Dynamic Impacts of School-based Internet Access on Student Learning: Evidence from Peruvian Public Primary Schools Online Appendix[*]
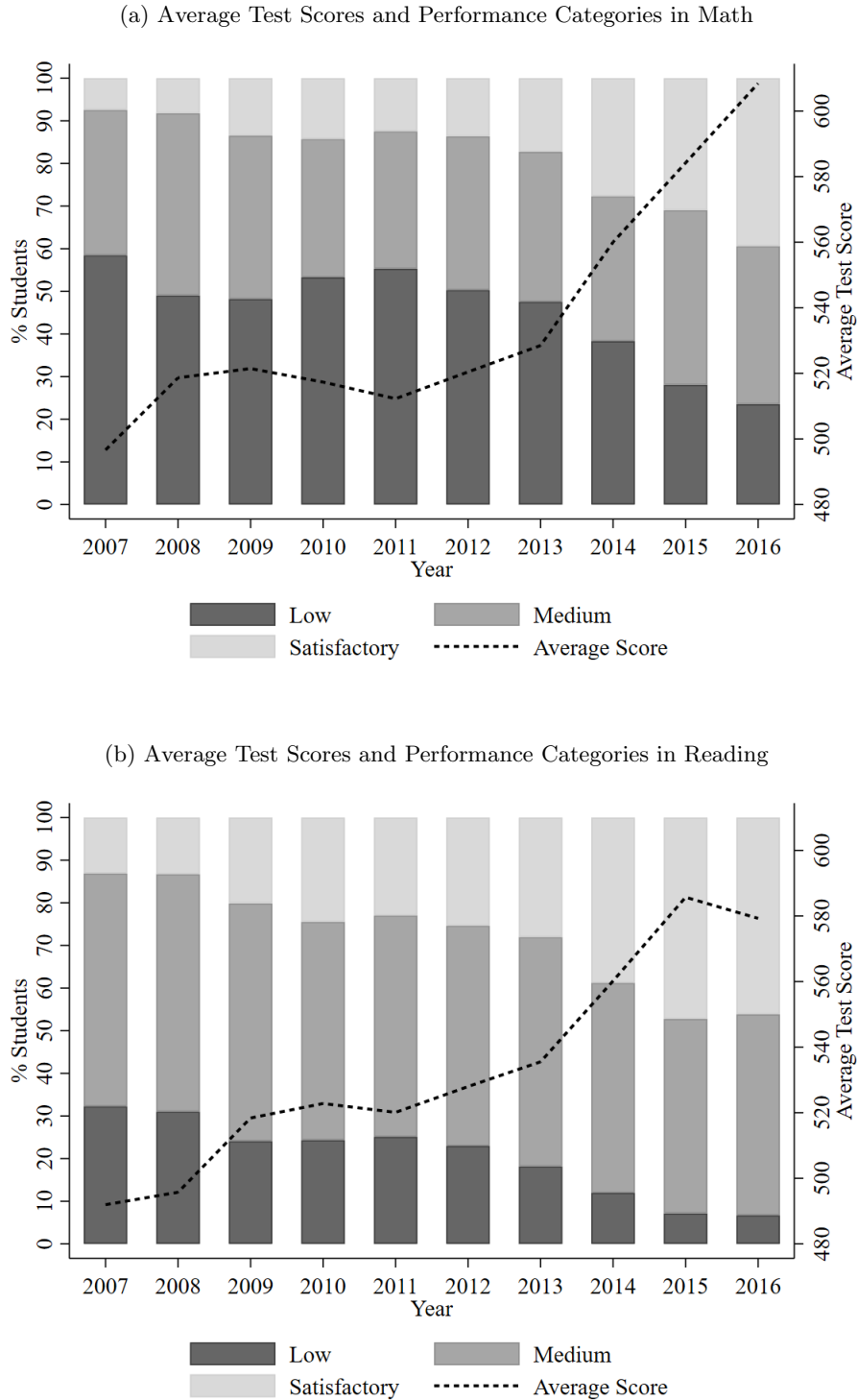
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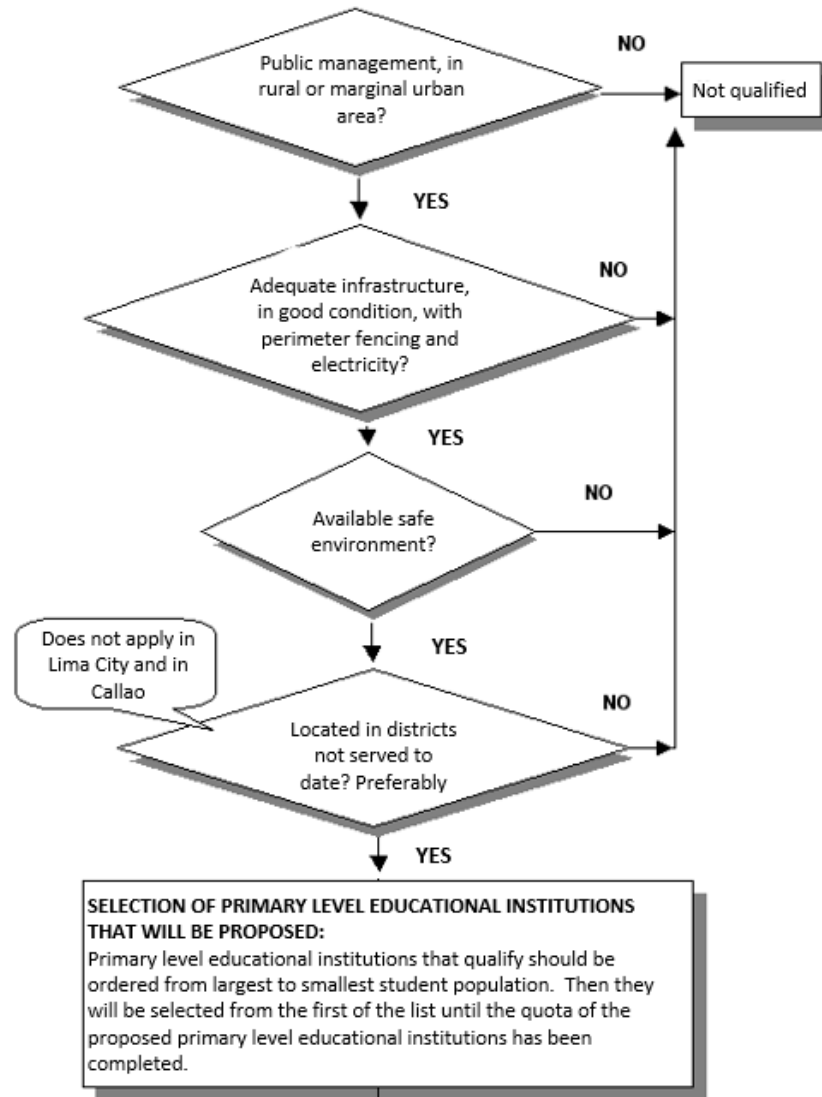
1   Appendix Figures and Tables

