The Essential Role of Pair Matching in Cluster-Randomized Experiments, with Application to the Mexican Universal Health Insurance Evaluation

Kosuke Imai
Princeton University
Gary King **Clayton Nall**
Harvard University

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Cluster-Randomized Experiments (CREs)

- Problem of many field experiments:
  - unit of randomization = clusters of individuals
  - unit of interest = individuals
- Public health & medicine: CREs have "risen exponentially since 1997" (Campbell, 2004)
- Cluster randomization $\rightarrow$ loss of efficiency & specialized methods
- Matched-Pair Designs (MPDs) to improve efficiency:
  1. Pair clusters based on the similarity of background characteristics
  2. Within each pair, randomly assign one cluster to the treatment group and the other to the control group

Methodological Recommendations Against MPDs

- "Analytical limitations" of MPDs (Klar and Donner, 1997):
    1. restriction of prediction models to cluster-level baseline risk factors
    2. inability to test for homogeneity of causal effects across clusters
    3. difficulties in estimating the intracluster correlation coefficient
- In 10 or fewer pairs, MPDs can lose power (Martin *et al.* 1993)
- Echoed by other researchers and clinical standard organizations
- But, we show these claims are all unfounded.

- No formal definition of causal effects to be estimated
- No formal evaluation of the existing estimators for MPDs

Contributions of Our Paper

- Conclusion: **pair-matching should be used whenever feasible**
    - MPDs improve bias, efficiency, and power
    - Not pairing = throwing away one's data!
- Show that "analytical limitations" do not exist or are irrelevant
- Show that power calculations rely on unrealistic assumptions
- Existing estimator is based on a highly restrictive model
- Formally define causal quantities of interest
- Propose new simple design-based estimators and s.e.'s
- Offer power and sample size calculations
- Extend the estimator to CREs with unit-level noncompliance
- Clarify the assumptions about interference

Motivating Example: Seguro Popular de Salud (SPS)

- Evaluation of the Mexican universal health insurance program
- Aim: "provide social protection in health to the 50 million uninsured Mexicans" (Frenk *et al.*, 2003)
- A key goal: reduce out-of-pocket health expenditures
- Sounds obvious but not easy to achieve in developing countries
- Individuals must affiliate in order to receive SPS services
- $12,824$ "health clusters"
- 100 clusters nonrandomly chosen for randomized evaluation
- Pairing based on population, socio-demographics, poverty, education, health infrastructure etc. (King *et al.*, 2007)
- "Treatment clusters": encouragement for people to affiliate
- Data: aggregate characteristics, surveys of $32,000$ individuals

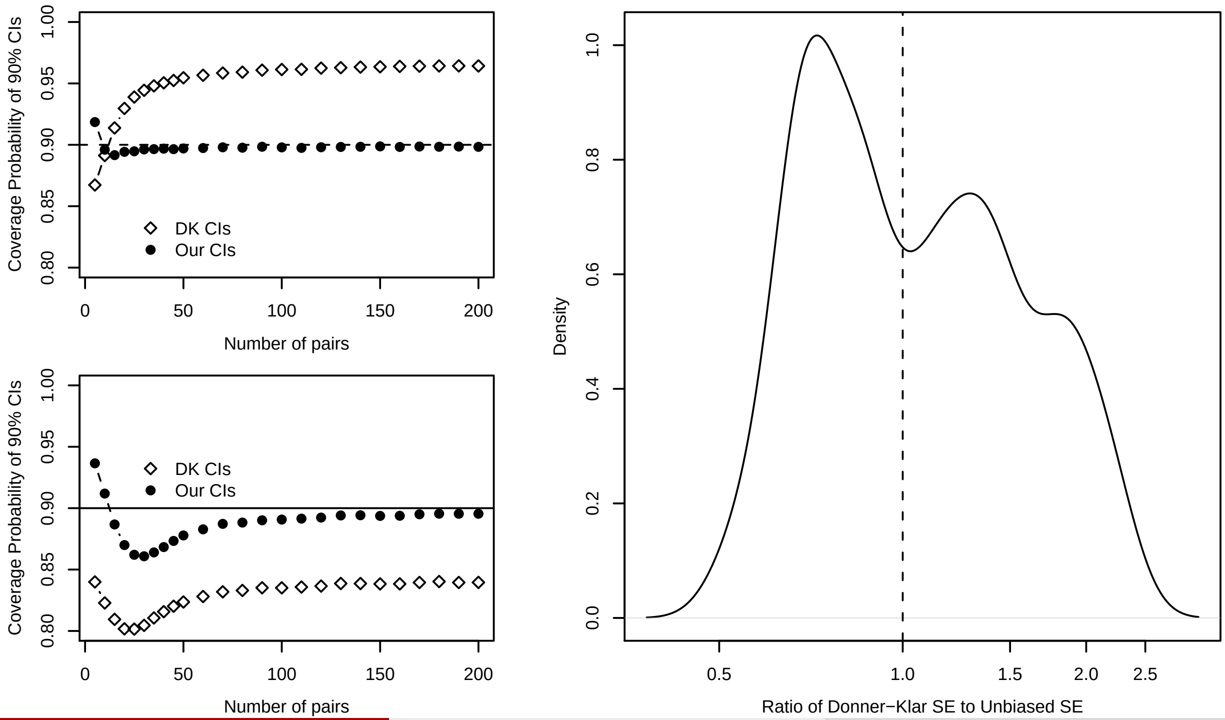
Design-based Analysis of CREs under MPDs

