Inducing Teacher Retention in Remote Locations: Evidence from Peru

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Introduction

Urban/Non-urban Disparities

Motivation

To what extent can governments attract and retain public workers in remote locations?

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Monetary incentives can be large

- Shortages and low quality in remote settings are still unresolved

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Ultimate goal is to improve public services in remote locations

- Educational results of students
- Health outcomes

Research Questions

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2. What characteristics enhance the efficacy of the incentives?

3. Do incentives affect the composition of teachers within schools?

Contribution

1. Construct dataset of the universe of public teachers ('13-'17) and job openings in Peru

2. New approach to study regression discontinuity designs in spatial settings

   Bayer et al. (2007) Black (1999), Dell (2010)

3. Use this approach to quantify the effect of monetary incentives

   Alva et al. (2017), Castro and Esposito (2018), Clotfelter et al. (2008)

4. Teachers' contract determine the efficacy of the monetary incentive

   $\Longrightarrow$ Permanent vs temporary

Preview of Results

- Retention of temporary teachers' increases significantly with monetary incentives

- The monetary incentives do not modify permanent teachers' behavior:
  - Job openings with a salary bonus are not more attractive
  - Retention remains similar with and without a bonus

- At the school level, the composition of teachers remains unaltered
  - Corollary: The experience of temporary teachers increases

Outline

Peruvian Education Institutional Details and Data

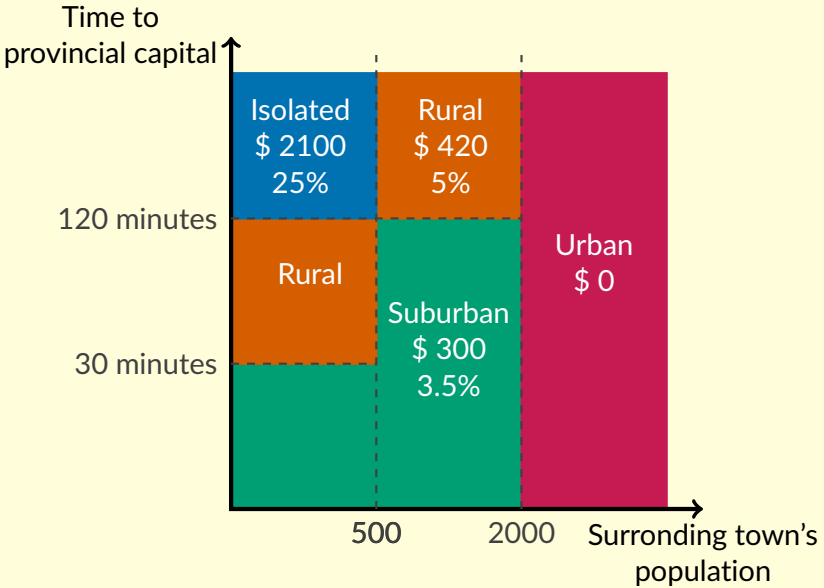
Peruvian Public Education System

- 2015: Government implemented monetary incentives aimed at remote school.
- The government spends on this program:
  - 120 million dollars
  - 5% of payroll
- The policy implemented by the government induced a quasi-experiment design:
  - (Implicit) Boundaries where created
  - On one side of the boundary teachers receive a 20% salary bonus

Contracts and wages

- Two types of contracts:
  - Permanent teachers with tenured
  - Temporary teachers with yearly contracts
- Wage structure:
  1. Permanent teachers face a 6-step base salary schedule Schedule
  2. Lowest base salary: $7,556
  3. Highest base salary: $13,219 (175% of first step)
  4. Temporary teachers receive lowest base salary ($7,556)

Bonus Structure



Treatment and Outcomes Variables

- Control: Rural ($400)
- Treatment: Isolated ($2100)
- Teacher retention:
  - Stay at a school one more year
- Teacher attraction:
  - Job opening is filled by a permanent teacher
- Teach composition:
  - Share of Permanent Teachers at the school level

Data

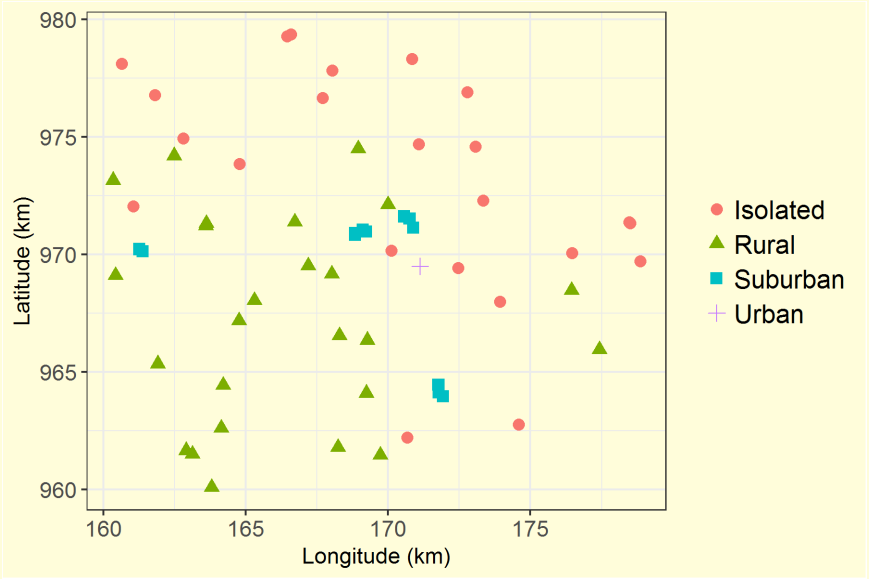
- Universe of Public Teachers
  - 2013 - 2017
  - Salary , Age, Contract type, Working location, College degree
- School data
  - School and surrounding town's characteristics
  - Average standardized test scores
- Job Openings data
  - 2015 - 2017
  - Covers 35-50% of school districts

Statistics Pre-reform (2013)

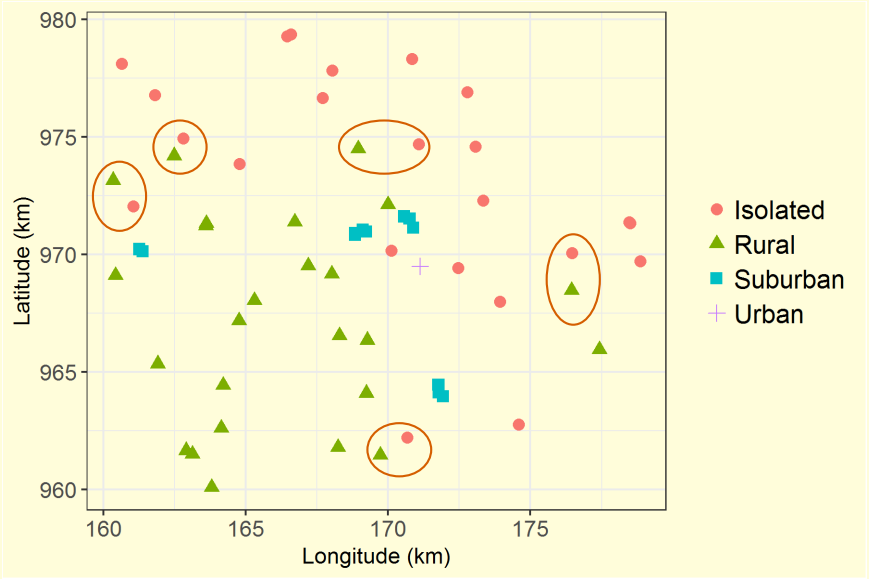
	(1) Isolated	(2) Rural	(3) Suburban	(4) Urban
Fraction of Permanent Teachers	0.63	0.74	0.81	0.80
	(0.43)	(0.38)	(0.33)	(0.32)
Retention Rate of Perm. Teachers	0.88	0.90	0.92	0.94
	(0.29)	(0.25)	(0.21)	(0.17)
Retention Rate of Temp. Teachers	0.12	0.12	0.12	0.16
	(0.30)	(0.28)	(0.27)	(0.30)
Students to Teacher Ratio	18.87	18.28	20.13	24.81
	(11.8)	(10.6)	(10.8)	(11.2)
Math Score	479.22	496.40	507.51	534.30
	(84.0)	(80.4)	(75.0)	(69.0)
Schools	10,831	12,347	7,996	13,641
Permanent Teachers	14,850	27,262	28,983	131,038
Temporary Teachers	8,569	8,401	5,367	16,776

