Teacher Compensation and Structural Inequality

Evidence from Centralized Teacher School Choice in Peru

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Dynamic Structural Econometrics: Market Design

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Motivation

- Large **within-country gaps** in schooling outcomes
  - Significant differences in access to inputs of HK production function

  $\Rightarrow$ **Attracting good teachers in disdvantaged areas could be a policy leverage**

- **Problem: rigid wage profiles** for public sector employees
  - Teachers sort on non-pecuniary aspects of employment

  $\Rightarrow$ **Reinforce disadvantage for children in remote/rural locations**

- How **teacher wage policies** can alleviate **unequal distribution of teaching quality**?

This Paper

1. **Link inequality in teacher quality to location choices**
   - Admin Data linking teachers, schools and students with job postings and applications
   - Survey Data eliciting non-pecuniary preferences of teachers

2. **Evaluate the policy impact of unconditional wage increases** in remote schools
   - Estimate 'ceteris paribus' effect using a RD design
   - Estimate overall/spatial effect using a model of teacher school choice

3. **Study counterfactual wage policies** using estimated teacher preferences
   - Insights from market design to propose alternative bonus schemes given a policy objective

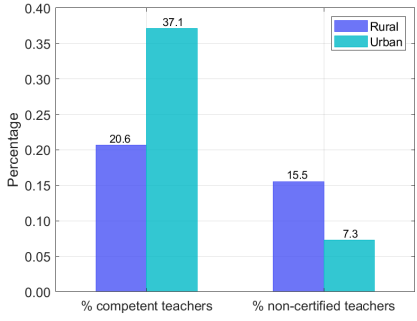
Main Results

1. Large effects of wage increases on teacher quality (0.45σ) and student achievement (0.33-0.38σ)
   - Clotfelter et al. (JPubE 2008), **De Ree et al. (QJE 2018)**, Cabrera and Webbink (JHR 2020)
2. Quantify importance of non-pecuniary aspects in teacher preferences
   - Boyd et al. (JoLE 2013), Tincani (QE 2021), **Biasi et al (WP 2022), Bates et al (WP 2022)**
3. Cost-effective bonus policy dramatically improves equity vis-a-vis the actual scheme
   - **Agarwal (AER 2015, AERP&P 2017)**, Agarwal and Budish (HIO 2022)

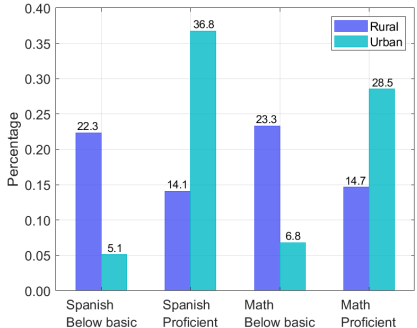
Public Sector Teachers in Peru

- 74% of Peruvian primary schools are public (98% in rural areas)
- Teacher wages vary by
  - Type of contract (permanent vs. temporary) and seniority
  - **Location and school characteristics** Wage Bonuses
- Centralized allocation mechanism Stats on Teachers
  - Step 0: all applicants take a competency test
  - Step 1: allocation of permanent contracts
  - **Step 2: allocation of temporary contracts**
    - Teachers choose a school district
    - Matching algorithm assigns teachers to schools using test scores as priorities
  - Step 3: remaining seats filled by non-certified teachers

Inequality of Education Inputs and Output



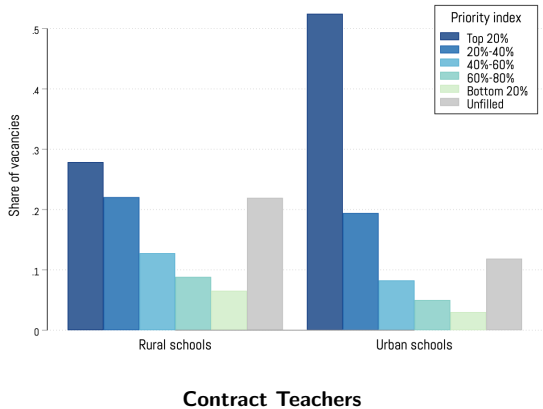
a) Teachers



b) Students

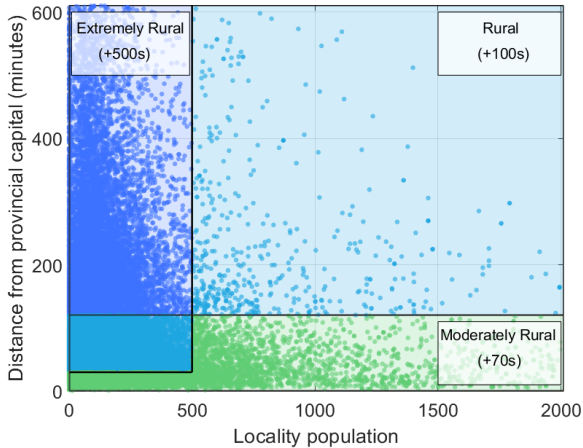
- Geography of competent teachers and proficient students Map
- Similar gaps across a broader set of indicators Gaps in School/Community Characteristics

Teacher Choices over Job Postings



- Rural vacancies are filled by teachers with 0.5 SD lower scores on average

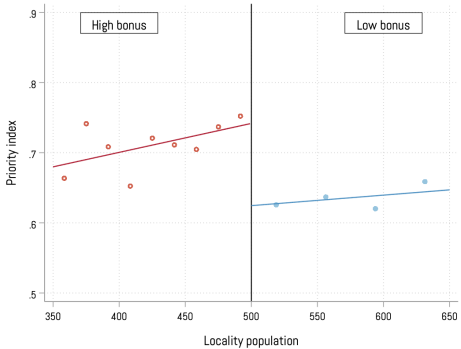
Policy Changes to Compensation in Rural Locations



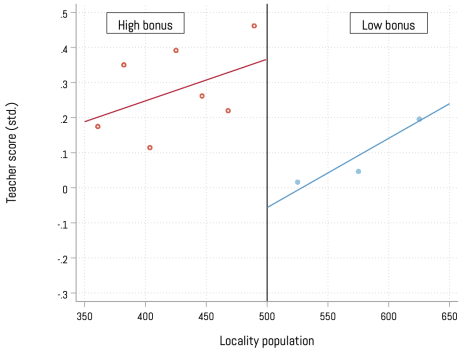
- From Rural to Extremely Rural wages increase by $\approx 1/3$ of base salary

Rural Bonus and Teacher Sorting

Estimates for Contract Teachers | Estimates for Permanent Teachers



a) Revealed Preferences



b) Competency Score

NOTES. The y-axis in Panel A is the priority in which a vacancy is chosen in the serial dictatorship mechanism (normalized so that it takes value from zero to one). Each marker in the Figure indicates the average of the outcome variable within each bin, defined following the IMSE-optimal evenly spaced method by Calonico, Cattaneo and Titiunik (2015). Solid lines represent the predictions from linear regressions estimated separately for observations to the left and to the right of the cutoff.