Figure A.1: Performance of Grade 2 Students in Public Schools on the ECE (2007-2014)

(a) Average Test Scores and Performance Categories in Math

(b) Average Test Scores and Performance Categories in Reading

Source: Peru Ministry of Education (MINEDU)

Figure A.2: Translated Excerpt of Flow Chart for Prioritization under *Plan Huascarán*

Figure A.3: Translated School Data Sheet for *Plan Huascarán*

ANNEX N ° 2

| DATA SHEET OF THE EDUCATIONAL INSTITUTION			
Name of Educational Institution			
School Site Code			
Address			
Department			
Province			
District			
Town Center			
Phone			
Principal's name			
Direct intermediary body			
Geographical area (urban, rural)			
Type of Management (State, Parish, Cooperative, Supervised, etc.)			
Number of computers for school use (only Pentium I or more)			
Number of computers for administrative use (only Pentium I or more)			
Do you have electricity?			
Number of hours of electricity			
Number of students and teachers per level		Students	Teachers
Initial			
Primary			
High school			
Number of students and teachers per shift		Sections	
Morning			
Late			
Night			
Number of sections per shift		Sections	
Morning			
Late			
Night			
Number of sections per level		Students	Teachers
Initial			
Primary			
High school			
Is there home-based telephone in the locality?			
Native language of students			
Distance to the nearest Huascarán Program educational institution			