Boundary Discontinuity Design

Unobserved Boundaries



Unobserved Boundaries



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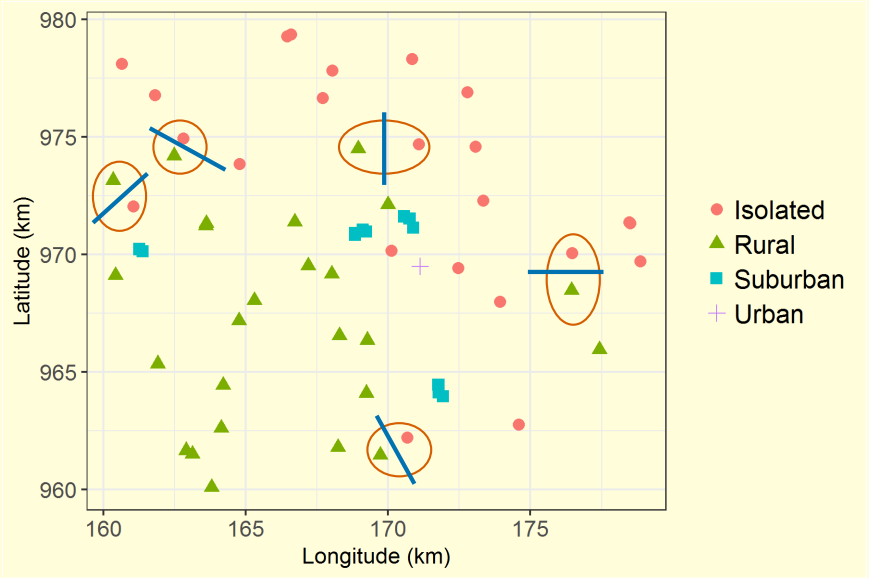

Potential Outcome Framework

Potential Outcome Framework

- Rubin (1974)
- Teacher i
- Treatment variable W_i

$$W_i = \begin{cases} 1 & \text{if teacher } i \text{ works at Isolated school} \\ 0 & \text{if teacher } i \text{ works at Rural school} \end{cases}$$

- N_1: Set of treated units
- N_0: Set of control units
- Potential outcome variable: $Y_i(1)$ (treatment) and $Y_i(0)$ (control)

Statistic of Interest

- Regression discontinuity's average treatment effect at the cutoff c for variable X

$$\text{ATET}_c = \mathbb{E}\left[Y_i(1) - Y_i(0) \middle| W_i = 1, X = c \right]$$

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$$\text{ATET}_c = \mathbb{E}\left[Y_i(1) - Y_i(0) \middle| W_i = 1, X = c \right]$$

- Average treatment effect at the boundary

$$\text{ATET}_{\mathcal{B}} = \mathbb{E}\left[Y_i(1) - Y_i(0) \middle| W_i = 1, \mathcal{B} \right]$$

where $\mathcal{B}$ is the boundary between two bonus regions

Estimator

- Researcher only observes Y_i

$$Y_i \equiv \begin{cases} Y_i(1) & \text{if } W_i = 1 \\ Y_i(0) & \text{if } W_i = 0 \end{cases}$$

- Main goal when estimating average treatment effect for the treated:

Construct an approximation $\hat{Y}_i(0)$ for treated units

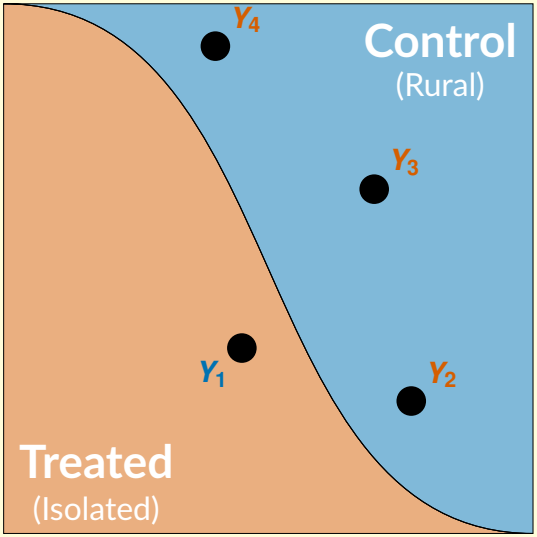
Estimator

- The $\text{ATET}_{\mathcal{B}}$ estimator

$$\widehat{\text{ATET}}_{\mathcal{B}} = \frac{1}{N_1} \sum_{i \in N_1 \cap \mathcal{B}} \left(Y_i - \hat{Y}_i(0) \right)$$