- Existing Model-based approach: assume DGP for observed data
- The Donner-Klar estimator assumes the homogeneity across clusters: no point of matching to begin with!

- Our Design-based approach avoids modeling assumptions (Neyman, 1923)
- Randomness comes from:
  1. randomization of treatment assignment
  2. random sampling of clusters and units within clusters
- Conditions for unbiasedness:
  1. Exact match on sample cluster sizes
  2. Exact match on within-cluster ATEs
- Match on cluster sizes and important covariates.

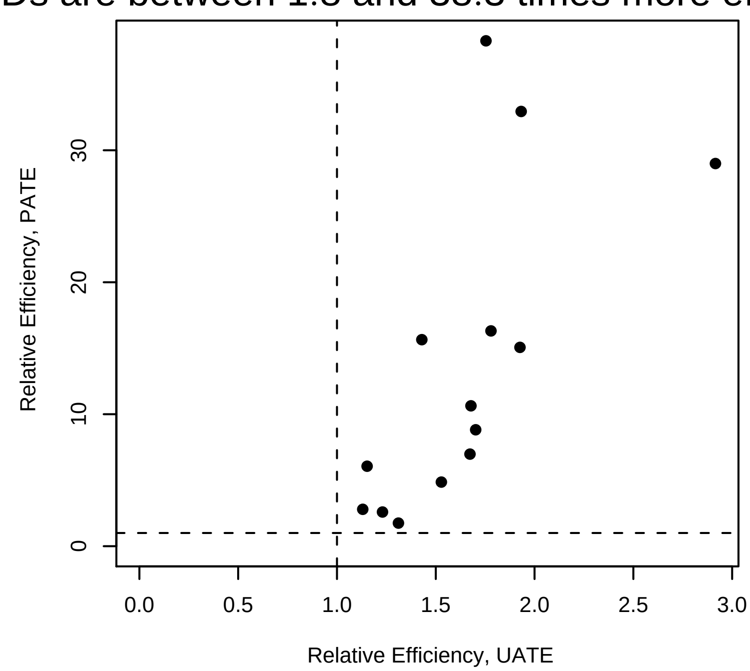
Bias and Inefficiency of Existing Approach

- Simulation: ours (bias=0, RMSE=6), DK (bias=21, RMSE=22)



Relative Efficiency of MPDs

- UATE: MPDs are between 1.1 and 2.9 times more efficient
- PATE: MPDs are between 1.8 and 38.3 times more efficient!



Initial Empirical Analysis of SPS Data

- Average causal effects of SPS on the prob. of a household suffering from catastrophic health expenditures
- More than 30% of annual post-subsistence income (10% of all households)
- Its reduction is a major aim of SPS

	SATE		CATE		UATE		PATE	
ITT	$-.014$	$(\leq .007)$	$-.023$	$(\leq .015)$	$-.014$	$(.007)$	$-.023$	$(.015)$
CACE	$-.038$	$(\leq .018)$	$-.064$	$(\leq .024)$	$-.038$	$(.018)$	$-.064$	$(.024)$