Rural Bonus and Student Achievement (Math) Spanish

	No vacancy	Vacancy		
	(1)	(2)	(3)	(4)
		Any vacancy	Permanent teacher	Contract teacher
High Bonus	0.028	0.378	-0.016	0.483
	(0.177)	(0.144)	(0.249)	(0.160)
Bandwidth	125.996	108.117	162.799	101.104
Schools	379	691	274	561
Observations	4014	9698	3196	8146

NOTES. This table reports the effect of crossing the population threshold on the standardized (z-score) 4th grade math test score taken in 2018 for different sub-samples of primary schools. Each cell reports the bias-corrected regression-discontinuity estimates obtained using the robust estimator proposed by Calonico et al. (2014). Standard errors clustered at the school×year level are reported in parentheses. Regressions are defined within a mean-square error optimal bandwidths, which are reported at the bottom part of the table.

Takeaways from RD Analysis

1. Rural bonus **shifted supply of teachers** towards disadvantaged areas
   - Evidence supporting SUTVA (Distance from 'Just-Above' Schools) (RD by Teachers' Origin) (Model-based Validation)
2. Higher competition for these positions **increased teacher quality**
   - But only when assignment ignores discretionary step (Sorting by Contract Type)
   - No effect on the share of filled vacancies
   - Selection Vs. reallocation effects (New Entrants)
3. **Students perform better** in schools that pay higher wages
   - But only in schools that attracted better quality teachers
   - Effects are concentrated among lower performing students (Composition Effect on Student Achievement)

$\Rightarrow$ Study **global effect** of the policy through a model of **teacher sorting**

An Empirical Model of Teachers School Choice

- Define teacher i's payoff from being matched with school j as:

$$v_{ij} = \alpha_i w_j + \boldsymbol{\beta}_i' \boldsymbol{z}_j + \boldsymbol{\delta}' \boldsymbol{d}_{ij} + \boldsymbol{\lambda}' \boldsymbol{m}_{ij} + \epsilon_{ij},$$
$$v_{i0} = \boldsymbol{\eta}_0 + \boldsymbol{\eta}_1' \boldsymbol{q}_i + \epsilon_{i0},$$

  $\Rightarrow$ Heterogeneous preferences over compensation: $\alpha_i = \alpha_0 + \boldsymbol{\alpha}_1' \boldsymbol{x}_i + \sigma \nu_i$

  $\Rightarrow$ Heterogeneous preferences for locality/school characteristics: $\boldsymbol{\beta}_i = \boldsymbol{\gamma}_0 + \Gamma_1 \boldsymbol{x_i}$

- Use realized match to infer preferences over schools

  $\Rightarrow$ **Serial dictatorship implies discrete choice model with personalized choice sets**

Identification Assumptions for Discrete Choice Model

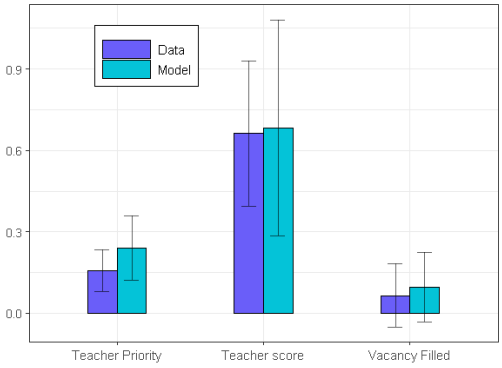
1. Observables are independent from both taste shifter and random coefficient
   $\Rightarrow$ **Wages are set exogenously via deterministic rules**

2. Choice sets are independent from taste shifter conditional on observables
   $\Rightarrow$ Vertical preferences of the schools over applicants (by the competency score)

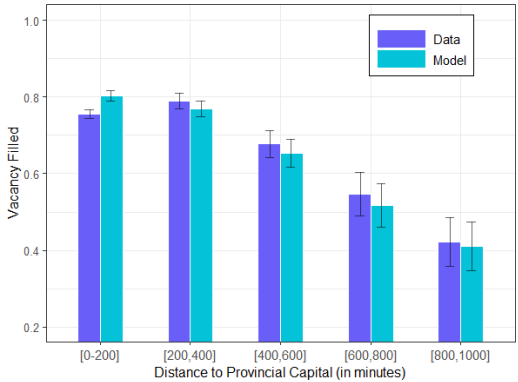
3. Full support: some schools may be unreachable to low scoring teachers
   $\Rightarrow$ We include a discrete index of competency, rather than the overall score

Model Fit (Local and Global)

More Moments on Teachers' Competency Score



a) Simulated Threshold Crossing Effects

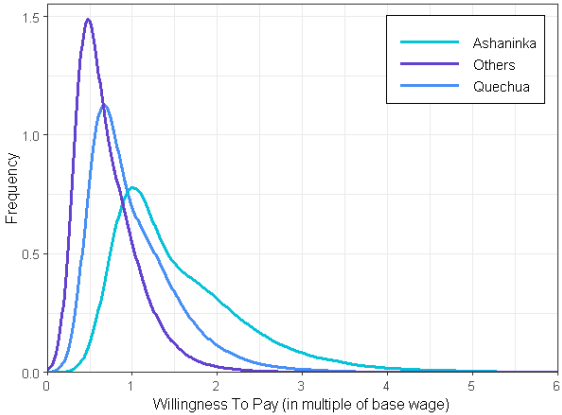


b) Share of Filled Vacancies by Remoteness

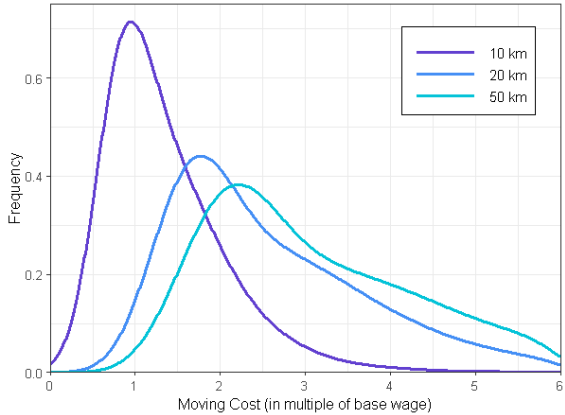
NOTES. To assess model fit in Panel A, we predict indirect utilities for each teacher and simulate the match using the serial dictatorship algorithm. We then estimate on simulated data the change in average outcomes at the population cutoff and compare it with the estimated RD effects observed in the data.