Matching Estimator

Matching Estimators

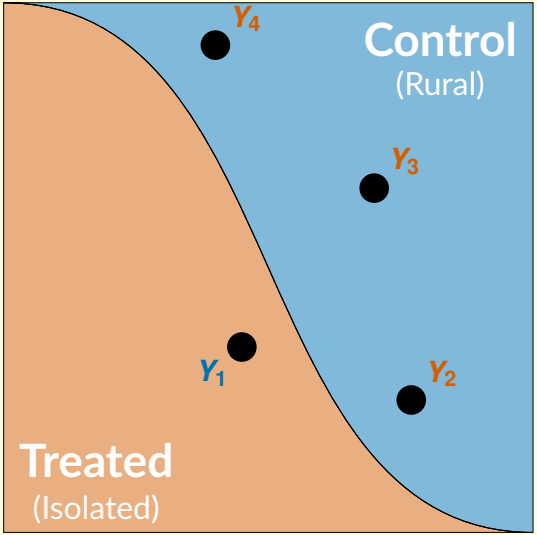


Objective

Construct a control group for Y_1

$$\hat{Y}_1(0) \equiv f(Y_2, Y_3, Y_4)$$

Matching Estimators



One-Nearest-Neighbor

$$\hat{Y}_1^{1NN}(0) = Y_2$$

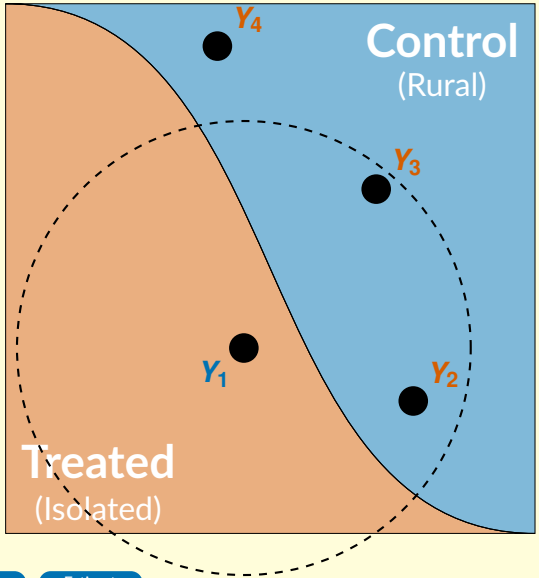
Two-Nearest-Neighbors

$$\hat{Y}_1^{2NN}(0) = \frac{1}{2}\left(Y_3 + Y_2\right)$$

Kernel ▸ Kernel

$$\hat{Y}_1^{K}(0) = \omega_{13} Y_3 + \omega_{12} Y_2$$

Matching Estimators



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$\text{ATET}_{\mathcal{B}}$

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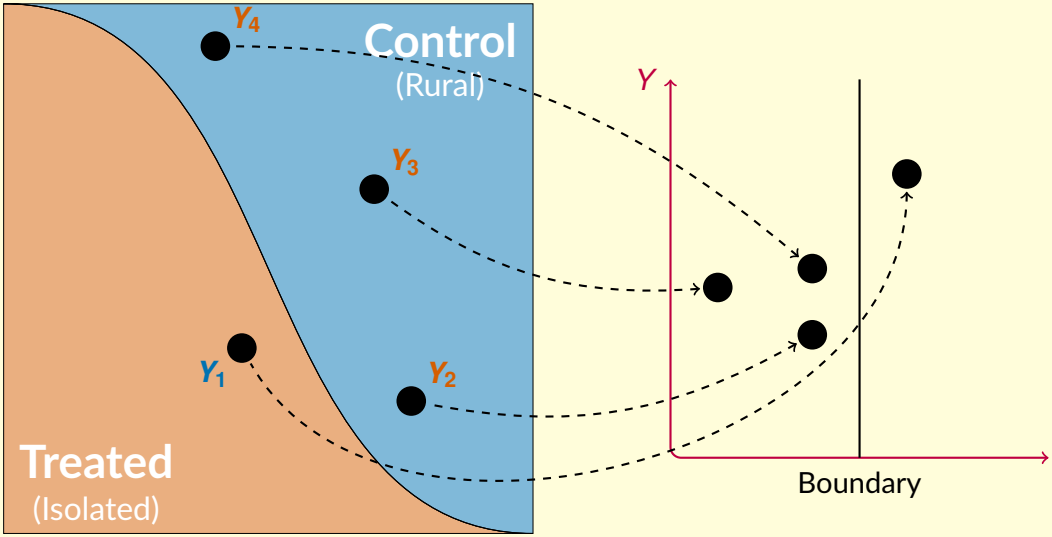
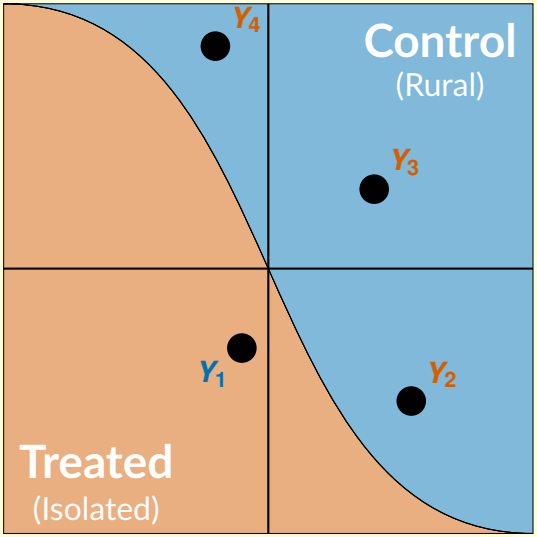
$$\widehat{\text{ATET}}_{\mathcal{B}} = \frac{1}{N_1} \sum_{i \in N_1 \cap \mathcal{B}} \left(Y_i - \hat{Y}_i(0) \right) = \begin{cases} \frac{1}{N_1} \sum_{i \in N_1 \cap \mathcal{B}} \left(Y_i - \hat{Y}_i^{1NN}(0) \right) \\ \frac{1}{N_1} \sum_{i \in N_1 \cap \mathcal{B}} \left(Y_i - \hat{Y}_i^{2NN}(0) \right) \\ \frac{1}{N_1} \sum_{i \in N_1 \cap \mathcal{B}} \left(Y_i - \hat{Y}_i^{K}(0) \right) \end{cases}$$

