Experimentally Validating Welfare Evaluation of School Vouchers

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Introduction

- Governments routinely provide benefits in-kind (education, health, food assistance, etc.)
  - central question in public finance: costs/benefits of direct in-kind provision versus vouchers
  - default approach: evaluate based on impacts on outcomes (e.g. nutrition, test scores, etc.)
    - reflects focus on what a paternalistic policymaker or taxpayer may care about
- Yet, this approach ignores preferences of beneficiaries
- More generally, policy evaluations should consider impacts on outcomes and beneficiary valuation
  - rarely done, in part because difficult to estimate (e.g. Piketty et al. 2017)

Background

- We complement an existing impact evaluation of private school vouchers by estimating WTP for program and its overall welfare impact
- Andhra Pradesh School Choice Project:
  - randomized voucher offers for primary school across both *markets* and students
    - targeting: those otherwise likely to attend government school
    - per pupil voucher amount: 2,600 Rs.
      ($\approx$ 30% of per pupil government school spending)
  - gains in subjects not taught in government schools (Hindi and English), but limited impacts in math and local language (Muralidharan and Sundararaman 2015)

$\Rightarrow$ Revealed preference through take-up suggests students prefer private schools for reasons beyond test score impacts

What We Did: Part 1

- Generated predictions for voucher use based on structural models estimated on only control data
  - estimation blinded to treatment data + pre-commitment (Arcidiacono, Muralidharan, Shim, and Singleton 2021 WP)
- Two kinds of school choice models compared:
  - Random coefficient demand: standard in IO
  - Ability-to-pay constrained: students may not attend private school absent voucher because not in their (unobserved) choice set
- Both models match the patterns in the control data...
  - ...but our constrained model predicts much higher take-up ($>$100% increase) and greater welfare gains

What We Have Done: Part 2

- Ability-to-pay constrained model fits relatively better to a) out-of-sample "controls"; b) voucher choices
- But $\sim$**20 point** gap between predicted and actual voucher use
  - after adjusting for endogenously lowered attrition

What We Have Done: Part 2

- Ability-to-pay constrained model fits relatively better to a) out-of-sample "controls"; b) voucher choices
- But $\sim$**20 point** gap between predicted and actual voucher use
  - after adjusting for endogenously lowered attrition
- Validation further reveals that all control models miss that:
  1. private school attendance of voucher *losers* is 15 points higher than control applicants
  2. conditional on using voucher, winners sort *negatively* on tuition (...which they don't pay)

What We Have Done: Part 2

- Develop and provide empirical support for unified model with two added mechanisms:
  1. search response: (anticipated) voucher increased return to searching private school options
  2. supply-side response: private schools used program surplus to incentivize enrollment
     - voucher set to 90th %tile tuition
- Unified model estimated on the entire data successfully explains attendance and take-up patterns

  $\Rightarrow$ \$1 of scaled, targeted program $\approx$ \$1.85 in total welfare
     - 61% from reducing spending; 17% from surplus to "marginal" households that otherwise choose a government school

Contributions (Substantive)

Schools as differentiated products, valued for reasons beyond impacts on outcomes favored by policymakers

$\Rightarrow$ WTP for voucher $\approx$ 6% median annual consumption; WTP for 1σ increase in math VA $\approx$ 1%

- welfare impacts of vouchers economically meaningful when offer targeted and/or fiscal externality large
  - impact evaluation of vouchers (e.g. Rouse 1998; Angrist et al. 2002, 2006)
- estimating preferences for school quality requires accounting for choice frictions (e.g. search, credit constraints)
  - incentives at scale (e.g. Andrabi et al. 2017; Allende et al. 2019; Bau 2022)

Contributions (Methodological)

- Two approaches to combining experimental data with structural econometric models:
  1. using to *fit* models (e.g. Attanasio et al. 2012)
  2. using to *validate* models (e.g. Todd and Wolpin 2006)
     - hold-out samples guard against "structural data-mining" (Schorfheide and Wolpin 2016)