Ethnolinguistic Match Effects and Moving Costs

Wage Elasticities



a) Ethnolinguistic Match

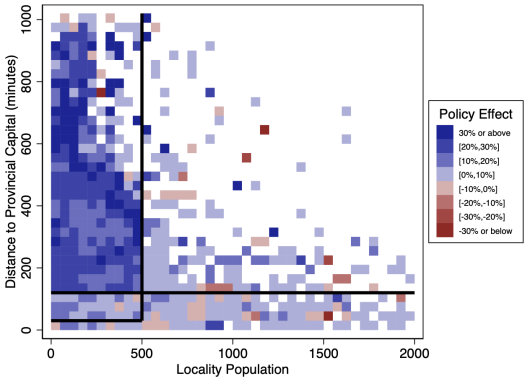


b) Disutility of Distance

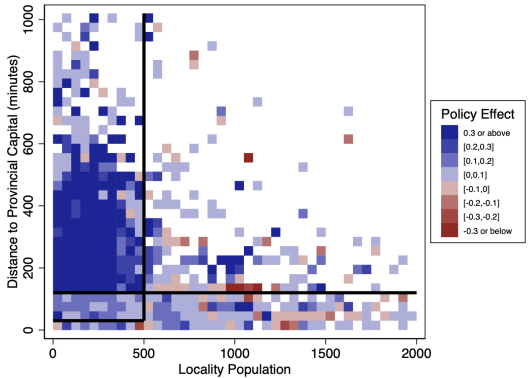
NOTES. Panel A plots the estimated distributions of the willingness to pay (in multiple of the base wage) for indigenous teachers to get assigned to (bilingual) schools with secondary language of instruction that is the same as their own language. Panel B plots the estimated distributions of the cost incurred by teachers when moving away from their previous location by 10km, 20km and 50km, respectively.

The Effect of the Wage Bonus on Teacher Sorting

Aggregate Policy Effects



a) Share of Filled Vacancies



b) Teacher Scores

NOTES. This Figure uses simulated assignment data, which is generated by running the serial dictatorship algorithm using predicting utilities computed from the estimated preference parameters as well as a randomly drawn set of taste shocks.

Takeaways from Model Estimates

1. **Wage bonus is effective** in shifting teacher labor supply **away from the policy cutoffs**
   - $\Rightarrow$ Reduce the teacher-quality gap for extremely rural vs. other rural schools
   - $\Rightarrow$ Fill very undesirable vacancies that would not have been filled otherwise

2. **Positive net reallocation effect** of the wage incentive scheme
   - $\Rightarrow$ Inflow (outflow) of teachers from (to) the outside option Selection Effects

3. **Wage schedule features limited variation** for schools in Extremely Rural areas Predicted Utilities
   - $\Rightarrow$ Scope for improvement with more flexible targeting that leverages heterogenous preferences

Optimal Wage Policies

- We quantify alternative bonus schemes that achieve a given policy objective
  1. Fill at least one vacancy in each school
  2. Recruit at least one 'high-quality' teacher in each school

- A matching-with-contracts framework (Hatfield and Milgrom, 2005)
  - Schools bid for teachers in simultaneous ascending auctions
  - Teachers have preferences over school-wage pairs
  - Encode policy objectives into school preferences Details

$\Rightarrow$ **School-proposing generalized DA algorithm delivers cost effective bonus**

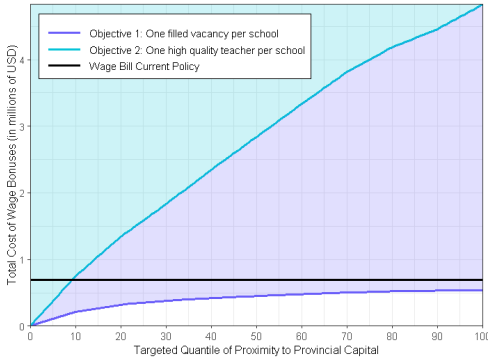
Counterfactual Wage Bonuses: Targeting

Policy Target		Fill all Schools	Fill All Schools with HQ Teachers
Bonus Scheme	Actual Policy	Optimal Policy	Optimal Policy
Total Cost (monthly, USD)	**0.68M**	**0.54M**	**4.83M**
Share of Total Cost			
in Extremely Rural	0.794	0.787	0.619
Dist.$\in$ [120min,400min]	0.683	0.274	0.445
Dist.$\in$ [400min,800min]	0.216	0.244	0.238
Dist.$>$ 800min	**0.102**	**0.481**	**0.317**
in Rural	0.159	0.120	0.218
in Moderately Rural	0.039	0.031	0.058
in Urban	**0.008**	**0.062**	**0.105**

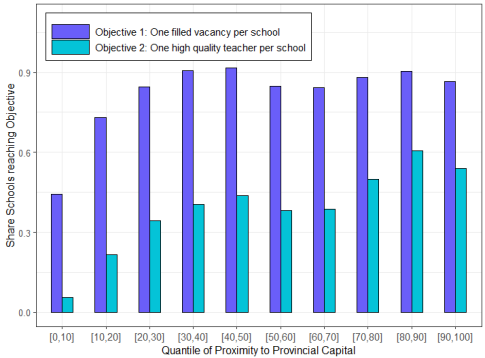
$\Rightarrow$ Attracting qualified teachers is more costly than merely filling vacancies

$\Rightarrow$ Optimal policy **targets very remote localities more aggressively + some urban localities** that lack amenities/infrastructures

Counterfactual Wage Bonuses: Equity and Efficiency



a) Optimal Policy – Total Cost



b) Actual Policy – Matching Outcomes

$\Rightarrow$ At balanced budget, **the share of under-performing students in most remote communities would decrease from 80% to less than 50%** under the optimal policy

Conclusions

1. Evidence that **raising unconditional pay can be consequential** for both teachers and students
   - ⇒ Shifts labor supply towards undesirable areas
   - ⇒ Increase teacher quality across schools (positive net reallocation)
   - ⇒ Large effect on student outcomes (only through recruiting)

2. **Market design tools to design cost-efficient policies**
   - ⇒ Current wage bonus policy is largely misallocated Cost-Effectiveness
   - ⇒ Counterfactual balanced-budget wage bonus improves equity and efficiency
   - ⇒ Targeted supply-side policies can be highly effective Complementary Policies

Data Sources

Back

1. **Centralized teacher job application/assignment system**
   - Vacancies posted at all public schools in the country
   - Teacher job applications, competency scores and other characteristics
2. **Career path and payroll data**
   - Panel on all teachers linked to schools, type of contract.
3. School/Locality census with **school inputs and characteristics**
   - Number of pupils, libraries, computers, classrooms, sport facilities, staff.
   - Locality characteristics: access to basic services and infrastructure, poverty index.
4. Individual records of **student academic outcomes**
   - National standardized test results (Math and Spanish).

Table: Summary Statistics

Back

	Rural schools		Urban Schools	
	Mean	Sd	Mean	Sd
		School characteristics		
Number of students	40.16	(45.89)	339.9	(262.0)
Bilingual school	0.249	(0.432)	0.00864	(0.0926)
Single-teacher school	0.393	(0.488)	0.0151	(0.122)
Multigrade school	0.466	(0.499)	0.0868	(0.282)
Number of teachers	5.092	(4.050)	24.59	(13.58)
% of permanent teachers	0.677	(0.468)	0.807	(0.394)
% of certified contract teachers	0.164	(0.371)	0.114	(0.317)
% of non-certified contract or other teachers	0.158	(0.365)	0.0790	(0.270)
% of competent teachers	0.210	(0.407)	0.386	(0.487)
		School infrastructure		
No water	0.311	(0.463)	0.0355	(0.185)
No electricity	0.233	(0.423)	0.0127	(0.112)
Cafeteria	0.284	(0.451)	0.211	(0.408)
Computer	0.619	(0.486)	0.932	(0.252)
Kitchen	0.392	(0.488)	0.372	(0.483)
Internet	0.186	(0.389)	0.912	(0.283)
Library	0.207	(0.405)	0.564	(0.496)
Sport facility	0.190	(0.392)	0.614	(0.487)
Gym	0.0126	(0.111)	0.118	(0.323)
Stadium	0.00268	(0.0517)	0.0419	(0.200)
		Locality infrastructure		
Electricity	0.803	(0.398)	0.997	(0.0553)
Sewage	0.259	(0.438)	0.915	(0.279)
Library	0.0166	(0.128)	0.430	(0.495)
Doctor	0.324	(0.468)	0.869	(0.338)
Internet access point	0.0554	(0.229)	0.845	(0.362)
Village phone	0.0498	(0.218)	0.0928	(0.290)
Drinking water	0.582	(0.493)	0.945	(0.228)