Regression Discontinuity



Fixed-Effects



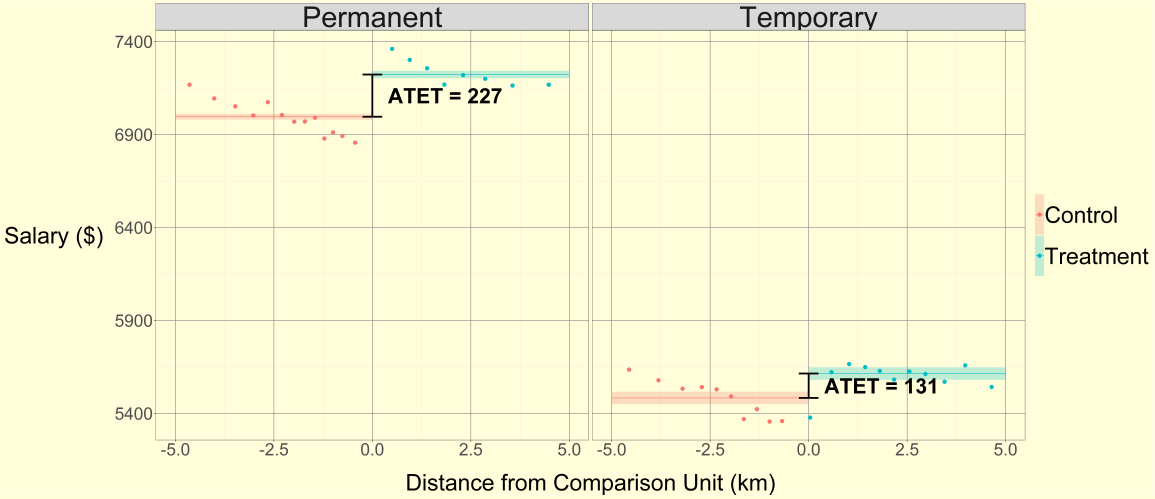
Block fixed-effects

Matching Estimators: Pros and cons

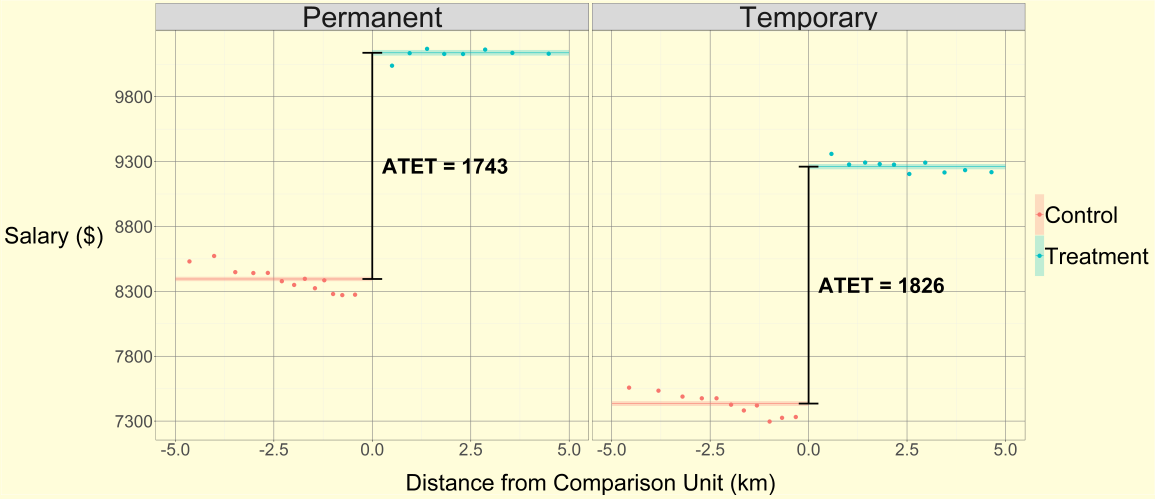
- Pros:
    1. Readily available
    2. No need to know the exact location of boundary
    3. Allows more complex distance measures (travel time)
- Cons:
    1. Only allows binary treatment
    2. Lose graphical representation

Results

Salary 2013 - Pre-reform

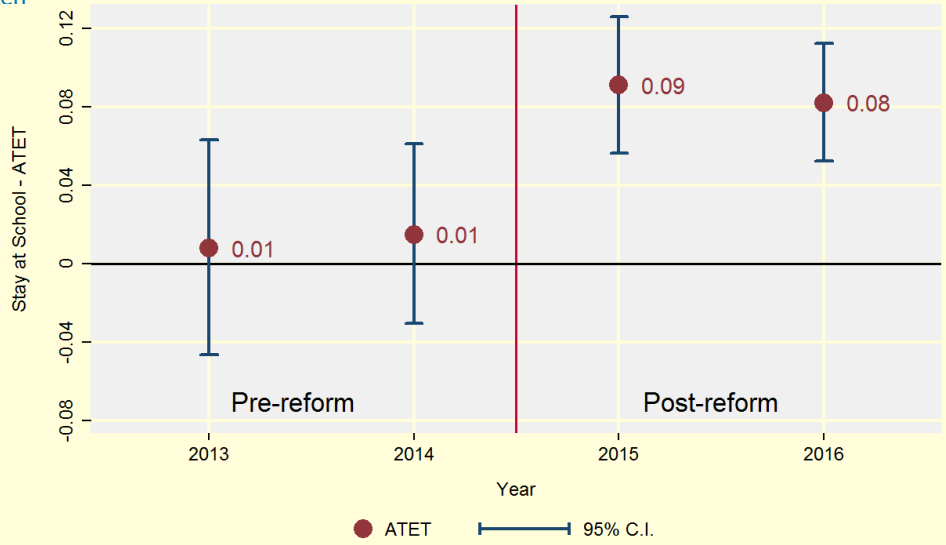


Salary 2016 - Post-reform



Teacher Retention of Temporary Teachers

Kindergarten



Teacher Retention of Permanent Teachers

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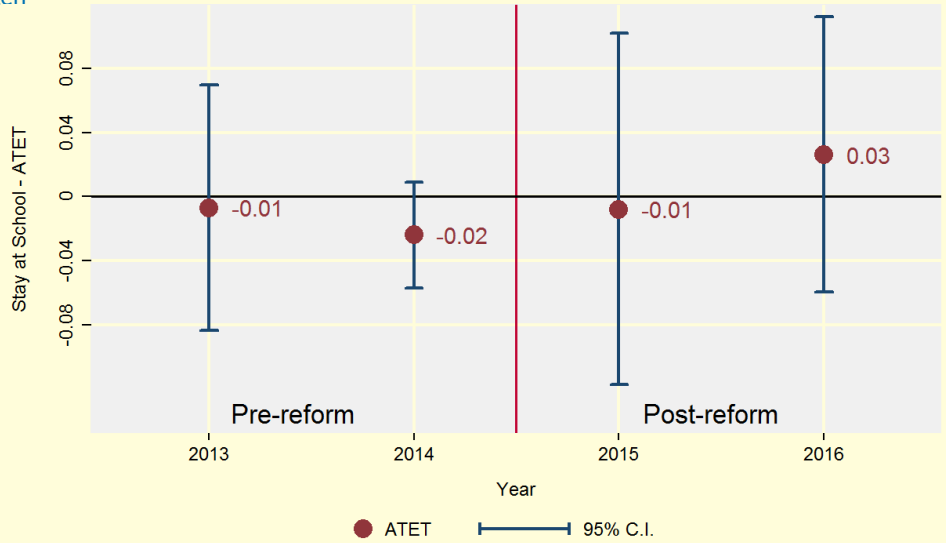
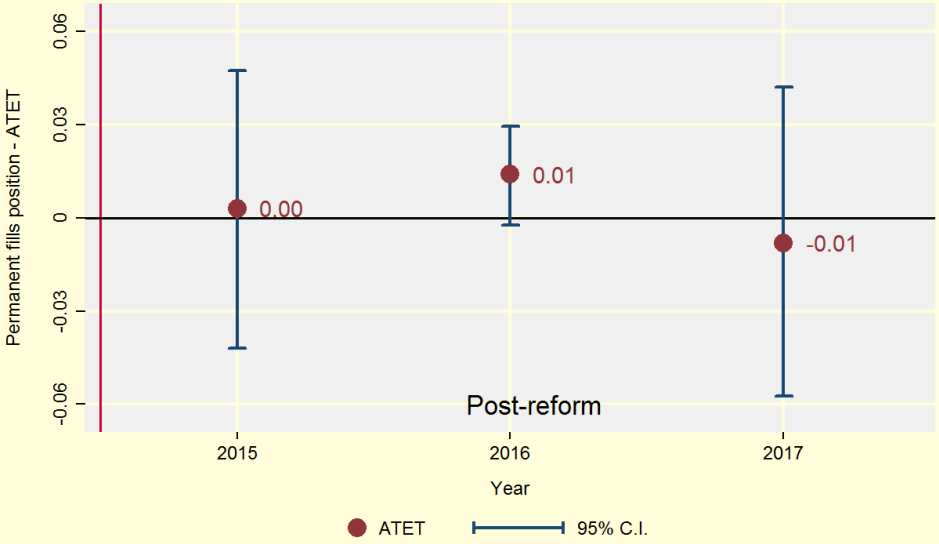