- Our experience: credible policy analysis requires estimating a) equilibrium models; b) using treatment/policy variation
  - effects of vouchers on choice process and supply-side not anticipated
  - treatment data and double randomization design necessary for quantifying mechanisms

    $\Rightarrow$ hold out just portion of treatment data

Outline

Introduction

Background and Research Design

Control Models and Results

Treatment Markets Validation
- Non-Experimental
- Experimental

Unified Model
- Welfare Estimates

Background and Data

Andhra Pradesh School Choice Project

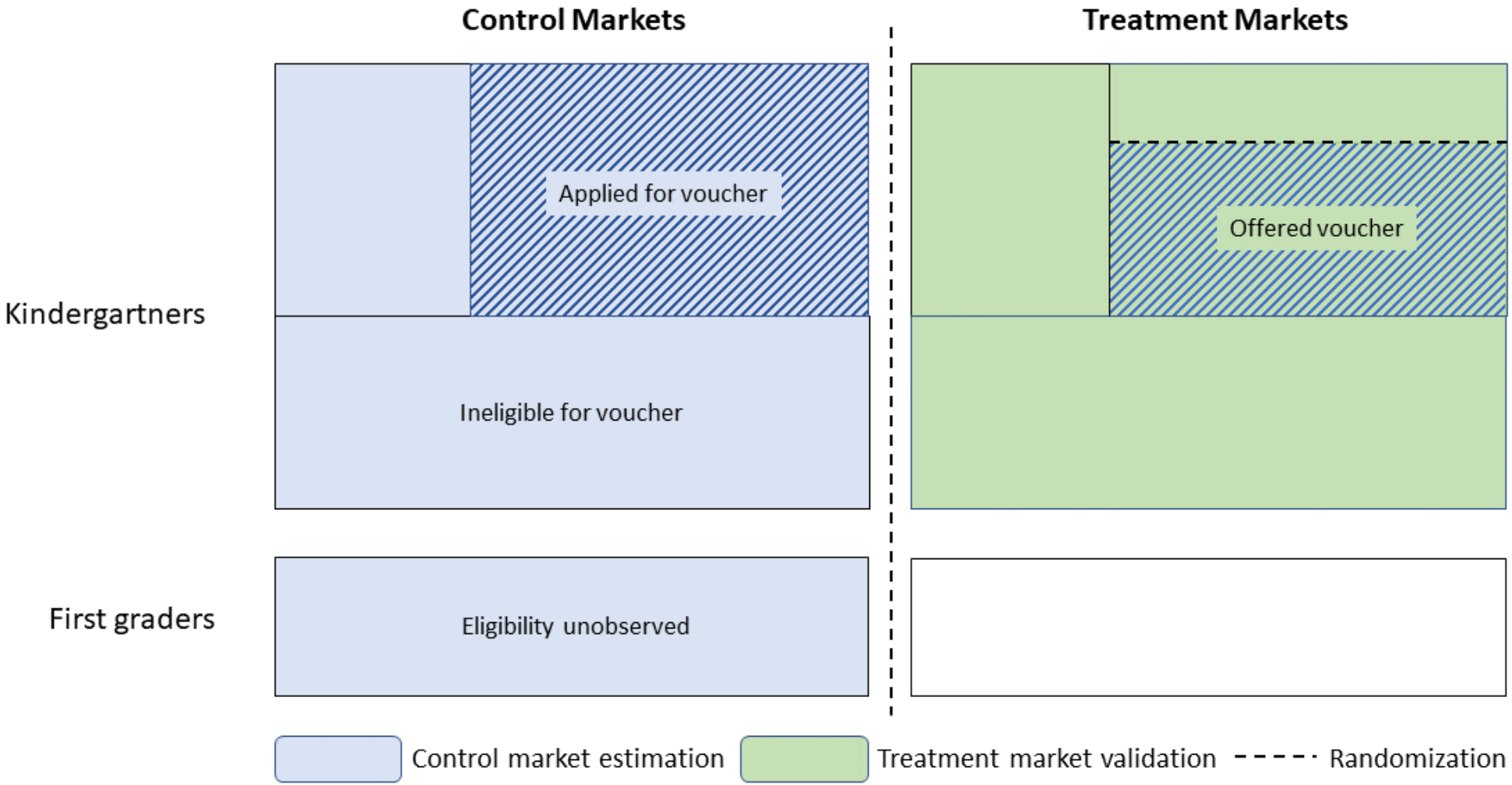
- Private school voucher RCT in 180 villages of Andhra Pradesh (70% rural)
  - waste and inefficiency in government schools
    - e.g. 24% of teachers absent from classroom (Muralidharan et al. 2014)
  - growth of low-cost, fee-charging private schools
- Voucher for tuition and fees at (gov't-recognized) private schools in village for primary schooling
  - targeted at students otherwise likely to attend government schools
    - our data: 42% cite **economic reasons** for choice
- Two-stage randomization design (villages and students)