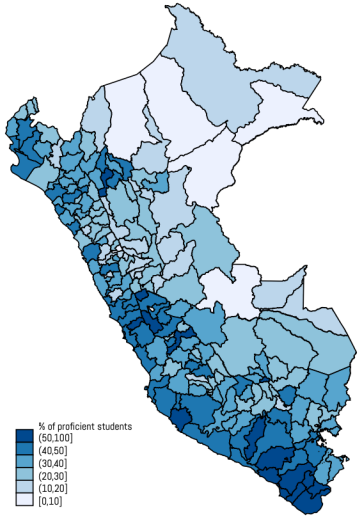
Table: Applicant Characteristics

Back

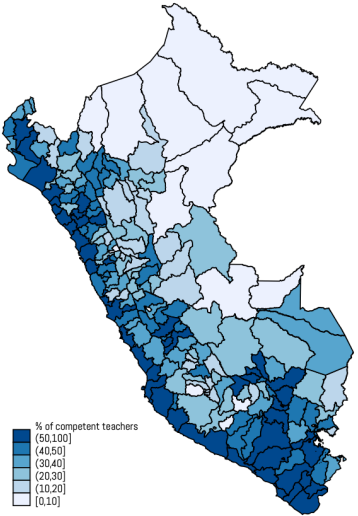
	Only contract		Contract and permanent		Only Permanent	
	Mean	Sd	Mean	Sd	Mean	Sd
Age	37.72	6.934	34.50	5.802	34.48	5.465
Female	0.698	0.459	0.837	0.369	0.696	0.460
Indigenous	0.300	0.458	0.119	0.324	0.189	0.391
University degree	0.289	0.453	0.454	0.498	0.415	0.493
Curricular knowledge	40.29	13.17	67.95	6.578	70.04	7.408
Competency score	89.81	24.65	145.2	11.11	148.1	12.45
New entrant	0.344	0.475	0.313	0.464	0.166	0.372
Prior teaching experience in public schools	0.776	0.417	0.737	0.440	0.868	0.339
Prior teaching experience in private schools	0.448	0.497	0.739	0.439	0.619	0.486
Previous school: Urban	0.321	0.467	0.673	0.469	0.499	0.500
Previous school: Extremely rural	0.291	0.454	0.0852	0.279	0.189	0.391
Previous school: Rural	0.255	0.436	0.133	0.340	0.188	0.391
Previous school: Moderately rural	0.132	0.339	0.108	0.311	0.124	0.330
Number of teachers	119490		7630		8916	

NOTES. This table reports the summary statistics for the applicants to the 2015 and 2017 centralized teacher assignment system. Applicants are split in three groups: i) applicants to the contract teaching positions only; ii) unassigned applicants to the permanent teaching positions who applied to a contract teaching position; iii) applicants to the permanent teaching positions (assigned). The information on whether the applicant speaks a Peruvian indigenous language ($Indigenous$) is available for the first round of the assignment system only (2015). $Newentrant$ is a dummy variable that takes value 1 if the teacher has not been employed as public sector teacher (i.e. she was not observed in *NEXUS* teacher occupation and payroll system) before the teacher assignment process. The (self-reported) information on applicants' prior teaching experience in public and private schools is collected at the time of the application.

Figure: Geographic Distribution of Student Achievement and Teacher Competency Back



a) % of Proficient Students



b) % Competent Teachers

Figure: The Different Wage Bonuses for Disadvantaged Schools Back

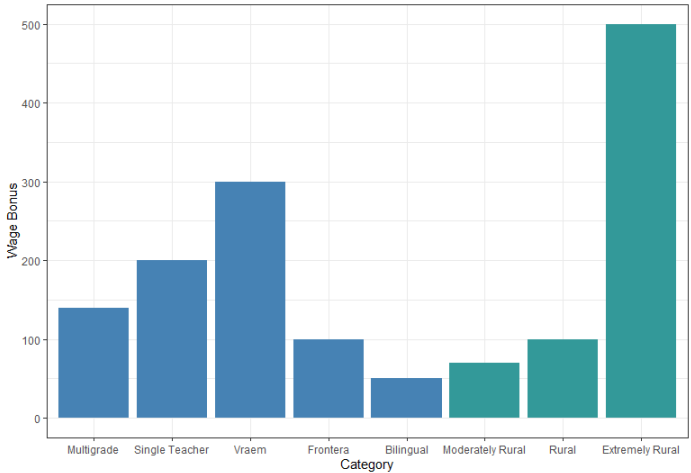
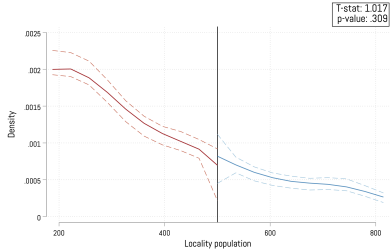
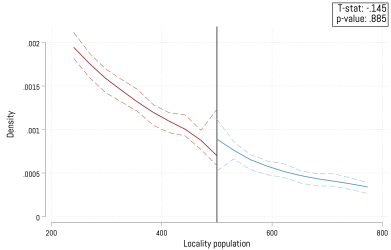


Figure: Density Tests Around Extremely Rural Cutoff

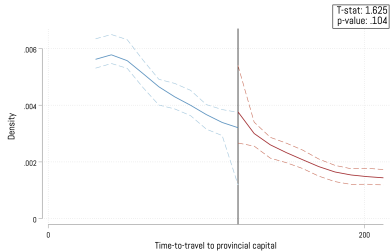
Back



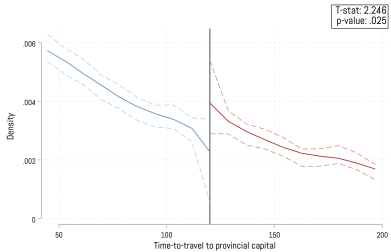
a) Population (2015)



b) Population (2017)



c) Time-to-travel (2015)



d) Time-to-travel (2017)

