SCHOOL OF
PUBLIC HEALTH

DEPARTMENT OF HEALTH SERVICES
ADMINISTRATION

Design Effect Anomalies in the American Community Survey

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Overview

- Background
- Results
- Potential causes
- Practical significance

Design Effects

- A relative measure of sample efficiency

$$DEFF = \frac{\sigma^2_{complex}}{\sigma^2_{SRS}}$$

< 1: More Efficient
> 1: Less Efficient

- Sensitive to design elements
  - Stratification (-)
  - Intra-cluster correlation (+)
  - Variance in the weights (+)
- Typically 2-4
  - DEFF = f(sample design, variable)

Brief Review of ACS Sample Design

- Separate design for HU and GQ
- Housing Unit Design
  - Frame: MAF
  - Each county chosen with certainty
  - Sub-county strata defined on population and RR
  - **1/3 Non-responders sampled for personal interviews**
- PUMS created as a systematic sample such that a 1% sample of each state is formed

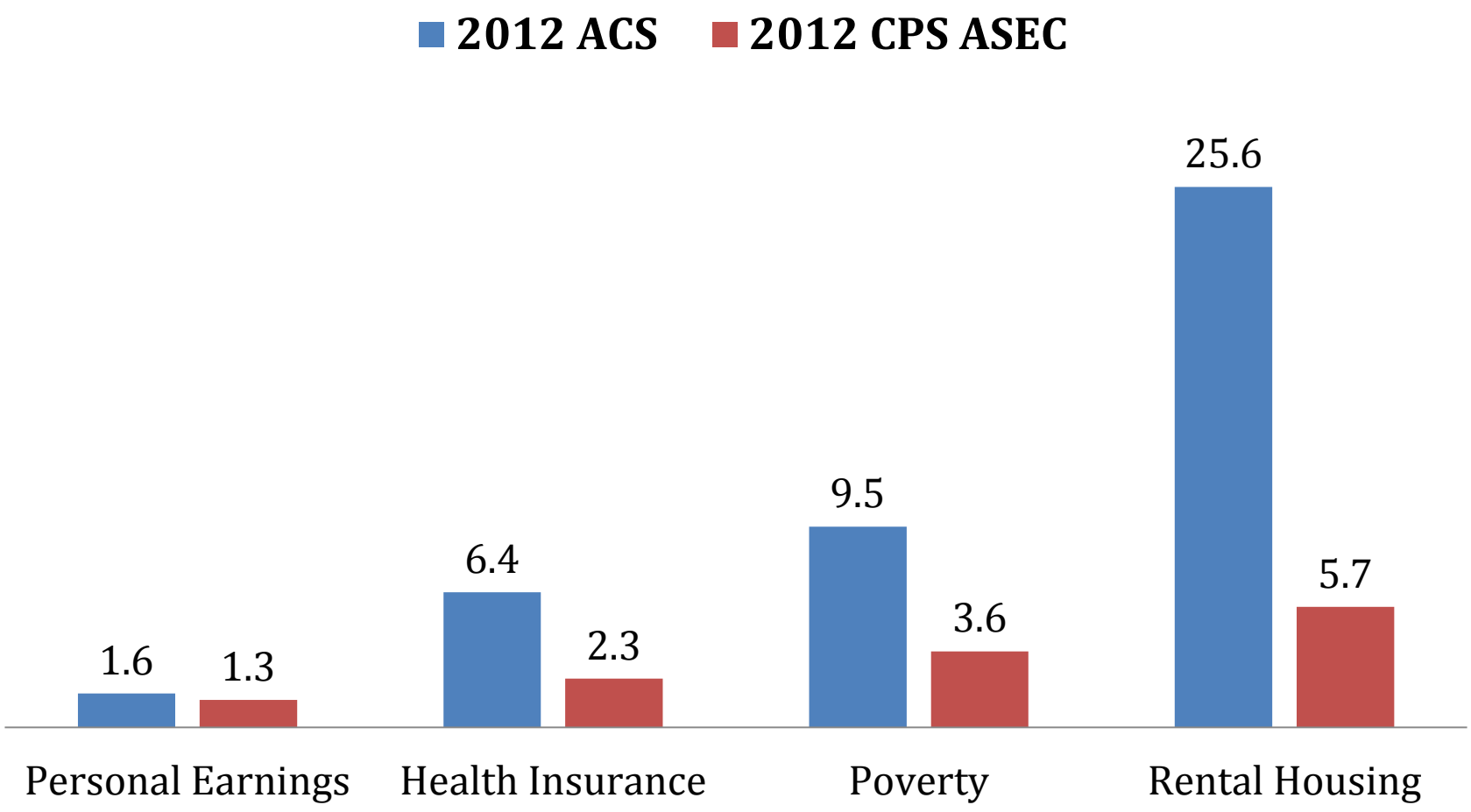
Variance Estimation

- Successive Difference Replication (SDR)
  - Similar to BRR w/Fay's adjustment
  - Geographic sort order is informative
- Replicate Weights (80 replicates)
  - 1 of 3 replicate factors applied to each case
    - 1.0 (50% of cases), 0.3, 1.7
    - Factor assigned using a Hadamard Matrix (RF)
  - BW adjusted with replicate factor
  - Weighting adjustments repeated

SDR Formula

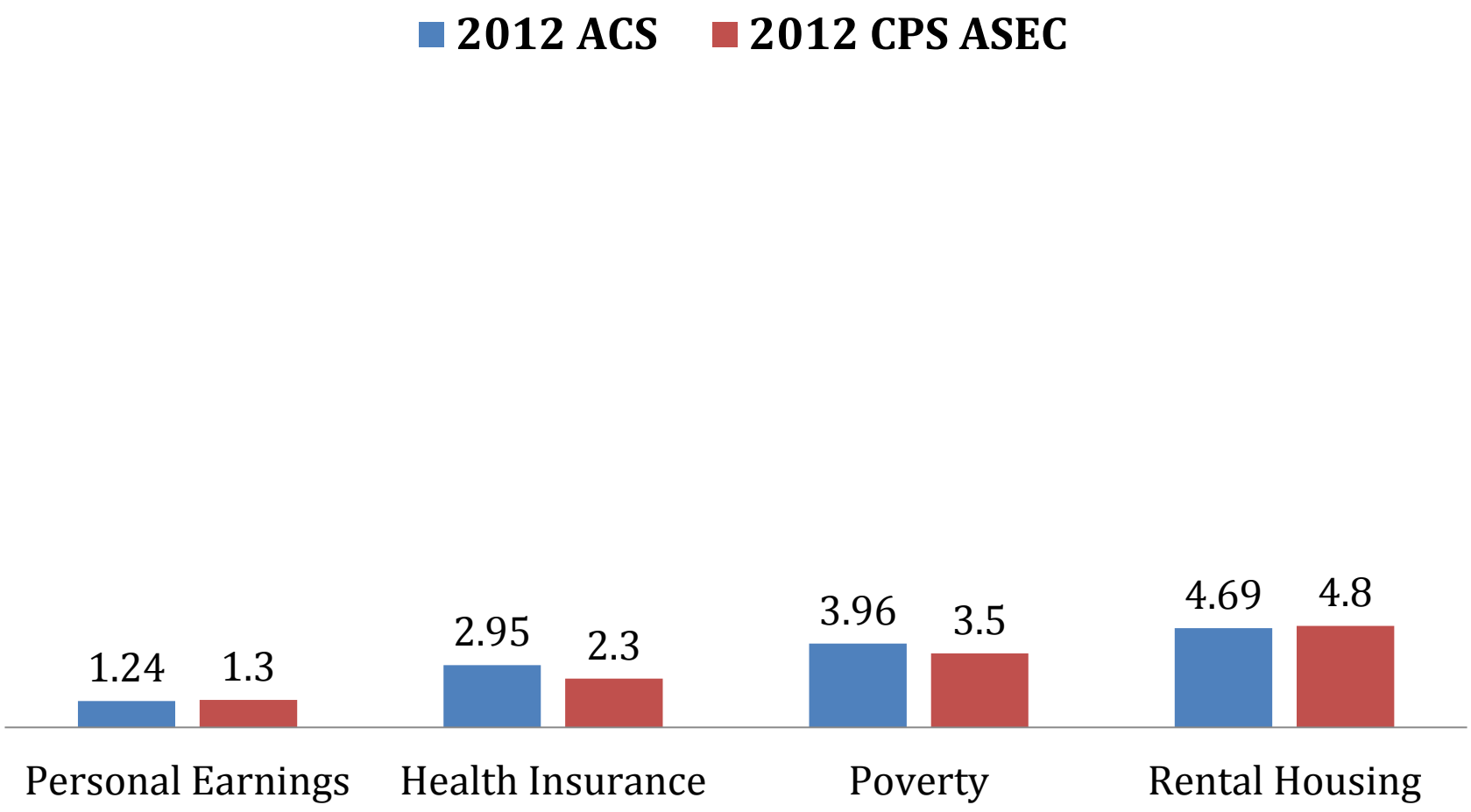
$$S.E._{x} = \sqrt{\frac{4}{R}\sum_{r=1}^{R}(x_r - x_0)^2}$$