Attraction of Permanent Teachers

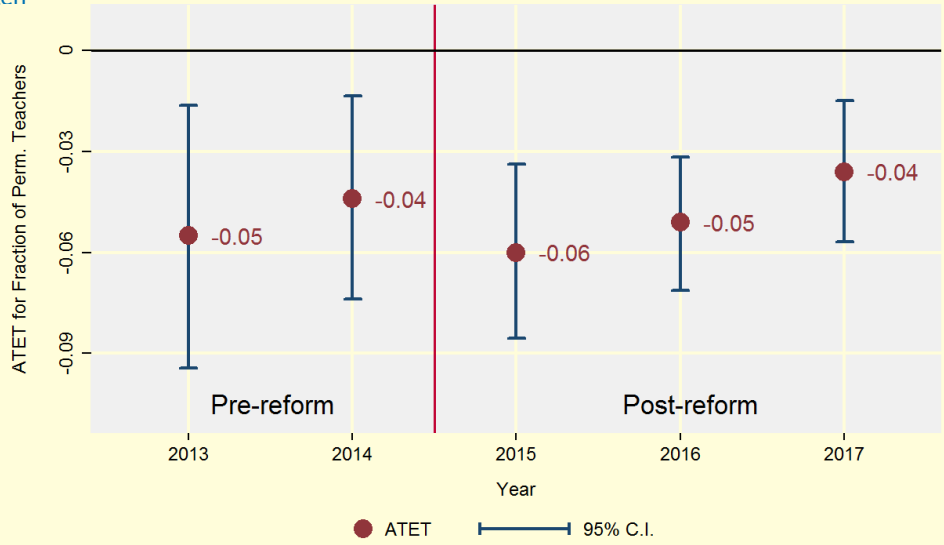
Pooled



Table

Fraction of Permanent Teachers

Kindergarten



Difference in Differences at Boundary

Kindergarten

- Control for difference in fraction of permanent teacher (F_t) before the reform

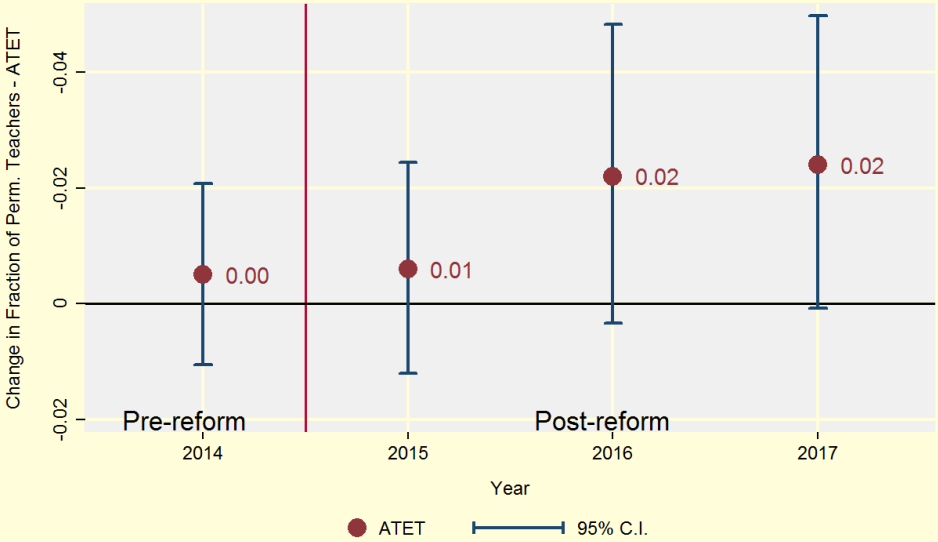
- Difference in difference at the boundary (Difference-in-Discontinuities)

- Outcome variable

$$Y_{i,t} = \Delta F_t \equiv F_t - F_{2013}$$

Difference in Differences at Boundary

Kindergarten



Robustness checks

- Matching methods
  - Kernel matching: 5, 10, 15 and 20 km bandwidths
  - Nearest-neighbor: 1 to 6 nearest-neighbors
- Three levels of education
  - Kindergarten
  - Elementary School
  - High School
- Two additional boundaries ▸ Table
  - Coca-growing region bonus boundary
  - Frontier bonus boundary
- Estimated separately by age and income groups

Interpreting retention results

Temporary Teachers in the Isolated/Rural Boundary

1. An 8 p.p. increase in retention is significant
   - It represents a 25-40% increase of temporary teachers' retention rate
2. Is it harder to obtain statistically significant results for permanent teachers?

   Back-of-the-envelope calculation
   - Retention rate for
     - Temporary teachers: 25%
     - Permanent teachers: 90%
   - $\hat{\text{ATET}}_{\mathcal{B}}$ for temporary teachers = 8 percentage points
   - Using discrete choice model for permanent teacher: $\hat{\text{ATET}}_{\mathcal{B}} = 2.4$ p.p

Limitations

- Threat to identification: Potentially stable unit treatment value assumption (SUTVA) does not hold
  - Control unit on one side of the border move towards higher bonus schools.
  - Permanent teacher would be more likely to show an effect if SUTVA did not hold
  - This threat works against my results for permanent teachers
- Higher retention rates of permanent teachers reduces power of tests

Conclusions

- Monetary incentives can significantly affect teacher retention
- The efficacy depends on the type of contract
- The incentives end up not modifying the composition of teachers within schools
- The new approach to study boundary discontinuity designs is
  - Intuitive
  - Simple to use

Policy

- It is difficult to alter permanent teachers' behavior
  - Reduce the scope of the bonus to certain age group (loan repayment)
  - Back-load bonus
  - Tie bonus to quality measures
- There are no teacher shortage problems
  - No need to provide incentives for temporary teachers

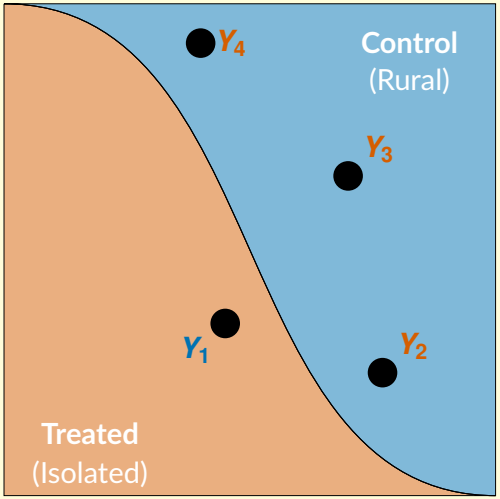
Thanks!

Salary Schedule

(1) Step	(2) Base Year Salary ($)	(3) % of First Step	(4) Distribution of Permanent Teachers	(5) Distribution of Temporary Teachers
First	7,556	100%	34%	100%
Second	8,311	110%	29%	0%
Third	9,066	120%	20%	0%
Fourth	9,821	130%	11%	0%
Fifth	11,332	150%	4%	0%
Sixth	13,219	175%	1%	0%

Back

Bias-adjustment (Abadie and Imbens, 2011)