Table: Covariate Smoothness (RD sample) Back

	2015			2017		
	(1) Any vac.	(2) Permanent	(3) Contract	(4) Any vac.	(5) Permanent	(6) Contract
Village amenities						
Electricity	0.062	0.011	0.012	0.026	-0.043	0.058
	(0.090)	(0.126)	(0.083)	(0.053)	(0.064)	(0.068)
Drinking water	0.260**	0.231	0.309**	0.110	0.174	0.144
	(0.132)	(0.173)	(0.150)	(0.083)	(0.115)	(0.101)
Sewage	0.179	0.067	0.171	-0.022	-0.030	-0.001
	(0.115)	(0.153)	(0.127)	(0.070)	(0.097)	(0.080)
Medical clinic	0.056	0.030	0.066	0.000	-0.069	0.001
	(0.107)	(0.151)	(0.122)	(0.082)	(0.100)	(0.091)
Meal center	0.186**	0.246**	0.146	0.069	0.113	0.075
	(0.087)	(0.117)	(0.101)	(0.081)	(0.093)	(0.085)
Community phone	-0.007	-0.059	-0.036	-0.034	-0.033	-0.086
	(0.093)	(0.135)	(0.114)	(0.069)	(0.091)	(0.075)
Internet access point	0.054	0.153*	0.070	0.022	-0.004	0.024
	(0.058)	(0.084)	(0.079)	(0.051)	(0.059)	(0.062)
Bank	0.023*	0.000	0.031*	0.010	0.005	0.013
	(0.013)	(0.000)	(0.016)	(0.007)	(0.008)	(0.009)
Public library	0.018	-0.059	0.019	-0.004	0.002	0.006
	(0.032)	(0.049)	(0.043)	(0.023)	(0.030)	(0.016)
Police	-0.079	-0.161	-0.094	-0.056	-0.124	-0.078
	(0.082)	(0.118)	(0.097)	(0.063)	(0.089)	(0.067)
School amenities						
Number of students	-2.912	5.555	-18.543	-1.045	-4.498	-3.479
	(10.290)	(11.990)	(11.635)	(6.499)	(8.513)	(6.736)
Indigenous language students	-0.038	-0.052	-0.056	0.017	-0.042	0.014
	(0.097)	(0.143)	(0.108)	(0.067)	(0.087)	(0.075)
% indigenous language students	-0.022	0.028	-0.030	-0.008	-0.040	0.015
	(0.085)	(0.112)	(0.103)	(0.046)	(0.066)	(0.065)
% proficient students (math)	3.863	-0.939	4.796	1.331	-4.160	2.993
	(3.144)	(7.601)	(3.305)	(3.477)	(3.511)	(3.722)
% proficient students (spanish)	6.294	5.182	8.202**	-2.264	-5.437	0.278
	(4.070)	(5.609)	(4.114)	(3.775)	(4.073)	(4.049)

Table: Wage Increment and the Selection of Permanent Teachers

Back

	(1) Stated Preferences	(2) Vacancy filled	(3) Competency score
High Bonus	0.188	0.026	-0.037
	(0.069)	(0.074)	(0.155)
Bounds			[-.302; .205]
Mean dep. var. (Low Bonus)	0.755	0.371	-0.080
Bandwidth	166.986	169.330	259.213
Schools	835	847	830
Observations	1009	1725	1167

NOTES. This table reports the effect of crossing the population threshold on the selection process of permanent teachers. In Column (1) the outcome variable is a dummy equal to one if a school was mentioned in at least one application, while in Column (2) is an indicator for whether the vacancy was filled by a certified teacher in the assignment process for permanent teachers. The regression displayed in the last column uses the standardized competency score obtained by the teachers in the centralized test as outcome variable. Cells report the bias-corrected regression-discontinuity estimates obtained using the robust estimator proposed in Calonico et al. (2014). Standard errors clustered at the school$\times$year level are reported in parentheses. Regressions are defined within a mean-square error optimal bandwidth (BW), reported at the bottom part of the table. In Column (1) and in Column (3) the sample is restricted to vacancies that were actually filled by a certified teacher. In those cases, the table also reports the RD bounds estimated using the procedure developed in Gerard et al. (2020). The table also reports the mean of the dependent variable computed within the interval $(-BW, 0]$ (Low Bonus).

Table: Wage Increment and the Selection of Temporary Teachers

Back

	(1) Revealed Preferences	(2) Vacancy filled	(3) Competency score
High Bonus	0.130	0.051	0.483
	(0.036)	(0.048)	(0.124)
Bounds	[.116; .138]		[.391; .5]
Mean dependent variable (Low Bonus)	0.634	0.900	0.063
Bandwidth	150.781	159.432	152.768
Schools	836	935	851
Observations	1917	2199	1955

NOTES. This table reports the effect of crossing the population threshold on the selection process of contract teachers. Column (1) shows the effects on the rank in which a vacancy was chosen in the deferred acceptance mechanism (normalized so that it takes values from zero to one), while in Column (2) is an indicator for whether the vacancy was filled by a certified teacher in the assignment process for permanent teachers. The regression displayed in the last column uses the standardized competency score obtained by the teachers in the centralized test as outcome variable. Cells report the bias-corrected regression-discontinuity estimates obtained using the robust estimator proposed in Calonico et al. (2014). Standard errors clustered at the school$\times$year level are reported in parentheses. Regressions are defined within a mean-square error optimal bandwidth (BW), reported at the bottom part of the table. In Column (1) and in Column (3) the sample is restricted to vacancies that were actually filled by a certified teacher. In those cases, the table also reports the RD bounds estimated using the procedure developed in Gerard et al. (2020). The table also reports the mean of the dependent variable computed within the interval $(-BW, 0]$ (Low Bonus).

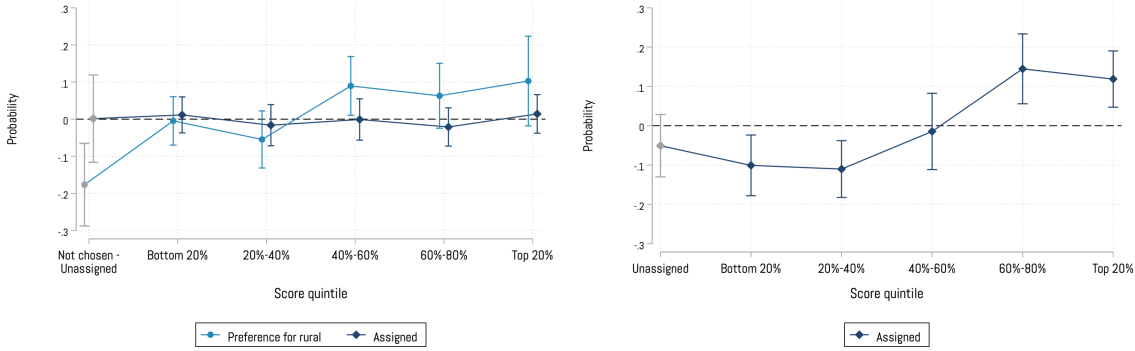
Table: Wage Increment and Student Achievement (Spanish) Back

	No vacancy	Vacancy		
	(1)	(2)	(3)	(4)
		Any vacancy	Permanent teacher	Contract teacher
High Bonus	0.001	0.327	-0.012	0.330
	(0.160)	(0.130)	(0.195)	(0.139)
Bandwidth	123.388	104.702	173.915	113.922
Schools	368	662	286	615
Observations	3916	9386	3355	8893

NOTES. This table reports the effect of crossing the population threshold on the student-level average in the 4th grade Spanish test score taken in 2018 for different sub-samples of primary schools. Each cell reports the bias-corrected regression-discontinuity estimates obtained using the robust estimator proposed by Calonico et al. (2014). Regressions are defined within a mean-square error optimal bandwidth (BW), which are reported at the bottom part of the table. The table also reports the mean of the dependent variable computed within the interval $(-BW, 0]$ (left-hand-side of the cutoff). SE are clustered at the school$\times$year level.