DEFF in ACS and CPS ASEC

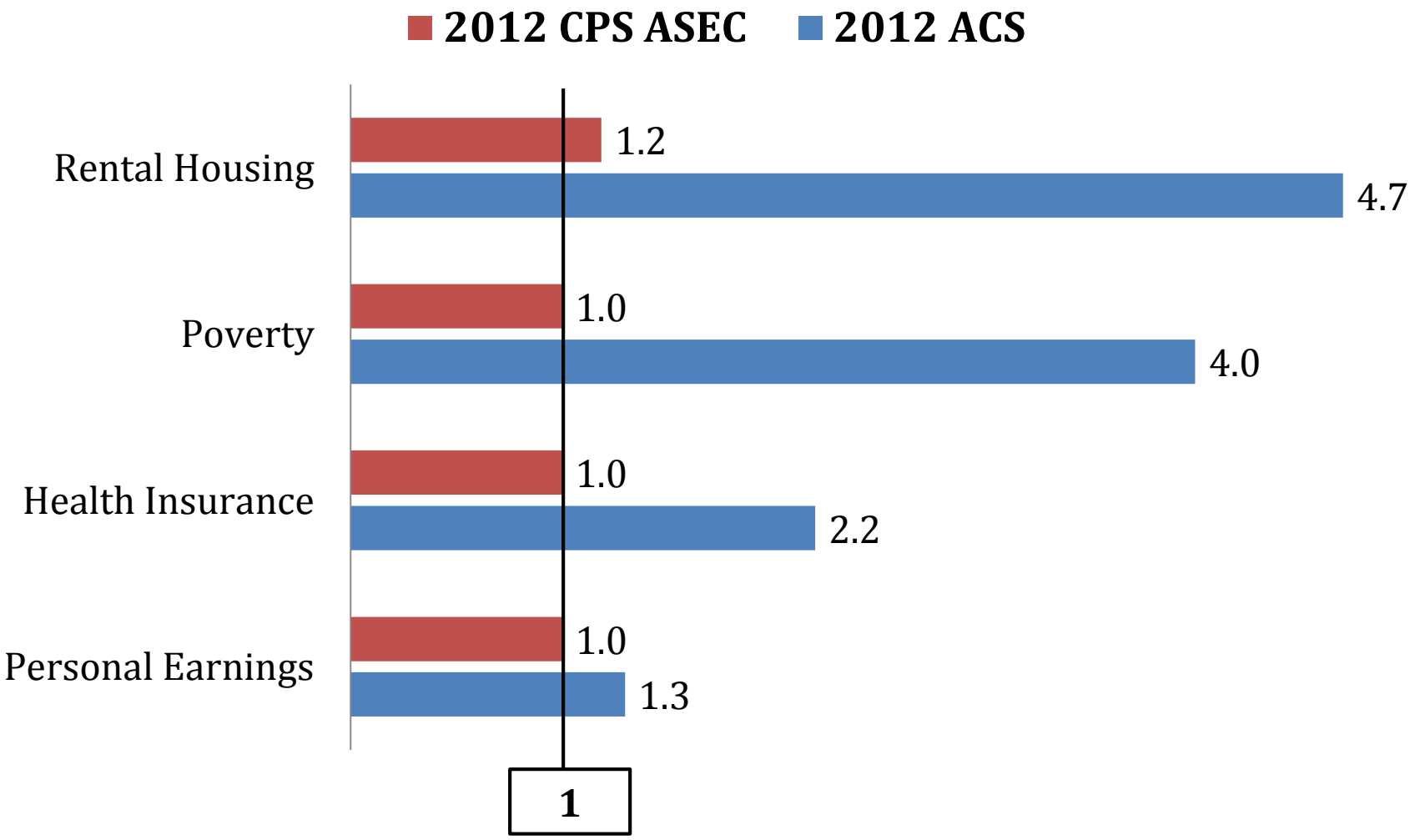


* Based on the Civilian Non-institutional Population

Average DEFF Across the States



Ratio: National vs State Average



Consistent Across Files

- Across different years of the PUMS
- Apparent in internal file

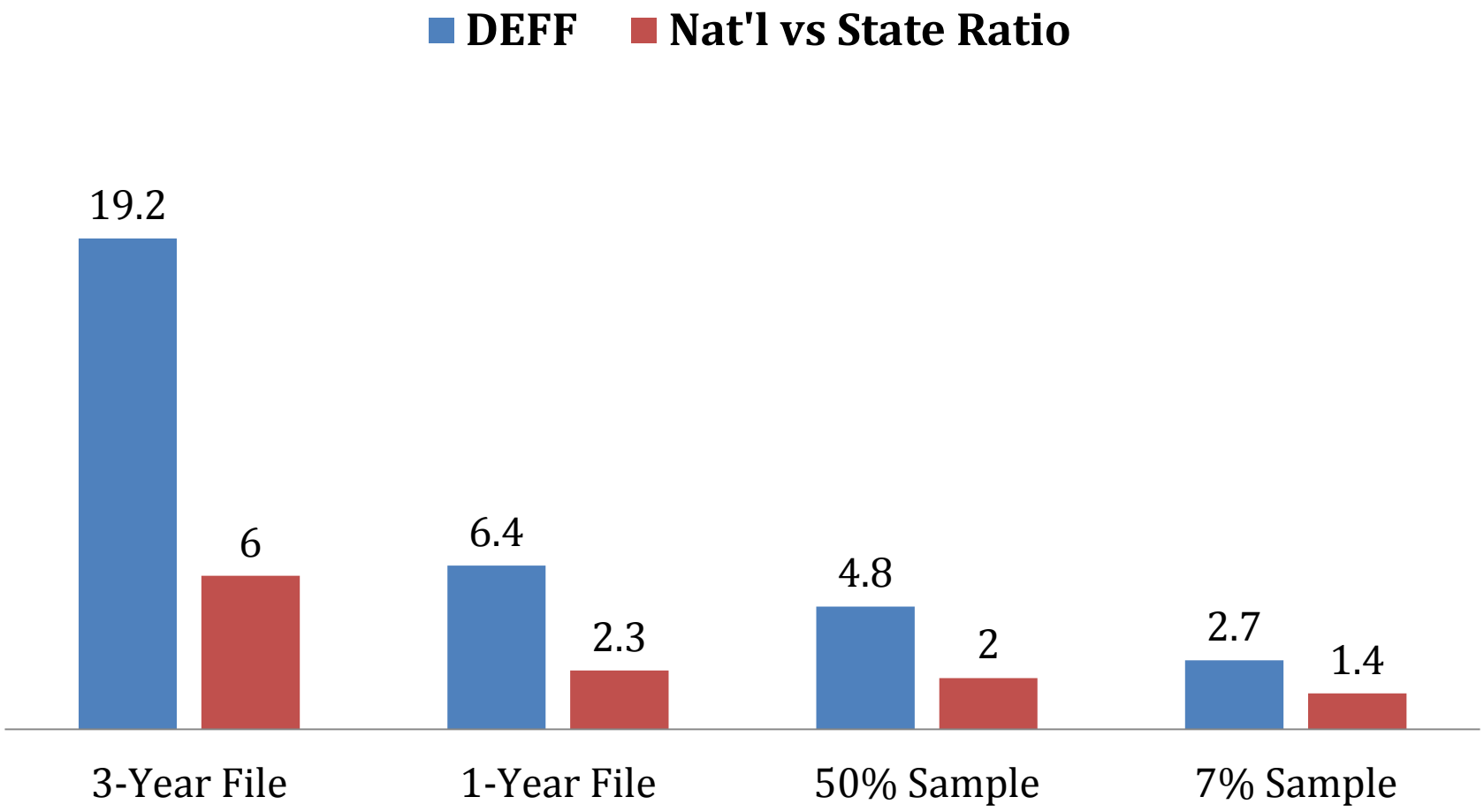
Excluded Causes