Control for other covariates

- Age is a covariate: A_i
- Regress A_i on Y_i only within control units

$$Y_i(0) = \hat{\beta}_0 A_i + \hat{\varepsilon}_i$$

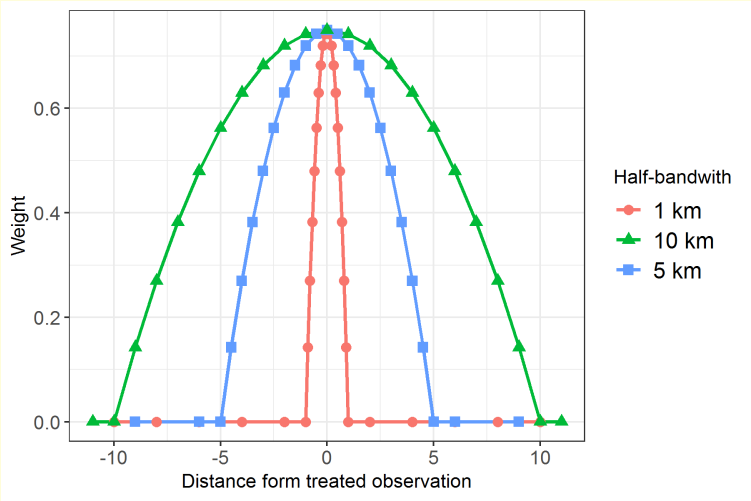
- The bias-adjusted $\hat{Y}_1^{1NN}(0)$

$$\hat{Y}_1^{1NN}(0) \equiv Y_2 - \hat{\beta}_0 A_2 + \hat{\beta}_0 A_1$$

Boundaries

Bonus	Salary Bonus	% of Lowest Base Salary	% of Highest Base Salary
Non-urban Classification			
Isolated	$2100	28.1%	18.7%
Rural	$400	5.6%	3.7%
Suburban	$300	3.9%	2.6%
VRAEM	$1300	16.8%	11.2%
Frontiers	$400	5.6%	3.7%

Figure: Epanechnikov kernel with 1 km, 5km and 10 km half-bandwidths



Back

Statistics (2013)

	(1) Isolated	(2) Rural	(3) Suburban	(4) Urban
Town's population	191.25	294.09	602.76	96,862.75
	(637.6)	(1307.4)	(1104.5)	(171590.2)
Town with water network	0.44	0.62	0.74	0.88
	(0.46)	(0.44)	(0.39)	(0.26)
Fraction of Permanent Teachers	0.63	0.74	0.81	0.80
	(0.43)	(0.38)	(0.33)	(0.32)
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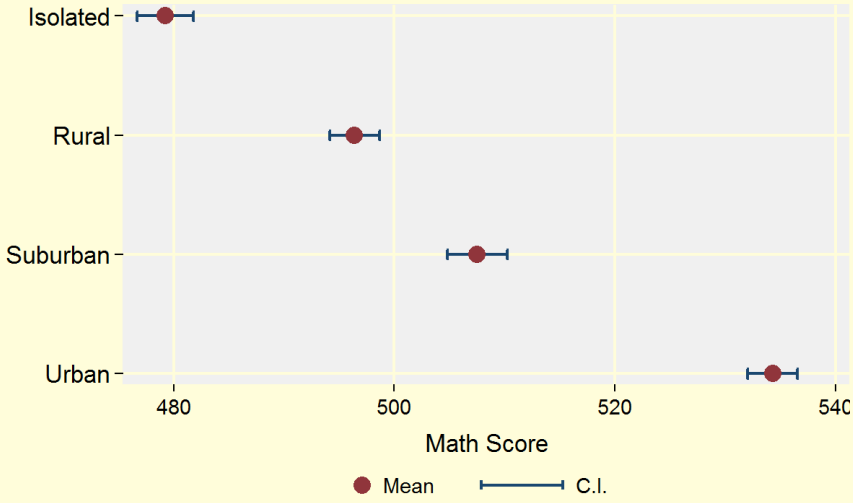
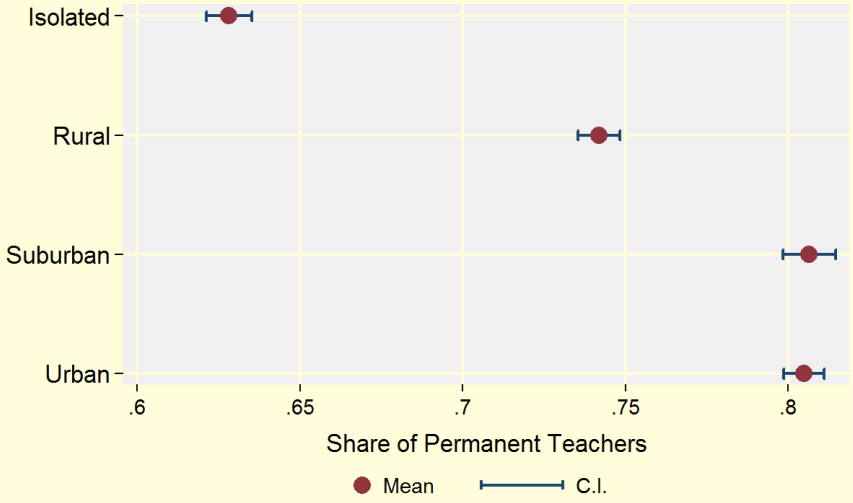
Back

Math Scores Pre-reform (2013)



Back

Share of Permanent Teachers Pre-reform (2013)



Back

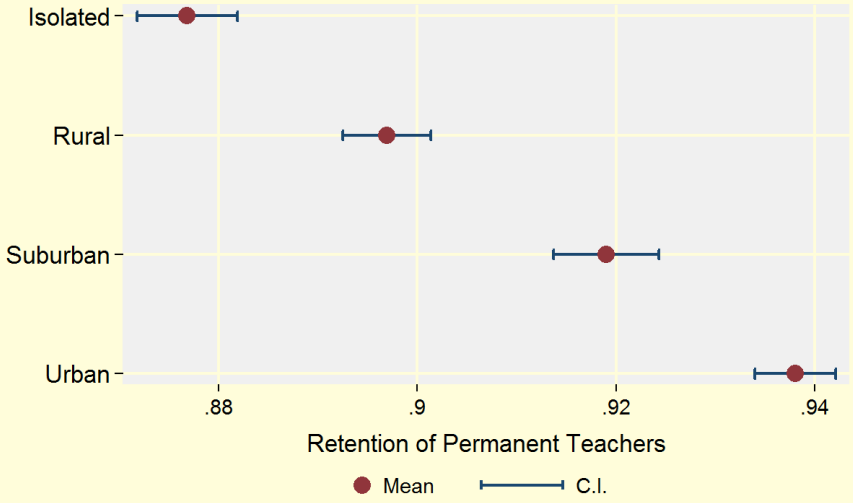
Validity Test - Pre-reform

	(1) Student to Teacher Ratio	(2) Reading Score	(3) Math Score	(4) Town with Electric service	(5) Town with Water service
ATET (Isolated vs Rural)	-0.382	-2.634	-0.729	-0.0502***	-0.0564***
s.e.	(0.29)	(3.28)	(4.37)	(0.01)	(0.01)
N	16,485	6,069	6,070.0	15,675.0	15,675.0

* p<0.05, ** p<0.01, *** p<0.001

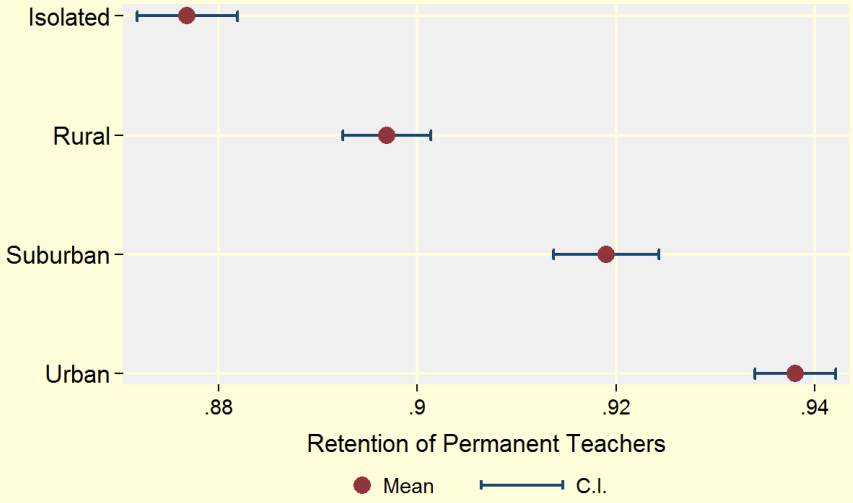
Back

Retention of Permanent Teachers Pre-reform (2013)