Figure: Wage Increment and Sorting by the Competency Score

Back



a) Permanent Teachers **b) Contract Teachers**

NOTES. Circles in panel (a) indicate the point estimates from a set of regressions where the dependent variable is either a dummy equal to one if a school was not mentioned in any application for a permanent teaching position or a set of binary indicators for whether the school was mentioned by at least a teacher whose score falls into the quintile of the test score distribution reported on the x-axis. Similarly, diamonds in panel (a) and (b) are the point estimates from a set of regressions where the dependent variable is either a dummy equal to one if a teaching position remained unfilled, or was filled by a non-qualified teacher, or a set of binary indicators for whether the vacancy is filled by a teacher whose score falls into the decile of the score distribution reported on the x-axis. Non qualified teachers are defined as teachers who did not pass the minimum required grade for a permanent position (panel a), and teachers without a score in the standardized test (panel b). Markers and vertical lines indicate the robust bias-corrected regression-discontinuity estimates and confidence interval (at the 90% level) obtained using the robust estimator proposed in Calonico et al. (2014). Regressions are defined within a mean-square error optimal bandwidth.

Table: Applicant Survey (Participation and Choice Attributes)

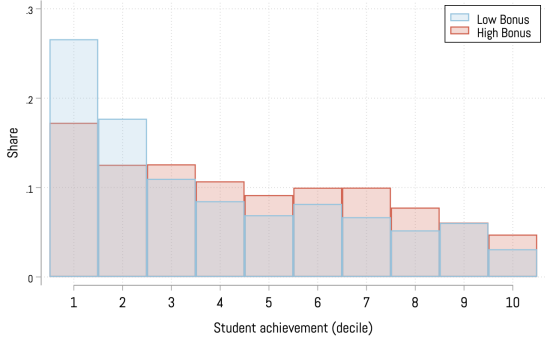
Back

	All Teachers				Score in Top Quartile			
	Rank				Rank			
	1^{st}	2^{nd}	3^{rd}	In Top 3	1^{st}	2^{nd}	3^{rd}	In Top 3
Panel A: Why did you apply to the centralized assignment mechanism? (% of respondents)								
Career	33.77	30.35	20.57	84.69	33.73	29.97	21.35	85.05
Stability	51.08	17.04	14.76	82.88	50.66	18.26	13.92	82.84
Formation Opportunities	9.63	29.15	21.81	60.59	9.57	26.73	20.32	56.62
Better Wage Opportunities	2.08	9.51	23.84	35.43	2.14	11.41	22.75	36.30
Social Benefits	1.04	7.78	7.96	16.78	1.10	7.00	7.58	15.68
Prestige	1.71	4.28	7.19	13.18	1.62	3.24	7.73	12.59
18 mil Soles Incentive	0.69	1.89	3.87	6.45	1.18	3.39	6.33	10.90
Panel B: What are the most important characteristic for your ranked choices? (% of respondents)								
Close to House	44.17	11.66	8.00	63.83	49.77	13.22	8.76	71.75
Safe	10.66	24.19	19.25	54.10	7.65	24.50	19.35	51.50
Well Connected	9.69	20.62	20.20	50.51	8.23	18.70	19.67	46.60
Prestige	17.92	14.12	12.29	44.33	21.13	15.77	12.68	49.58
Cultural Reasons	10.61	9.67	12.31	32.59	7.58	9.45	12.61	29.64
Good Infrastructure	2.02	8.40	12.86	23.28	1.81	7.23	11.83	20.87
Good Students	1.24	4.52	6.08	11.84	0.84	4.36	5.95	11.15
Possibility other Jobs	1.93	3.72	4.90	10.55	1.62	4.10	4.71	10.43
Career	1.76	3.10	4.09	8.95	1.36	2.67	4.44	8.47

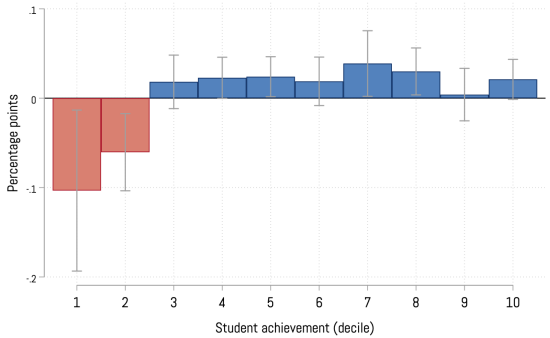
NOTES. This table displays the share of the 5,553 survey respondents that chose the corresponding answers to Question A and B. The first three columns show which answer they chose and how they ranked them (by order of importance) while column 4 shows the share of respondents that listed the corresponding choice in their top 3 reasons. The last four columns display the same results for respondents that scored above the top quartile of the test score distribution for tenured teachers.

Figure: Wage Bonus and Composition Effects on Student Achievement

Back



a. Shares at Population Cutoff

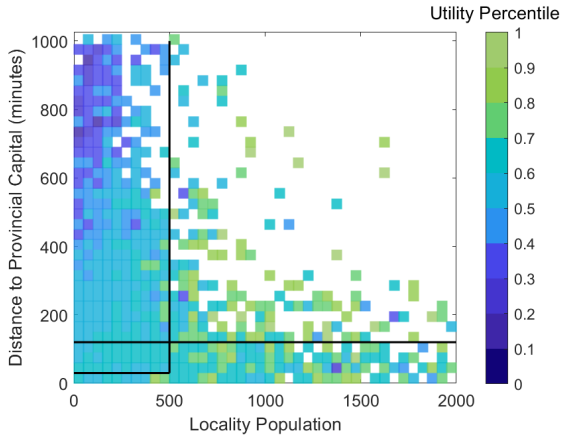


b. RD Estimates

NOTES. Panel A reports the relative shares of students by decile of the distribution of the average score in Spanish and math, separately for schools located to the right (Low Bonus) and left (High Bonus) of the population cutoff. Bars and vertical lines depicted in Panel B indicates the corresponding bias-corrected regression-discontinuity estimates of crossing the population threshold and the associated confidence intervals at the 90% level (Calonico et al., 2014) The sample includes schools with an open position for contract teachers.