- Heterogeneity in the weights (1+L)
  - 1+L in line with expectations; not correlated with geography (for full weight and replicates)
- Rounding of the weights
  - ACS rounds, CPS does not
  - Ruled this out by imputing digits in ACS and rounding pooled CPS files

Sample Size

- An obvious distinction
  - National ACS vs CPS
  - National ACS vs State ACS

DEFF for Health Insurance by Sample Size, ACS



Why Sample Size?

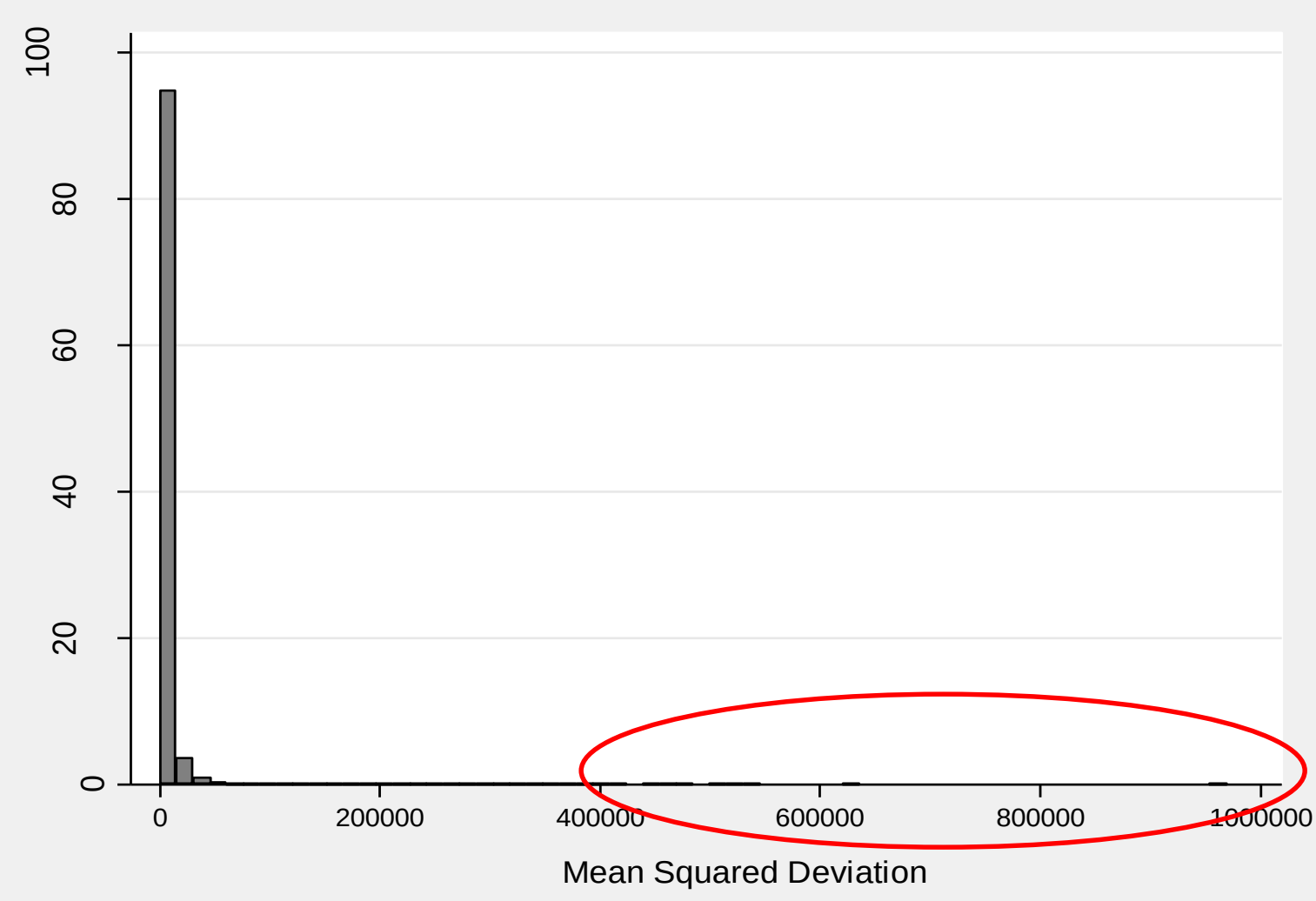
- Working Conjecture
  - As sample size increases, the probability of capturing a meaningful outlier increases
  - The quantity with leverage is the observation specific contribution to variability
  - Mean Squared Deviation