Back

Retention of Temporary Teachers Pre-reform (2013)



Back

Teacher Composition and Standardized Math Scores

Outcome variable: Math Scores

	(1)	(2)	(3)
Fraction of Temporary	-58.2***	-32.8***	-6.97**
	(3.84)	(1.94)	(2.51)
Constant	552.4***	547.3***	544.4***
	(1.84)	(0.79)	(0.49)
Obs	55984	55984	53165
R^2	0.10	0.28	0.66
Time FE	✓	✓	✓
School District FE		✓	
School FE			✓

Regression Discontinuity

Usual RD

$$Y_i = \beta \times \text{Treated}_i + f\left(\text{distance to boundary}_i\right) + \varepsilon_i$$

as in Michalopoulos and Papaioannou (2013) and Schumann (2014) or

$$Y_i = \beta \times \text{Treated}_i + f\left(\text{longitude}_i, \text{latitude}_i\right) + \varepsilon_i$$

as in Dell (2010).

Regression with block fixed-effects

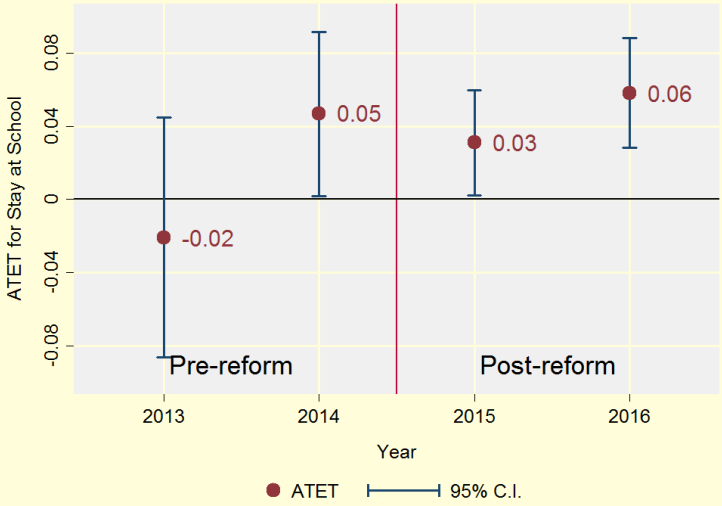
$$Y_i = \beta \times \text{Treated}_i + \xi_b + \varepsilon_i$$

where ξ_b is a X km^2 fixed-effect (Black, 1999).

Back

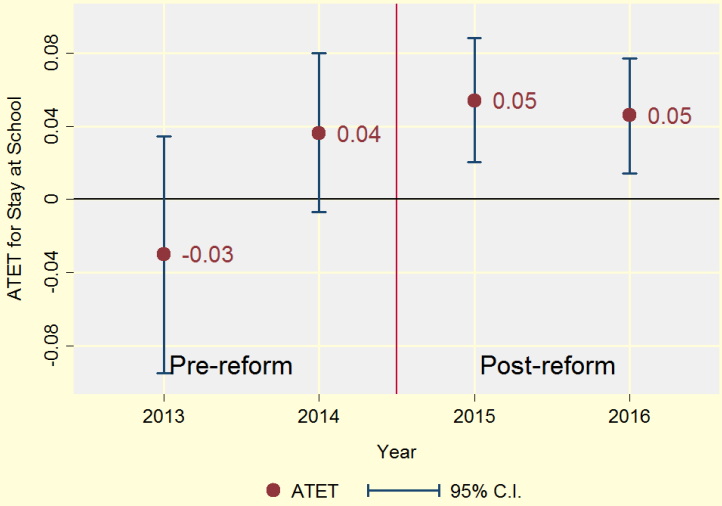
Teacher Retention of Temporary Teachers

Elementary



Teacher Retention of Temporary Teachers

High-School



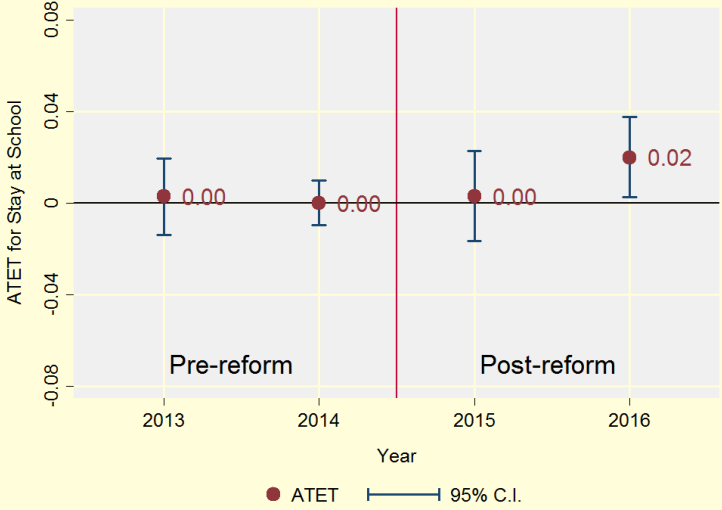
Teacher Retention of Temporary Teachers

	Pre-reform						Post-reform					
	2013			2014			2015			2016		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Kinder	Elem.	H-S	Kinder	Elem.	H-S	Kinder	Elem.	H-S	Kinder	Elem.	H-S
Kernel (b = 5km)	0.05	0.03	0.03	0.04	0.06	0.05	0.10***	0.03	0.05	0.07**	0.06**	0.02
	(0.04)	(0.05)	(0.04)	(0.03)	(0.03)	(0.03)	(0.03)	(0.02)	(0.03)	(0.02)	(0.02)	(0.02)
Kernel (b = 10km)	0.01	-0.02	-0.03	0.02	0.05*	0.04	0.09***	0.03*	0.05**	0.08***	0.06***	0.05**
	(0.03)	(0.03)	(0.03)	(0.02)	(0.02)	(0.02)	(0.02)	(0.01)	(0.02)	(0.02)	(0.01)	(0.02)
Kernel (b = 15km)	0.02	-0.03	-0.00	0.00	0.02	0.03	0.09***	0.03*	0.05***	0.09***	0.06***	0.06***
	(0.02)	(0.03)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Obs (b = 5km)	609	582	637	1,561	1,189	1,451	1,828	2,334	1,912	2,780	3,434	2,814
Obs (b = 10km)	1,375	1,388	1,657	3,100	2,824	3,654	3,617	4,872	4,742	5,377	7,091	6,877
Obs (b = 15km)	1,914	1,942	2,470	3,977	3,869	5,159	4,535	6,242	6,679	6,809	9,116	9,677
Sample Share (b = 5)	0.22	0.20	0.15	0.30	0.22	0.18	0.32	0.28	0.19	0.32	0.29	0.19
Sample Share (b = 10)	0.51	0.47	0.38	0.60	0.51	0.45	0.63	0.59	0.46	0.62	0.61	0.47
Sample Share (b = 15)	0.70	0.66	0.56	0.77	0.70	0.63	0.79	0.76	0.65	0.79	0.78	0.67
Base Retention Rate	0.16	0.16	0.23	0.26	0.23	0.33	0.15	0.12	0.19	0.24	0.25	0.31