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Figure A.4: Schools and Students in ECE, 2007-2014

(a) Primary Schools tested in ECE
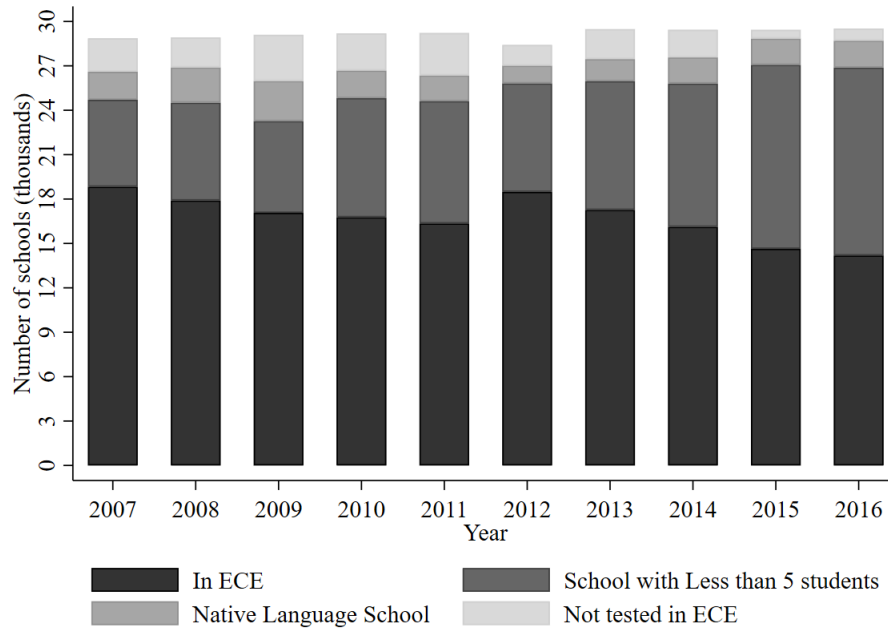
(b) Primary Students tested in ECE
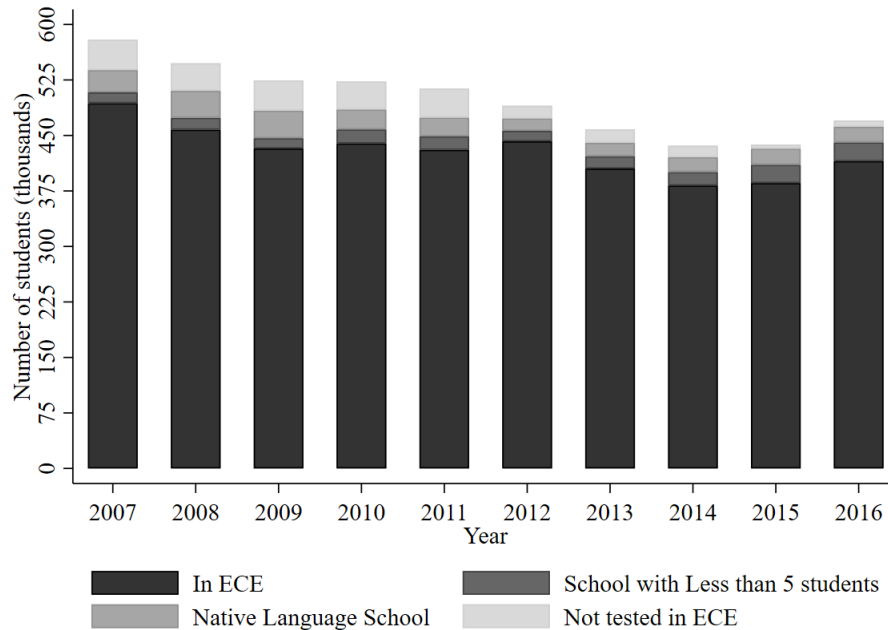
Source: Authors' calculations based on the Peruvian *Censo Escolar* (CE) and *Evaluacion Censsal de Estudiantes* (ECE), 2007-2016.
* Note: Some schools both have fewer than five second graders and teach primarily in native languages. For simplicity, the graph includes these under "Fewer than five students."