$$MSD_i = \frac{1}{80}\sum_{r=1}^{80}(w_{ir} - w_{i0})^2$$

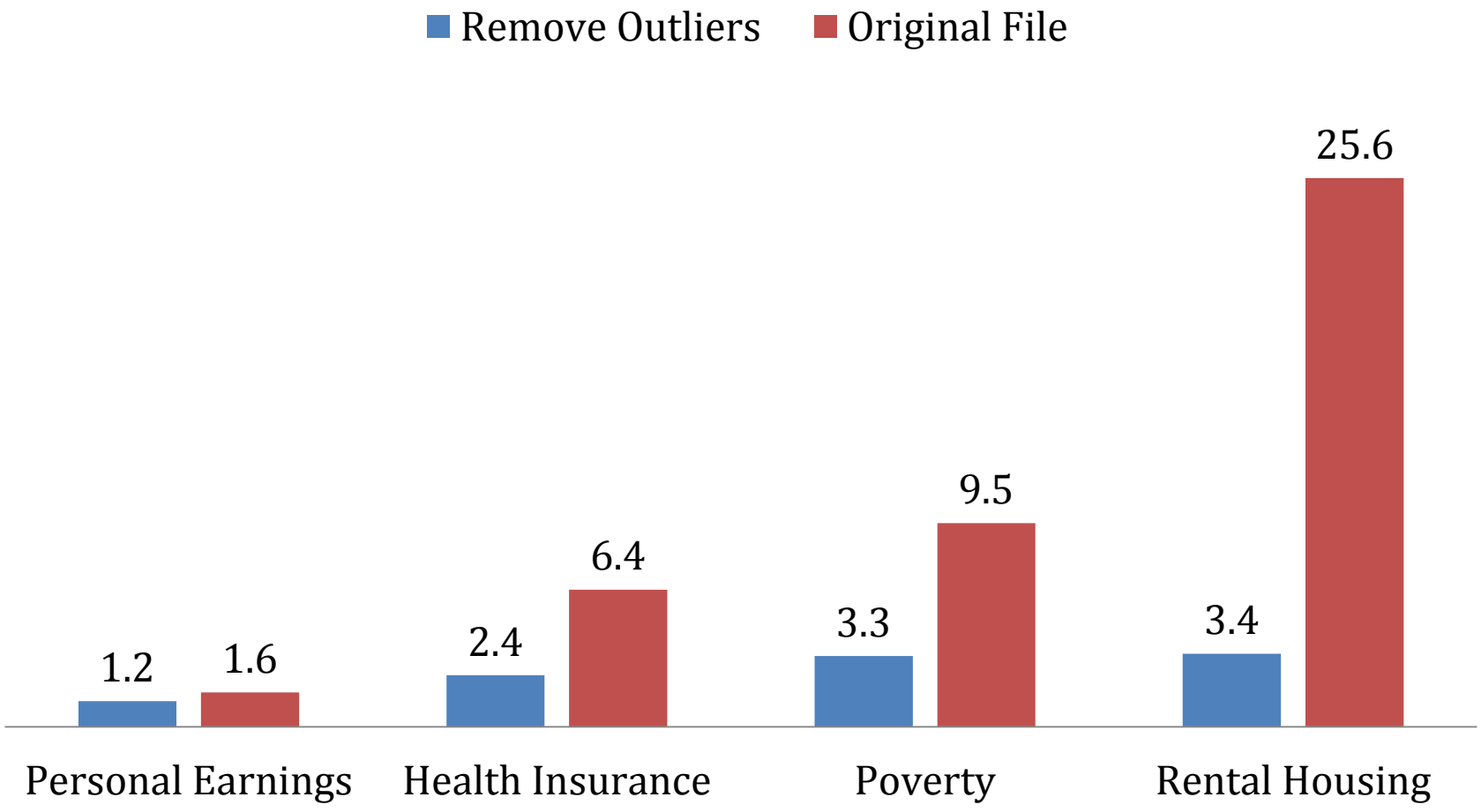
What contributes to MSD?