Predicted Utility Without Wage Bonus

Back



- Extremely undesirable schools far from the policy cutoffs (3.5 $\times$ base wage)

School Preferences

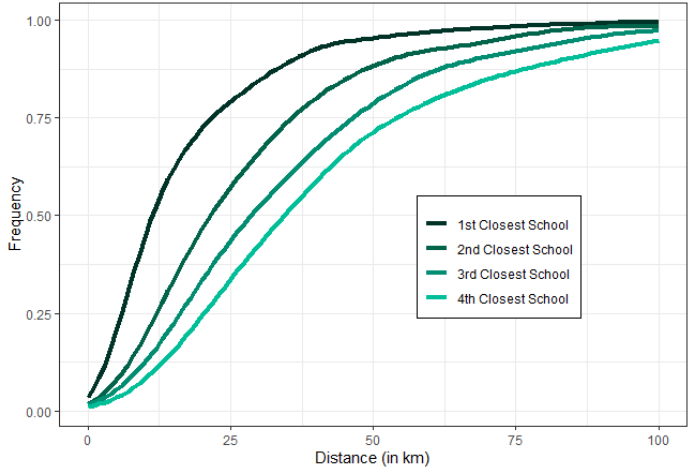
Back

(A1) For a fixed wage, we assume that schools have the same preferences as in the actual assignment mechanism. Teachers are individually ranked by test scores and the most preferred group of q teachers is the one composed of the q best scoring teachers. Schools cannot leave a vacancy empty if a teacher would be willing to fill it at that wage.

(A2) We assume that schools have lexicographic preferences when ranking two allocations with different wages. Keeping all slots empty is dominated by any other allocation at any given wage. Otherwise, schools will always prefer the allocation with the lowest wage

$\Rightarrow$ These preferences satisfy the substitute condition (Kelso-Crawford 1982, Hatfield-Milgrom 2005)

Figure: Distance from Schools Just Above the Population Cutoff Back



NOTES. This figure plots the CDF of the distance in Kilometers for the four closest below-cutoff schools from schools just above the cut-off. The sample includes schools with an open position for contract teachers during the 2015 and 2017 recruitment drives.

Table: Wage Increment and the Selection of New Entrant Teachers

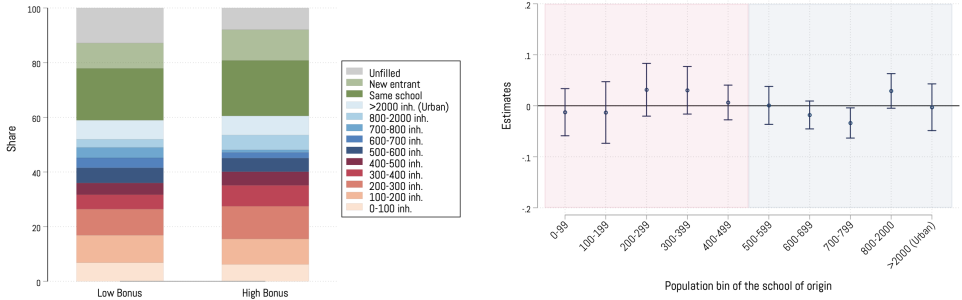
Back

	All	Age		Private sector experience	
	(1)	(2) <30	(3) ≥ 30	(4) Yes	(5) No
High Bonus	0.047	0.041	0.004	0.051	-0.003
	(0.037)	(0.017)	(0.031)	(0.028)	(0.025)
Mean dep. var. (Low Bonus)	0.156	0.032	0.126	0.092	0.065
Bandwidth	140.335	160.224	160.479	137.804	165.653
Schools	805	943	943	789	979
Observations	1927	2215	2215	1894	2289

NOTES. This table reports the effect of crossing the population threshold on the selection of new entrant teachers. In Column (1), the outcome variable is a binary indicator for whether the vacancy is filled by a teacher who was not previously teaching in any public school (new entrant teacher). In Columns (2) to (5), the outcome variable is the interaction between the new entrant indicator and a set of additional characteristics of the assigned teacher. Cells report the bias-corrected regression-discontinuity estimates obtained using the robust estimator proposed in Calonico et al (2014). Standard errors reported in parentheses are clustered at the school$\times$year level. Regressions are defined within a mean-square error optimal bandwidths, reported at the bottom part of the table. The table also reports the mean of the dependent variable computed within the interval $(-BW, 0]$.

Figure: Wage Increment and the Origin of Newly Recruited Teachers

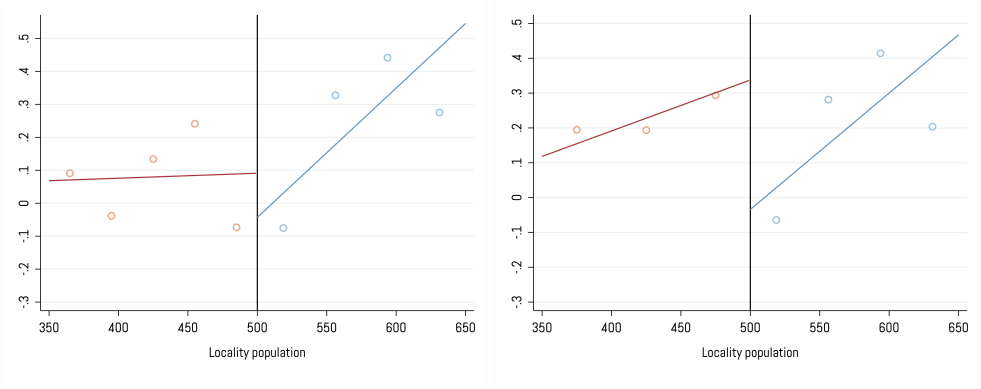
Back



a. Shares at Population Cutoff **b. RD Estimates**

NOTES. Panel A displays the relative shares (computed at the population cutoff) of the contract teachers who are assigned through the assignment mechanism based on the location of the previous schools recorded in the teacher occupation and payroll system (*NEXUS*), separately for schools located to the right (Low Bonus) and left (High Bonus) of the population cutoff. Panel B reports the effect of crossing the population threshold on the probability that the vacancy is filled by a teacher whose previous location falls into the population bin indicated in the x-axis. The sample includes all contract teacher vacancies assigned to a certified teacher in the 2015 and 2017 processes. Bars report the bias-corrected regression-discontinuity estimates along with confidence intervals at the 90% level obtained using the robust estimator proposed in Calonico et al. (2014)

Figure: Simulated Threshold-Crossing Effects With and Without Rural Bonus Back



a) Without Rural Bonus **b) With Rural Bonus**

NOTES. This figure uses simulated assignment data which is generated by running the serial dictatorship algorithm using predicting utilities computed from the estimates from Table **??** as well as a randomly drawn set of taste shocks ϵ_{ij}. The counterfactual scenario depicted in Panel A is computed assuming the presence of all the existing wage bonuses except the S/ 500 rural wage bonus for localities with population smaller than 500 inhabitants and time-t-o-travel distance to the provincial capital higher than 120 minutes.