Figure A.5: Standardized Math Scores over Time, by Year of Initial School Access
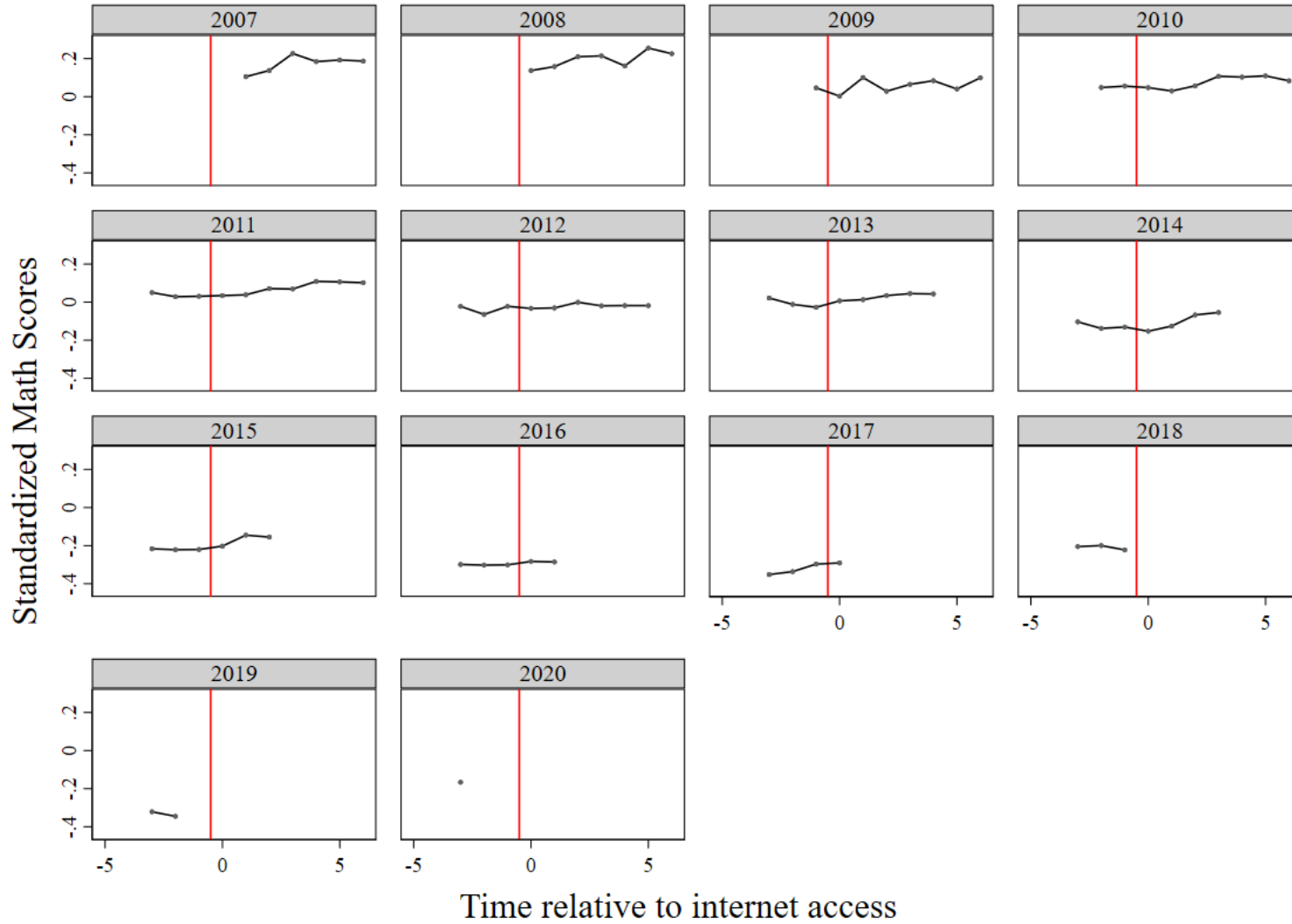
This figure plots the standardized test scores against time relative to internet access, separately for by the year of initial internet connection.