Two-stage Randomization

1. Eligible students in all villages surveyed as to interest in participating in voucher program
2. Market-level randomization into treatment and control villages
3. Among applicants in treatment villages, randomization into treatment group

$\Rightarrow$ uncontaminated control sample of 90 markets

Research Design



Characteristics of (First Grader) Households

	Attend Gov't		Attend Private	
	Mean	T-C Diff	Mean	T-C Diff
Female	0.52	0.02	0.47	0.02
Lower caste	0.34	0.01	0.12	-0.01
Muslim	0.06	-0.00	0.09	-0.01
Older sibling in gov't school	0.50	0.01	0.11	-0.06***
Both parents completed primary school	0.09	-0.00	0.34	-0.03
Both parents laborers	0.45	-0.01	0.18	0.04*
Telugu score (baseline)	0.03	0.07**	0.72	-0.03
Owns home	0.75	0.01	0.76	0.05*
Pucca house	0.72	0.01	0.92	-0.02
Household toilet	0.24	-0.02	0.58	-0.00
Asset level < 3	0.39	-0.02	0.13	0.02
Asset level $= 3$	0.27	0.00	0.21	-0.02
Asset level $= 4$	0.20	0.02	0.29	-0.03
Asset level > 4	0.13	0.00	0.37	0.02
Market share	0.43		0.57	
N households	4439		975	

Kindergartners

Characteristics of Schools

	Government		Private	
	Mean	T-C Diff	Private	T-C Diff
Tuition and fees (Rs.)	0.81	-1.45	1,924	226**
English medium	0.02	0.00	0.57	-0.08*
Unrecognized	0	.	0.23	-0.04
Mid-day meals	0.99	0.00	0.03	-0.01
Full pucca building	0.89	-0.01	0.52	0.08**
Functioning toilet	0.65	0.01	0.84	0.05
Separate toilet for girls	0.34	0.07*	0.60	0.02
Multi-class teaching	0.70	0.10***	0.24	-0.06*
Pupil-teacher ratio	26.53	1.00	16.68	1.20
Share teachers absent	0.21	-0.04***	0.09	-0.01
Share teachers with BA	0.78	-0.00	0.54	-0.05
Share teachers from village	0.25	0.03	0.48	0.02
Share teachers female	0.50	-0.07***	0.71	-0.01
Offers Hindi instruction	0	.	0.44	0.02
Offers computer skills	0.01	0.01	0.13	-0.00
School value-added (math)	-0.04	0.02	0.04	-0.05
N schools	686		570	

Control Models and Results

Overview of Empirical Models

- Households choose a primary school from their village for child to attend:

$$\max_{j \in \mathcal{V}_i} u_{ij} \geq u_{ij'}$$

- Two types of models:
  1. Model 1: Random coefficient
     - standard IO approach, applied in school choice context in Neilson (2013) and Carneiro, Das, and Reis (2022)
     - lots of flexibility on preferences; price effect varies across groups
  2. Model 2: Ability-to-pay constrained
     - more restrictions on preferences
     - flexibility in how price operates comes through constraint

Model 1: Random coefficient

Household indirect utility:

$$u_{ij} = -(\alpha_0 + \alpha_1 A_i)p_j + X_j'\beta_i + \gamma_i \log(D_{ij}) + \xi_j + \epsilon_{ij}$$