- Replicate factor (1, 0.3, 1.7)
  - Varies by replicate and observation
- Initial base weight value
  - Average in-person interview weights are 3 times the size of the average mail/phone weight.

Histogram of MSD



DEFF After Removing Cases Above the 95th Percentile in MSD



Census Bureau Reaction

JSM 2013 - Survey Research Methods Section

Investigation of Anomalies in Derived Variances for Estimates from The American Community Survey Public Use Microdata File[1]

Sirius Fuller and Karen King
Decennial Statistical Studies Division
U.S. Census Bureau

Abstract
The American Community Survey releases Public Use Microdata Sample (PUMS) files annually for users to calculate their own estimates. PUMS contains individual housing unit and person records for a limited set of geographic areas. Two methods exist for users to calculate standard errors and variances for estimates: a generalized variance method (design factor) and a replicate weight based method.

Research conducted outside of the Census Bureau has shown that variance based on the replicate weights is much higher than the variance based on design factors for certain estimates at the national level. The Census Bureau is conducting research which will attempt to duplicate those findings and to look for possible causes of these results. It will look at the creation process for the replicate weights for PUMS records, focusing on the impact of PUMS sampling and weighting. It will examine the process to create design factors for PUMS data, focusing on the iterative linear regression used to create design factor candidates. This paper will show results and may offer some practical solutions to bring the two sets of standard errors and variances into better alignment.

Keywords: American Community Survey; Public Use Microdata Sample; Design Factors; Design Effects

Implications

- Our suggestion is that the ACS SE's are larger than they *should* be
- Our blunt approach detects this problem at the national level
  - Where it does not matter in most applications
- But we have suggestive evidence that it matters at lower levels of geography
  - A random selection of 7% of cases still shows a a ratio > 1

Concern and Investment

- Reducing statistical noise at low levels of geography is a clear priority
  - Sample expansion and GQ imputation
- Our results suggest that improving the variance estimator may also add precision.
  - Especially: Investigate the implication of sub-sampling
    - The problem could be exaggerated in surveys that use ACS as a sampling frame
  - Cheap (potentially)

In the mean time…

- For those wanting every last bit of precision
  - Remove outlying MSD values (SE do go down!)
  - Use an alternative variance estimator
    - Modified SDR (Fuller and King, 2013)
      - Calculate deviation from average replicate estimate
    - Taylor Series Linearization
      - Set PUMA as strata and Household as Cluster
      - More sophisticated approaches the leverage the implicit strata formed by the systematic sampling of the PUMS
- But data users are much more interested in precision of tabular estimates found on AFF
  - Census Bureau solution

Thank You!

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