Figure A.6: Standardized Reading Scores over Time, by Year of Initial School Access
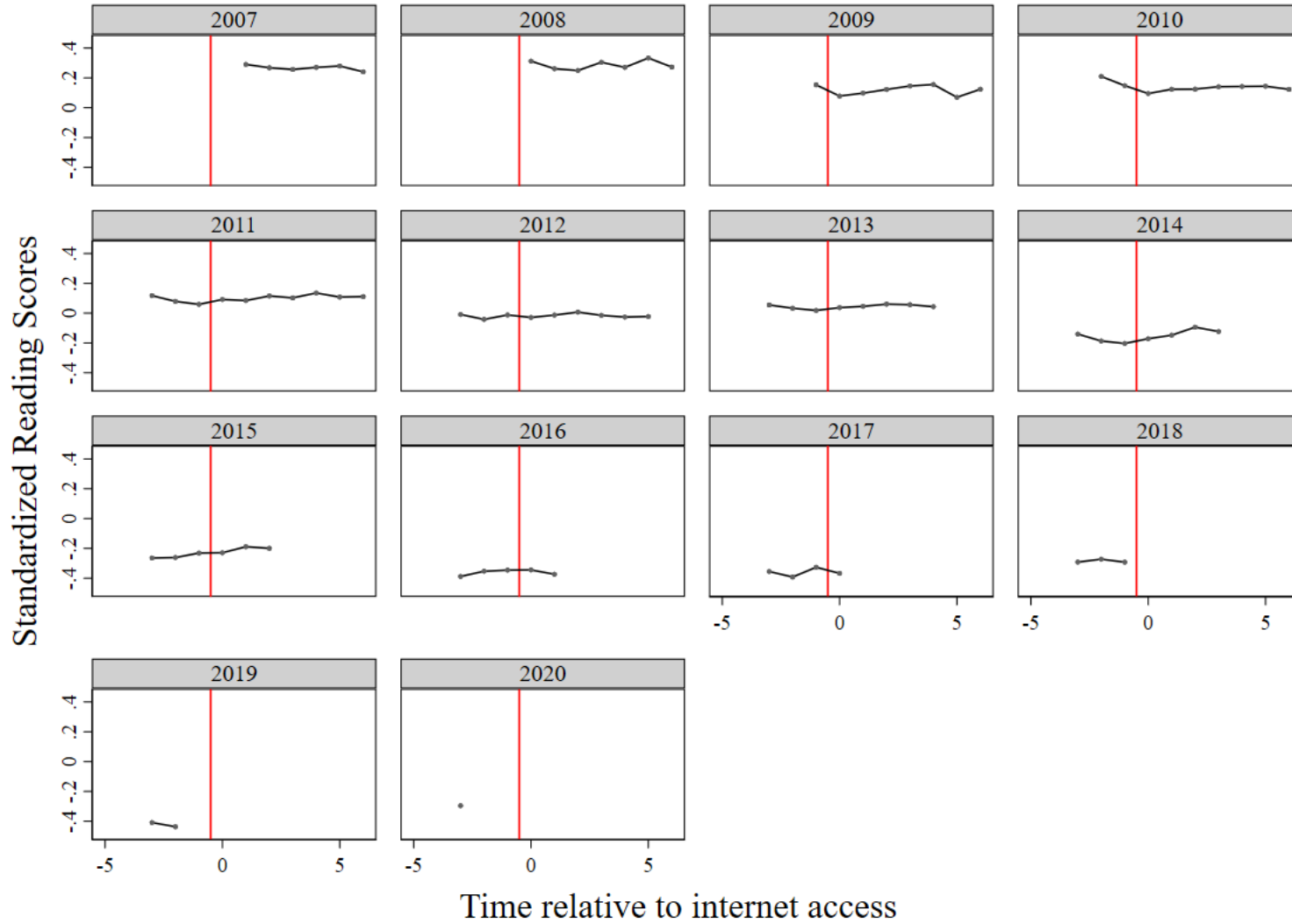
This figure plots the standardized test scores against time relative to internet access, separately for by the year of initial internet connection.