- p_j and X_j are monetary costs and observed characteristics of school j
  - A_i = indicators for asset level of household i
- D_{ij} is distance from i's location to school j
- $\xi_j = \rho[p_j - Z_j'\hat{\gamma}] + v_j$ is unobserved amenity index for j (control function) detail
- β,γ depend on observed household characteristics W_i
- $\beta_i^{Private} = \beta_0^{Private} + \beta_1^{Private} W_i + \zeta_i$
- ϵ_{ij} idiosyncratic EV taste shock

Model 2: Ability-to-pay constrained

- Same indirect utility as Model 1 except:
  - common coefficient on price
  - no unobserved random coefficient on private school
- Choice now subject to ability-to-pay constraint:

$$p_j \leq \omega_i$$

where ω_i is not known, but depends on household observables I_i and $\upsilon \sim N(0, \sigma_\omega^2)$, independent of ϵ

$\Rightarrow$ Empirical challenge: separating willingness-to-pay from (unobserved) ability-to-pay

Unobserved Choice Sets

- Let j^* index schools in i's village by tuition
- Probability that i can afford j^* but not more expensive schools is then:

$$\begin{aligned}\phi_{ij^*} &= P(p_{j^*} \leq \omega_i < p_{j^*+1}) \\ &= \Phi\left(\frac{\ln p_{j^*+1} - I_i'\lambda}{\sigma_\omega}\right) - \Phi\left(\frac{\ln p_{j^*} - I_i'\lambda}{\sigma_\omega}\right)\end{aligned}$$

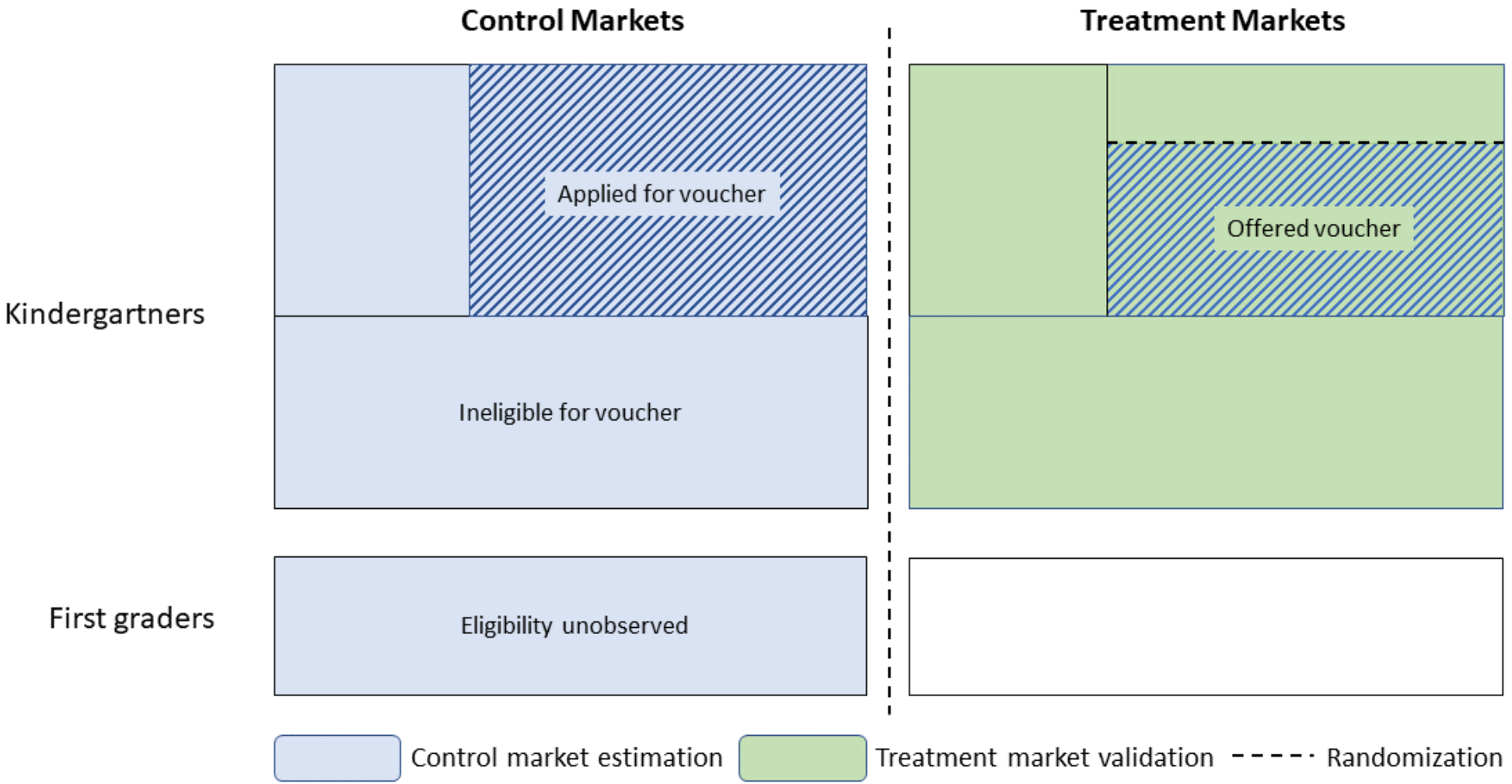
- Likelihood integrates out over the possible choice sets
- Household asset info only enters I_i