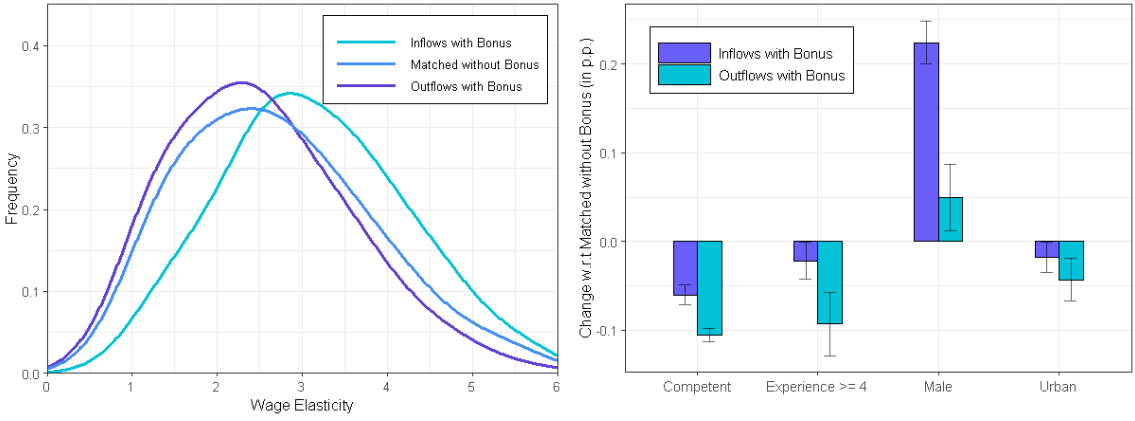
Table: Global Policy Evaluation

Back

Wage Schedule	No Bonus	Actual Policy
% Filled Schools	70.84	81.85
in Extremely Rural	55.43	75.99
in Rural	78.88	85.03
in Moderately Rural	84.73	88.36
in Urban	88.47	87.97
% Schools w. HQ Teacher	31.47	38.15
in Extremely Rural	16.39	28.36
in Rural	30.85	35.49
in Moderately Rural	40.46	44.85
in Urban	58.23	57.31
% Unassigned Teachers	90.45	88.85
% Unassig. HQ Teachers	85.28	82.28

NOTES. This table displays the matching outcomes of different allocations that would result from counterfactual wage bonus policies under the assignment mechanism currently in place in Peru. For each counterfactual scenario, it describes the matching outcome by showing, by rurality category, the share of schools with at least one filled vacancy, the share of schools with at least one high-quality teacher, and the share of teachers in the outside option.

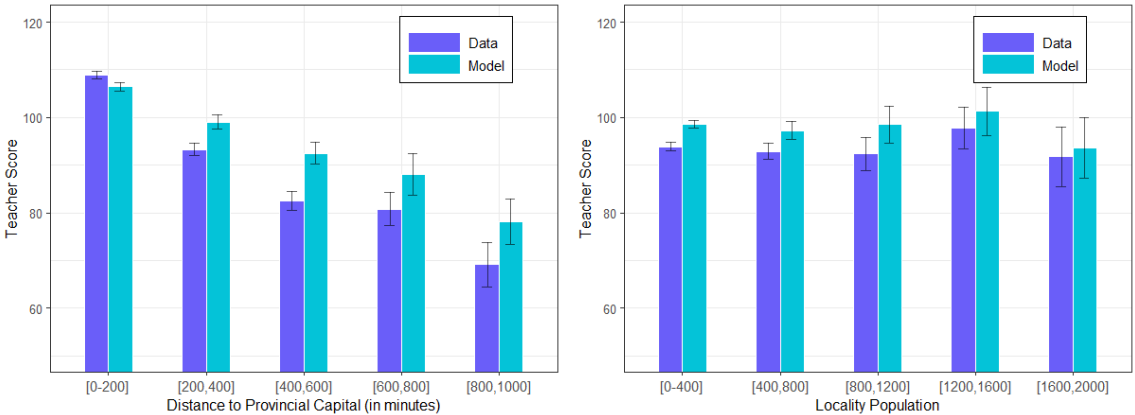
Figure: The Effect of the Wage Bonus on the Selection of Teachers Back



a) CDF of Wage Elasticities **b) Teacher Characteristics**

NOTES. Panel A of this Figure plots the PDF of the wage elasticity for the assigned teachers in the counterfactual scenario where all wage bonuses would be removed along with the distribution of the wage elasticity of the new teachers that chose to be matched rather than the outside option under the current policy. Panel B then plots the average characteristics of the individuals belonging to these two groups.

Figure: Model Fit: Teacher Score Back



NOTES. This figure uses simulated assignment data which is generated by running the serial dictatorship algorithm using predicting utilities computed from the estimates from Table **??** as well as a randomly drawn set of taste shocks ϵ_{ij}. It then compares the average score of teachers assigned to vacancies observed in the actual data and the simulated data depending on the associated school's distance to the provincial capital and locality population.

Table: Complementary Policies Back

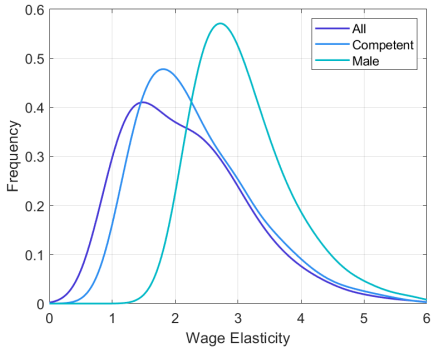
Policy Target	Fill All Schools			Fill All Schools with HQ Teachers		
Bonus Scheme	Optimal Policy	Equal Amenities	Targeted Supply Increase	Optimal Policy	Equal Amenities	Targeted Supply Increase
Total Cost (Monthly, USD)	**0.54M**	**0.37M**	**0.33M**	**4.83M**	**4.00M**	**4.71M**
Share of Total Cost						
in Rural	0.120	0.102	0.143	0.218	0.213	0.217
in Moderately Rural	0.031	0.023	0.040	0.058	0.063	0.058
in Urban	0.062	0.094	0.074	0.105	0.137	0.106

$\Rightarrow$ Investing in **local infrastructures would entail saving 20-30% of the total cost**

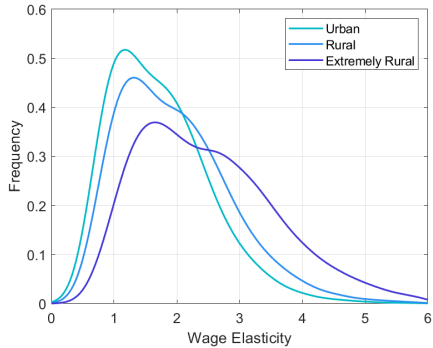
$\Rightarrow$ A **small increase in the local supply of teachers would entail saving 40% of the total cost** that is needed to fill all schools

Figure: Model Estimates: Wage Elasticities

Back Model



a) Teacher Characteristics



b) School Characteristics

NOTES: % change in in the conditional probability that teacher i chooses school j as a result of a 1% increase in wages.

Table: Counterfactual Wage Bonuses: Cost-Effectiveness Back

Policy Target		% Filled Schools = Baseline	% Schools with HQ Teachers = Baseline
Bonus Scheme	Actual Policy	Optimal Policy	Optimal Policy
Total Cost (monthly, USD)	**0.68M**	**0.16M**	**0.08M**
Share of Total Cost			
in Extremely Rural	0.794	0.848	0.867
in Rural	0.159	0.113	0.099
in Moderately Rural	0.039	0.022	0.026
in Urban	0.008	0.016	0.009

$\Rightarrow$ Optimal policy achieves the same objective of the actual policy at **23% of the total cost for vacancy filled and 12% for teacher quality**