* p<0.05, ** p<0.01, *** p<0.001

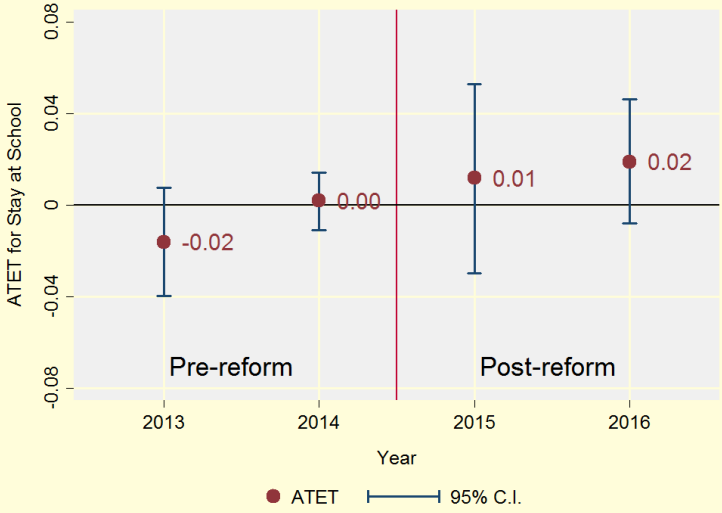
Teacher Retention of Permanent Teachers

Elementary



Teacher Retention of Permanent Teachers

High-School



Teacher Retention of Permanent Teachers

	Pre-reform						Post-reform					
	2013			2014			2015			2016		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Kinder	Elem.	H-S	Kinder	Elem.	H-S	Kinder	Elem.	H-S	Kinder	Elem.	H-S
Kernel (b = 5km)	-0.01	0.00	-0.01	-0.03	-0.00	0.01	0.05	0.02	0.01	-0.01	0.03*	0.05
	(0.05)	(0.01)	(0.02)	(0.03)	(0.01)	(0.01)	(0.09)	(0.01)	(0.03)	(0.06)	(0.01)	(0.03)
Kernel (b = 10km)	-0.01	0.00	-0.02	-0.02	0.00	0.00	-0.01	0.00	0.01	0.03	0.02*	0.02
	(0.04)	(0.01)	(0.01)	(0.02)	(0.00)	(0.01)	(0.06)	(0.01)	(0.02)	(0.05)	(0.01)	(0.01)
Kernel (b = 15km)	-0.04	-0.00	-0.01	-0.01	0.00	-0.01	-0.04	0.00	0.01	0.00	0.02	0.01
	(0.03)	(0.01)	(0.01)	(0.02)	(0.00)	(0.01)	(0.04)	(0.01)	(0.02)	(0.03)	(0.01)	(0.01)
Obs (b = 5km)	280	9,171	1,767	243	8,706	1,662	232	8,383	1,620	220	7,394	1,463
Obs (b = 10km)	622	15,912	4,623	555	14,912	4,354	551	14,287	4,260	465	13,491	3,852
Obs (b = 15km)	869	19,200	6,887	788	18,041	6,420	784	17,283	6,294	710	17,067	5,859
Sample Share (b = 5)	0.16	0.39	0.15	0.15	0.40	0.16	0.14	0.40	0.16	0.14	0.34	0.14
Sample Share (b = 10)	0.35	0.68	0.40	0.34	0.68	0.41	0.34	0.68	0.41	0.29	0.63	0.38
Sample Share (b = 15)	0.49	0.82	0.60	0.49	0.82	0.61	0.49	0.82	0.61	0.44	0.79	0.57
Base Retention Rate	0.83	0.93	0.89	0.97	0.97	0.98	0.72	0.87	0.74	0.91	0.92	0.91

* p<0.05, ** p<0.01, *** p<0.001

Teacher Attraction of Permanent Teachers

	Post-reform		
	(1)	(2)	(3)
	2015	2016	2017
Kernel (b = 10km)	0.00	0.01	-0.01
	(0.02)	(0.01)	(0.03)
Kernel (b = 15km)	0.00	0.01	-0.01
	(0.02)	(0.01)	(0.02)
Kernel (b = 20km)	-0.02	0.00	-0.03
	(0.02)	(0.01)	(0.02)
Obs (b = 10km)			
Obs (b = 15km)	1,471	6,515	1,413
Obs (b = 20km)	1,931	8,036	1,798
Sample Share (b = 5)			
Sample Share (b = 10)	0.49	0.62	0.59
Sample Share (b = 15)	0.64	0.76	0.75
Base Attraction Rate	0.26	0.095	0.15

Fraction of Permanent Teachers

	Pre-reform						Post-reform								
	2013			2014			2015			2016			2017		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
	Kinder	Elem.	H-S	Kinder	Elem.	H-S	Kinder	Elem.	H-S	Kinder	Elem.	H-S	Kinder	Elem.	H-S
Kernel (b = 5km)	-0.02	-0.05***	-0.02	-0.04*	-0.06***	-0.08*	-0.06**	-0.06***	-0.05	-0.05***	-0.05***	-0.06*	-0.03*	-0.00	-0.04
	(0.03)	(0.01)	(0.04)	(0.02)	(0.01)	(0.03)	(0.02)	(0.01)	(0.03)	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.02)
Kernel (b = 10km)	-0.06**	-0.04***	-0.06*	-0.04**	-0.07***	-0.09***	-0.06***	-0.07***	-0.06***	-0.05***	-0.08***	-0.07***	-0.04***	-0.04**	-0.05***
	(0.02)	(0.01)	(0.02)	(0.02)	(0.01)	(0.02)	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)
b20	-0.05**	-0.05***	-0.08***	-0.06***	-0.08***	-0.11***	-0.07***	-0.08***	-0.08***	-0.06***	-0.10***	-0.09***	-0.06***	-0.06***	-0.08***
	(0.02)	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Obs (b = 5km)	1,447	5,458	497	2,450	5,864	600	2,552	5,922	625	3,455	5,618	678	3,491	5,741	689
Obs (b = 10km)	2,949	9,409	1,292	4,725	10,085	1,544	4,899	10,172	1,612	6,475	10,352	1,733	6,538	10,608	1,766
Obs (b = 15km)	4,252	12,237	2,277	6,584	13,002	2,595	6,703	13,097	2,682	9,031	14,115	2,944	9,174	14,411	3,002
Sample Share (b = 5)	0.28	0.40	0.16	0.33	0.41	0.18	0.33	0.41	0.18	0.34	0.35	0.17	0.34	0.35	0.17
Sample Share (b = 10)	0.58	0.70	0.42	0.63	0.70	0.45	0.64	0.70	0.46	0.63	0.65	0.44	0.63	0.65	0.45
Sample Share (b = 15)	0.84	0.90	0.74	0.88	0.90	0.76	0.87	0.90	0.77	0.88	0.89	0.75	0.88	0.89	0.76
Base Retention Rate	0.38	0.89	0.71	0.24	0.84	0.55	0.23	0.74	0.46	0.17	0.70	0.39	0.16	0.68	0.36

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