Control Model Results

- Estimate several model specifications using only control data
  - estimates and predictions reported in July 2021 NBER WP
    ⏩ estimates
- Several main findings:
  - ability-to-pay and random coefficient models yield similar estimates for relatively affluent, educated households
  - around 24% of targeted households effectively unable to choose any private school
    - asset-poor households' valuation of private schooling much higher according to ability-to-pay model
    - average complier with AP voucher gains more surplus than average always taker from program
  - random coefficient model achieves marginally better fit to control sample

Treatment Markets Validation

Research Design



Out-of-Sample Validation

	Attend Private			Tuition|Private		
		Model			Model	
	Data	RC	CC	Data	RC	CC
Ineligible for voucher	0.99	0.99	0.98	1.87	1.96	2.02
Eligible non-applicants	0.16	0.19	0.17	1.95	2.00	2.04
Voucher losers	0.43	0.29	0.28	2.12	1.98	2.00
Voucher winners	0.83	0.58	0.67	2.11	2.46	2.48

Hypothesis Tests Using Non-Winners' Choices

$$U_{ij}^m = \hat{u}_{ij}^m + \pi_T^m Private_j + \pi_L^m \mathbf{1}[VoucherLoser_i] \times Private_j + \tau^m p_j + \epsilon_{ij}$$

	Random coef.		Ability-to-pay const.	
	(1)	(2)	(3)	(4)
Private school		-0.12		0.07
		(0.50)		(0.09)
Private school × Voucher loser		2.21		2.05
		(0.56)		(0.30)
Tuition and fees (1000s of Rs.)		0.00		-0.11
		(0.10)		(0.09)
AIC	2,399	2,260	2,411	2,265

$N = 846$

Coding Voucher Take-up

	Number	Share
accepted and admitted	425	67.6%
rejected voucher	57	9.1%
migrated	10	1.6%
attend non-voucher private	43	6.8%
under age	21	3.3%
admitted, dropped out	36	5.7%
waiting list not used	1	0.2%
school did not accept	36	5.7%
total	629	100.0%

- Note: all "school did not accept" belong to 8 treatment villages where no one successfully used voucher

Predictions for Voucher Take-up

	Data		$\hat{Use}$		Adj.† $\hat{Use}$	
	Control	Treat	RC	CC	RC	CC
Overall	0.27	0.85	0.50	0.60	0.56	0.65
Female	0.24	0.86	0.50	0.59	0.55	0.64
Muslim	0.47	0.98	0.70	0.79	0.80	0.86
Lower caste	0.18	0.77	0.42	0.53	0.47	0.57
Older sibling in gov't school	0.14	0.79	0.33	0.43	0.40	0.49
Both parents completed primary	0.41	0.88	0.64	0.70	0.69	0.74
≥ 1 parent completed secondary	0.46	0.76	0.67	0.74	0.71	0.77
Both parents laborers	0.21	0.77	0.44	0.54	0.49	0.59
Asset level < 3	0.21	0.85	0.47	0.57	0.54	0.63
Asset level $= 3$	0.29	0.85	0.51	0.61	0.56	0.65
Asset level $= 4$	0.25	0.85	0.50	0.60	0.56	0.65
Asset level > 4	0.38	0.89	0.59	0.66	0.64	0.70

