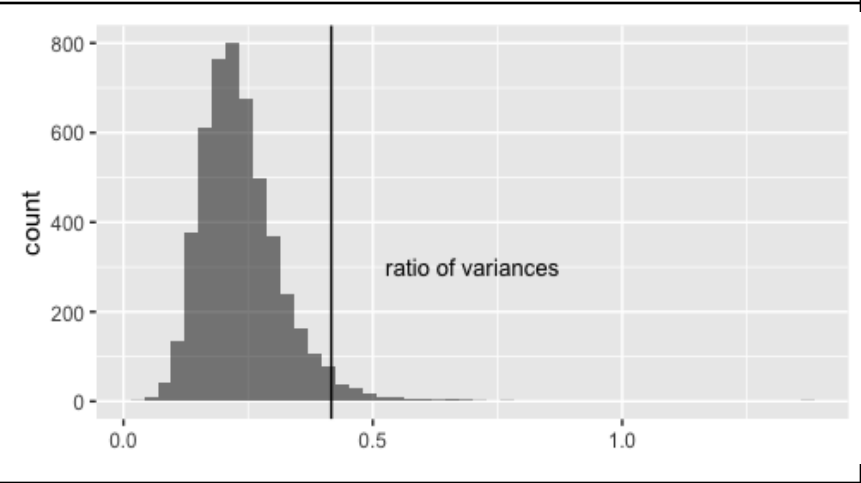

Multivariate associations

Compare statistical significance in regression models

Separately for the experimental and control data:

- 5000 bootstrap samples
- On each sample:
  - Calibration
  - Fit regression models
- Count # of times that predictors emerge as significant
  (*adjusted SE based on 30%/70%)

Multivariate associations

Outcome = Neighborhood satisfaction (1= very dissatisfied, 7= very satisfied)					
	Experimental		Control		
	Coeff	% sig	Coeff	% sig	
intuitive — Reputation	1.00	100%	0.95	100%	
Walk unsafe	-0.99	100%	-0.94	100%	
uncertain — Owner	0.24	74%	0.03	17%	Δ
Access to computer	-0.25	54%	0.19	39%	

Averaged coefficient across 5000 bootstrap samples

% of times the predictor emerge as significant

Multivariate associations

Outcome = Neighborhood satisfaction (1= very dissatisfied, 7= very satisfied)					
	Experimental		Control		
	Coeff	% sig	Coeff	% sig	
Reputation	1.00	100%	0.95	100%	
Walk unsafe	-0.99	100%	-0.94	100%	
Owner	0.24	74%	0.03	17%	Δ
Access to computer	-0.25	54%	0.19	39%	

Multivariate associations

A couple more models:

- Outcome: Likelihood of getting COVID-19 vaccine
- Outcome: personal homeowner

Result pattern:

- Intuitive associations: Adaptive design captures a few intuitive associations more stably
- Uncertain associations: Different results based on adaptive and standard design data

Costs

Incentive per respondent:

- Adaptive: $26.7; Standard: $25

Incentives account for about half of total survey costs

Other factors:

1. Labor intensive
2. Costs of preparing multiple versions of materials: e.g., design
3. Printing costs

Summary

Adaptive design + post-survey adjustment better than post-survey adjustment? Partly.

	With Adaptive design
Response rate	• Slightly higher in panel sample • No difference in refreshment sample
Representativeness	• More representative in education distribution
Univariate estimates – bias	• **No differences in bias**
Univariate estimates – variance	• **Smaller variances**
Multivariate associations	• More stable associations for a few intuitive predictors • Different results on uncertain predictors
Costs	• More costly and troublesome

Small benefit

Future research ideas

- How to design adaptive strategies?
  How to tailor the materials?
  Qualitative evidence
- Factorial experimental design: separate the effect of each strategy
- A more heterogeneous context? E.g., national sample?
- What sort of post-survey adjustment? E.g., calibration vs. propensity-score adjustment?
- Richer auxiliary information? E.g., panel data

References

- Brick, J. M., & Tourangeau, R. (2017). "Responsive survey designs for reducing nonresponse bias." *Journal of Official Statistics, 33*(3): 735–752.
- Brick, J. M., Kennedy, C., Flores Cervantes, I., Mercer, A. (2021). *An adaptive mode adjustment for multimode household surveys.* Manuscript submitted for publication.
- Groves, R. M., Singer, E., & Corning, A. (2000). Leverage-saliency theory of survey participation: description and an illustration. *Public Opinion Quarterly*, *64*(3), 299-308.
- Särndal, C.-E., & Lundquist, P. (2014). "Accuracy in estimation with nonresponse: A function of degree of imbalance and degree of explanation." *Journal of Survey Statistics and Methodology, 2*(4): 361–387.
- Särndal, C.-E., & Lundquist, P. (2017). "Inconsistent regression and nonresponse bias: Exploring their relationship as a function of response imbalance." *Journal of Official Statistics*, *33*(3): 709–734.
- Särndal, C.-E., & Lundquist, P. (2019). "An assessment of accuracy improvement by adaptive survey design." *Survey Methodology, 45*(2): 317–337.
- Schouten, B., Cobben, F., Lundquist, P., & Wagner, J. (2016). "Does more balanced survey responseimply less non-response bias?" *Journal of the Royal Statistical Society: Series A (Statisticsin Society), 179*(3): 727–748.
- Tourangeau, R., Michael Brick, J., Lohr, S., & Li, J. (2017). "Adaptive and responsive survey designs: A review and assessment." *Journal of the Royal Statistical Society: Series A (Statistics in Society), 180*(1): 203–223.