Figure A.7: Standardized Test Scores over Time in Schools Installing Internet before 2007 and in Schools without Access by 2020

(a) Math: Schools with Access before 2007

(b) Reading: Schools with Access before 2007

(c) Math: Schools without Access by 2020

(d) Reading: Schools without Access by 2020
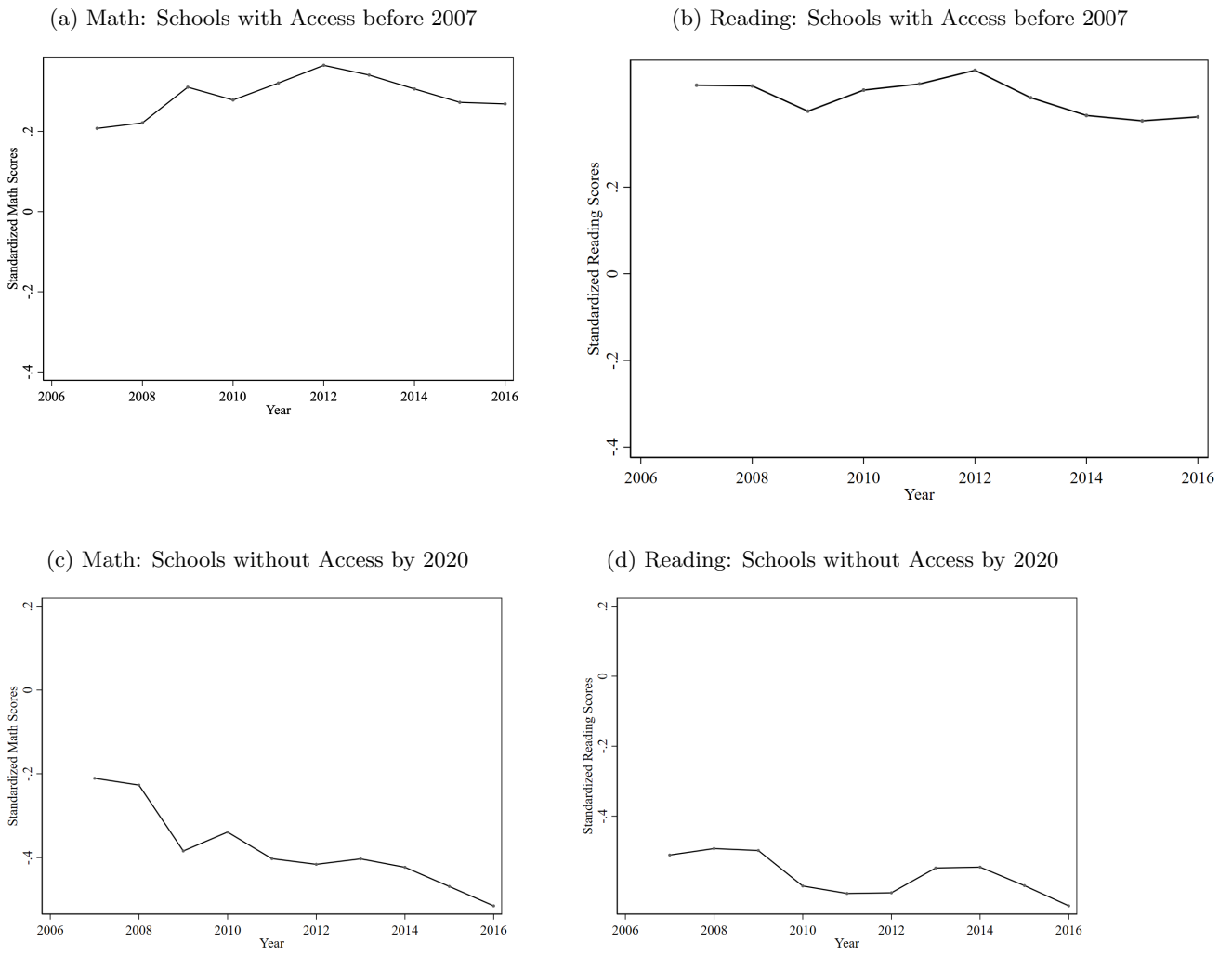
Figures A.7a and A.7b plot the standardized test scores for students from all public schools that had an internet connection prior to 2007. Figures A.7c and A.7d plot the standardized test scores for students from all public schools that had not been connected to the internet as of 2020.