† assumes excess attritors would have used voucher if treated

Hypothesis Tests Using Voucher Winners' Choices

$$U_{ij}^m = \hat{u}_{ij}^m + \hat{\alpha}_i^m p_j + \pi_V^m PrivateVoucher_j + \epsilon_{ij}$$

	Random coef.			Ability-to-pay const.		
	(1)	(2)	(3)	(4)	(5)	(6)
Private voucher school		4.72	7.49		2.60	5.28
		(0.30)	(0.46)		(0.22)	(0.40)
Tuition and fees (@ voucher school)			-1.32			-1.32
			(0.17)			(0.16)
$\hat{U}$se	0.56	0.84	0.84	0.65	0.84	0.84
AIC	1,496	1,198	1,135	1,400	1,235	1,164

$N = 574$

Summary of Validation

- Ability-to-pay constrained models fit relatively better to a) out-of-sample "controls"; b) voucher choices
  - $\sim$20 point gap between predicted and intended voucher use

But all models miss that...

1. voucher losers attend private schools 15 points more than control applicants
2. conditional on using voucher, winners sort *negatively* on tuition (...which they don't pay)

What Was Missed?

We propose and provide evidence for two additional mechanisms:

1. Search: *all* applicants expected to receive voucher
   - many voucher losers found high enough match qualities to pay tuition anyway

     $\Rightarrow$ test: is private attendance elevated even in non-complying treatment villages?

2. Enrollment incentives: supply-side response
   - voucher amount (paid directly to schools' bank accounts): 2,600 Rs.; average private school's tuition: 1,900 Rs.

     $\Rightarrow$ are winning households spending less on stuff other than their voucher child's tuition?

Evidence for Search

	Attend (Rec.)	Private
Offered AP voucher	0.377***	0.412***
	(0.030)	(0.031)
Offered × Non-complying village		-0.399***
		(0.115)
Applied for AP voucher	0.068**	0.068**
	(0.033)	(0.033)
Applied × Treatment village	0.155***	0.154***
	(0.039)	(0.039)
Applied × Non-complying village		-0.001
		(0.115)
Treatment village	-0.029	-0.025
	(0.026)	(0.027)
Non-complying village		-0.043
		(0.061)
Ineligible for AP voucher	0.622***	0.623***
	(0.031)	(0.030)
Constant	0.197***	0.197***
	(0.030)	(0.030)

$N = 2{,}960$

Evidence for Enrollment Incentives

	(1) Private	(2) Tuition and fees (Rs.)	(3)
Offered voucher	0.542***	-2,742***	-580.5***
	(0.0277)	(199.5)	(113.1)
Constant	0.220***	3,153***	760.5***
	(0.0424)	(263.1)	(127.1)
Observations	948	395	941
Sample	All	Private=1	All
	Siblings (ages 5-9)		
Offered voucher	0.152***	-860.9**	289.2
	(0.0470)	(392.4)	(179.0)
Constant	0.265***	1,396***	313.6*
	(0.0851)	(444.9)	(181.5)
Observations	452	183	441
Sample	All	Private=1	All

