Consequences of Sorting for Understanding School Quality

Jesse Bruhn

December 30, 2020

Brown University

This Paper

Does Quality or Selection Generate the Benefits of School Choice?

1. Use new lottery data to evaluate a school choice program in Massachusetts.
2. Estimate a rich model of treatment effect heterogeneity using a new application of empirical-Bayes.
3. Document Roy-type selection on observables by correlating observed heterogeneity with the application behavior of students.

Roy-type selection $\implies$ Lottery estimates of quality are not externally valid.

Educational Quality Matters

There is an emerging body of evidence documenting a causal link between educational interventions, test scores, and economic outcomes.

(Almond and Currie, 2011; Chetty et al., 2011, 2014; Deming et al., 2014; Dobbie and Fryer, 2015; Angrist et al., 2016)

Recent work uses randomization in the school assignment process to better identify and understand differences in educational quality.

(Angrist et al., 2013; Dobbie and Fryer, 2013; Deming et al., 2014; Abdulkadiroglu et al., 2017; Angrist et al., 2017)

This is a high stakes statistical endeavor.

Do Lottery Designs Identify Average Quality Differences?

Problem: Comparing students across schools in observational data is confounded by ability and family income.

Solution: Compare school choice lottery winners to losers.

Implicit Assumption:

Causal Increase $\iff$ Average Benefit is Higher $\iff$ Linear Constant Effect

Inter-district Choice Mechanism

In Theory:

- "Extra" seats offered to out of district students.
- Local school board may vote to opt-out.
- When over-subscribed, seats must be allocated via lottery.
- Sending district pays receiving district $5,000.
- Receiving district not required to provide transportation.

In Practice:

- Seat determination is at the total discretion of administrators.
- First-come first-serve is common even when demand regularly exceeds supply.
- Every district gives some form of sibling preference.
- Modal lottery conducted by a secretary picking names out of a hat.

District Choice Benefits the Students who Participate

$$y_{it} = \alpha + \beta d_{it} + \delta_\ell + \gamma W_i + u_{it}$$
$$d_{it} = \alpha' + \Pi Z_i + \delta'_\ell + \gamma' W_i + v_{it}$$

β identifies the average causal effect of **moving to a more preferred district** for lottery compliers at oversubscribed school choice districts that maintained and were willing to share high quality lottery records.

- Match scores increase by $.19\sigma$.
- 14% more likely to be enrolled in an AP class.
- More likely to graduate and attend a 4 year college (weak evidence).

Defining School Quality in the Presence of Heterogeneous Effects

Consider a simple potential outcomes framework:

$$y_i = d_i y_i^1 + (1 - d_i) y_i^0 = \beta_i d_i + \epsilon_i$$

A minimum definition of quality is:

$$\beta = \mathbb{E}(\beta_i)$$

Thus a necessary condition for lottery estimates to be externally valid is that:

$$\beta_i \perp d_i$$

A Test of Roy-selection on Observables

Let $\beta_i = \beta_k + v_i$. Then $\beta_i \perp d_i$ implies:

$$\mathbb{E}(\beta_k d_i) = 0$$

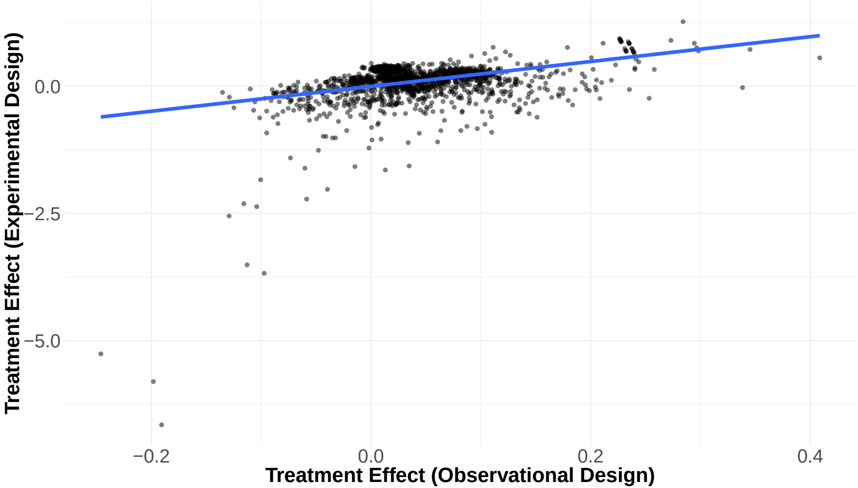
Except in the knife edge case where $\mathbb{E}(\beta_k d_i) = -\mathbb{E}(v_i d_i)$

Problem: Small sample; noisy procedure; many potential interactions.

What about the non-experimental student data?

Similar heterogeneity across samples should give us more confidence that lottery identified parameters are close to the local average heterogeneous effects of interest.

Correlation Between Experimental and Non-Experimental Heterogeneity



Posterior Mode of a Hierarchical Model of Treatment Effect Heterogeneity

$$\beta_k^s \equiv \beta_0 + \alpha_k(\hat{\beta}_k^e - \beta_0) + \delta_k(\hat{\beta}_k^n - \beta_0 - b_0)$$

- (α_k, δ_k) are a determined by correlation across samples and signal-to-noise ratio.
- Swap imprecise experimental variation for precise non-experimental variation.
- Converges to experimental estimand as experimental sample becomes large.
- When estimates are uncorrelated, system decouples into standard empirical-Bayes.

Testing for Roy Selection on Observables

	Take-up Indicator					
	Continue		Participate		Apply	
Heterogeneous Effect	0.10		0.15		0.32	
	(0.07)		(0.10)		(0.05)	
Heterogeneous Effect < 0		−0.08		−0.05		−0.17
		(0.03)		(0.04)		(0.02)
Subsample	Ever-Enrolled	Ever-Enrolled	Applicants	Applicants	Eligible	Eligible
Observations	860	860	1,621	1,621	2,730	2,730
Observations (students)	395	395	894	894	2,730	2,730
Dependent Variable Mean	0.85	0.85	0.46	0.46	0.38	0.38
Adjusted R^2	0.38	0.38	0.32	0.32	0.21	0.22

Consequences for External Validity

Assume: $v_i \perp (d_i, \tau_i)$.

Then my results imply the following average treatment effects:

Treated: 0.11σ

Applicants: 0.06σ

Non-Applicants: 0.02σ

At most, 18% of lottery LATE is the result of quality differences.

Benefits of Inter-district choice emerge from Roy-type selection

Implications for Lottery Designs Within and Across Districts

Within district lottery designs and their observational counterparts are probably fine.

- More horizontal differentiation across districts than within.
- Consistent with recent work showing fall-back option matters.
  (Chabrier et al., 2016)
- Charter school impact is negative outside of urban areas in MA.
  (Angrist et al., 2017)
- Results are consistent with work on marginal versus average benefit.
  (Walters, 2018)

Generalizable quality is much harder to pin down.

Summary Results

Inter-district Choice:

- Raises math scores by 0.19σ.
- Increases quality of coursework and probability of graduation / college attendance.

Roy-type Selection:

- Students who are negatively impacted are less likely to take up treatment.
- Selection drives a wedge between lottery parameter and school quality.
- LATE is almost entirely the result of Roy selection.

Cross-sample Empirical-Bayes:

- New method for using non-experimental data to increase precision.
- Useful for estimating rich heterogeneous effects models in noisy designs.