Unified Model

Unified Model

- Utility from participating private school for voucher winners

$$u_{ij}^V = u_{ij} + \alpha p_j + \underbrace{\theta(V - p_j) \times \mathbf{1}[V > p_j]}_{\text{Incentive}}$$

where u_{ij} is "control" utility

- Treatment market applicants search for private schools if:

$$\begin{aligned} c_i &< \ln \sum_{j \in \mathcal{V}_i} \exp u_{ij}^V - \ln \sum_{j \in G_i} \exp u_{ij} \\ &< -\ln(P_{iG|S}^V) \end{aligned}$$

where $P_{iG|S}^V$ is prob. chooses a gov't school with voucher post-search

$\Rightarrow$ voucher losers expect they will get voucher, but don't

Unified Model Estimates

	Control	Unified
Tuition and fees (1000s of Rs.)	-1.28	-1.52
	(0.58)	(0.11)
First stage residual	1.77	1.57
	(0.63)	(0.11)
Private random effect σ	2.66	1.73
	(0.27)	(0.17)
Enrollment incentive		2.04
		(0.25)
Search		
Location		-0.24
		(0.09)
Scale		0.36
		(0.04)
Ability-to-pay constraint		
Intercept	2.96	3.41
	(0.55)	(0.71)
Eligible for AP voucher	-1.29	-0.69
	(0.41)	(0.35)
Asset factor	1.09	1.20
	(0.23)	(0.29)
σ	1.34	1.51
	(0.28)	(0.34)
N households	4,251	8,374
N observations	35,796	69,413

⏩ Implications for search / constraint

Unified Model Fit

	Attend Private		Tuition Private	
	Data	Unified	Data	Unified
First graders				
Overall	0.57	0.58	1.71	1.70
Lower caste	0.34	0.36	1.65	1.62
Parents completed primary	0.27	0.28	1.48	1.60
Asset level < 3	0.28	0.33	1.45	1.58
Asset level $= 3$	0.52	0.54	1.72	1.70
Asset level $= 4$	0.68	0.66	1.84	1.76
Asset level > 4	0.78	0.78	1.67	1.69
Voucher program applicants				
Control markets	0.34	0.32	1.88	1.65
Voucher losers	0.48	0.45	2.13	1.91
Voucher winners	0.81	0.79	2.09	2.13

Evaluating Welfare Impacts

- Does a voucher program increase economic welfare?
- Components of welfare:
  1. Gain in consumer surplus
     $\Rightarrow$ Rs. such that indifferent between voucher and no voucher
  2. Cost of program
     $\Rightarrow$ 2,600 Rs. per year (present value=7,360 Rs.)
  3. Fiscal externality
     $\Rightarrow$ can cut 2/3rds of per pupil government school spending (8,390 Rs. per Dongre 2012)

discount factor $= 0.9 \times$ persistence rate

Welfare Effects of AP Voucher (1000s of Rs.)

	Control	Unified
(A) Gain in Consumer Surplus	3.46	4.84
(B) Cost of Program	4.61	5.60
(C) Fiscal Externality	4.73	6.96
(A−B+C) Net Welfare Change	3.59	6.09

Per recipient; median annual household consumption $\approx$ 86,000 Rs.; fiscal externality assumes 2/3rds of gov't spending could be cut

Welfare Effects of AP Voucher by Treated Subgroup

	Always takers		Compliers	
	Control	Unified	Control	Unified
Share of Applicants	0.32	0.32	0.30	0.44
(A) Gain in Consumer Surplus [excl. incentives]	5.48	8.11 [4.23]	5.60	5.11 [1.38]
(B) Cost of Program [tuition expense]	7.36 [5.63]	7.36 [4.96]	7.36 [6.88]	7.36 [5.24]
(C) Fiscal Externality	0	0	15.67	15.68

Per recipient; median annual household consumption $\approx$ 86,000 Rs.; fiscal externality assumes 2/3rds of gov't spending could be cut

Welfare Effects of Targeted, No-Incentives Program

	Overall	Always takers	Compliers
Share of Applicants		0.34	0.28
(A) Gain in Consumer Surplus	2.76	4.67	4.26
(B) Tuition Expense	3.84	5.59	6.89
(C) Fiscal Externality	4.35	0	15.68
(A−B+C) Net Welfare Change	3.28	-0.92	13.05

Per person; median annual household consumption $\approx$ 86,000 Rs.; fiscal externality assumes 2/3rds of gov't spending could be cut

Summary

- We evaluate welfare impacts of offering vouchers to attend private schools in rural India
- Models estimated on control markets alone underpredict experimental voucher take-up ($\geq$ 20pp)
  - ability-to-pay constrained models perform relatively better
- Treatment data suggest 1) anticipated voucher induced search; 2) private schools shared program surplus to incentivize enrollment
  - mechanisms jointly explain data patterns
  - estimates indicate program raises social welfare; most of the gain from fiscal externality

Characteristics of (Kindergartner) Households

	Applied		Non-app.		Ineligible	
	Mean	T-C Diff	Mean	T-C Diff	Mean	T-C Diff
Female	0.58	-0.02	0.55	0.07	0.47	-0.00
Lower caste	0.32	0.03	0.36	-0.02	0.11	-0.02
Muslim	0.07	0.02	0.07	-0.06*	0.08	0.02
Older sibling in gov't school	0.37	-0.00	0.48	0.02	0.10	-0.03
Both parents compl. primary	0.17	0.01	0.15	-0.02	0.35	-0.01
Both parents laborers	0.39	0.00	0.43	-0.05	0.19	-0.03
Telugu score (baseline)	0.00	0.04	-0.04	-0.42***	0.39	-0.15**
Owns home	0.76	-0.01	0.76	-0.00	0.77	0.00
Pucca house	0.75	0.01	0.65	0.03	0.91	-0.00
Household toilet	0.28	-0.03	0.23	0.04	0.57	0.05
Asset level < 3	0.36	0.04	0.40	-0.06	0.12	0.01
Asset level $= 3$	0.26	-0.02	0.26	-0.01	0.20	-0.03
Asset level $= 4$	0.23	-0.01	0.23	0.04	0.27	0.00
Asset level > 4	0.15	-0.01	0.11	0.04	0.40	0.01
N households	1915		258		787	

Back

Endogeneity of Tuition

- ξ_j observed by private schools when setting tuition
- Control function (Petrin and Train 2010). "First stage":

$$p_j = Z_j'\Gamma + \mu_j$$

  $\hat{\mu}_j$ and random effect inserted into indirect utility function

- Excluded instruments:
  1. index of non-tuition characteristics of *other* schools in same village (Berry et al. 1995)
  2. average tuition of similar private schools in *other* villages (Hausman 1994; Nevo 2001)

Back

Control Model Estimates

	RC	CC
Tuition and fees (1000s of Rs.)	-2.35	-1.28
	(0.28)	(0.58)
× Eligible for AP voucher	0.07	
	(0.12)	
× Asset level = 2	0.45	
	(0.20)	
× Asset level = 3	0.74	
	(0.20)	
× Asset level = 4	1.12	
	(0.20)	
× Asset level > 4	0.81	
	(0.21)	
First stage residual	1.60	1.77
	(0.20)	(0.63)
Private random effect σ	2.23	2.66
	(0.22)	(0.27)
Ability-to-pay constraint		
Intercept		2.96
		(0.55)
Eligible for AP voucher		-1.29
		(0.41)
Asset factor		1.09
		(0.23)
σ		1.34
		(0.28)

$N = 4{,}251$ households Back

Unified Model Estimates: Ability-to-pay and Search

	Share unable to pay for...				Search privates	
	Any private		Priciest private			
	Control	Unified	Control	Unified	Control	Unified
First graders						
Overall	0.09	0.04	0.18	0.09	1.00	0.52
Lower caste	0.13	0.07	0.25	0.13	1.00	0.43
Parents completed primary	0.11	0.04	0.23	0.10	1.00	0.35
Asset level < 3	0.24	0.13	0.44	0.25	1.00	0.43
Asset level $= 3$	0.09	0.04	0.20	0.09	1.00	0.51
Asset level $= 4$	0.03	0.01	0.08	0.03	1.00	0.56
Asset level > 4	0.01	0.01	0.03	0.01	1.00	0.60
Voucher program applicants						
Control markets	0.13	0.06	0.25	0.12	1.00	0.47
Voucher losers	0.12	0.07	0.27	0.14	1.00	0.81
Voucher winners	0.17	0.07	0.33	0.16	1.00	0.82

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