Figure A.8: Randomization Exercise

(a) Standardized Math Scores
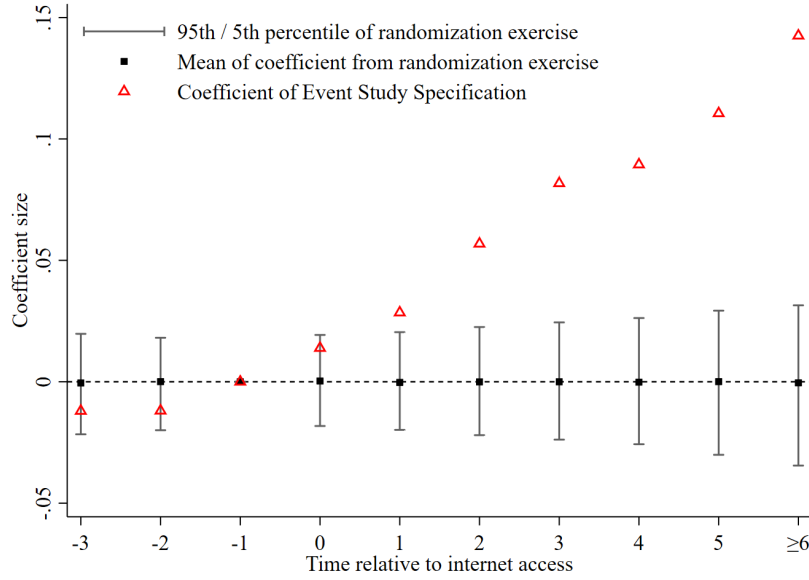
(b) Standardized Reading Scores
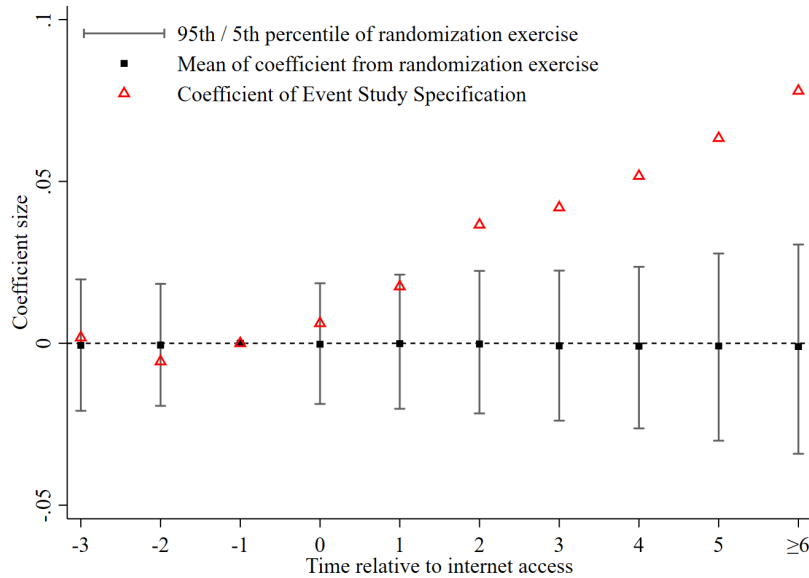
These figures plots the median as well as the 5th and 95th percentile of the coefficients from the following placebo test: We randomly reassign internet installation years to schools in our sample (including non-adoption), maintaining the actual distribution of installation years and thus ensuring that the sample sizes of each of our "treatment cohorts" matches our baseline specification. We then use the randomly assigned installation years to generate the false event study variables and estimate equation 1. We repeat this process 500 times. For reference, we also plot the estimates from our baseline specification (equation 1). Control variables include sex, class size, indicator variables for the number of 2nd grade classes at the school, total school enrollment, number of second grade students that took the ECE, facilities (computer room, library, administrative offices), resources per student (classrooms, computers, and teachers), UGEL-specific enrollment tercile by year fixed effects, and school fixed effects. The sample includes all grade 2 students in all public schools that gain internet between 2007 and 2020 or remain unconnected by 2020. Standard errors are clustered by school.

Figure A.9: Effect of Internet Access in Schools Connected between 2009 and 2015: Event Study Results
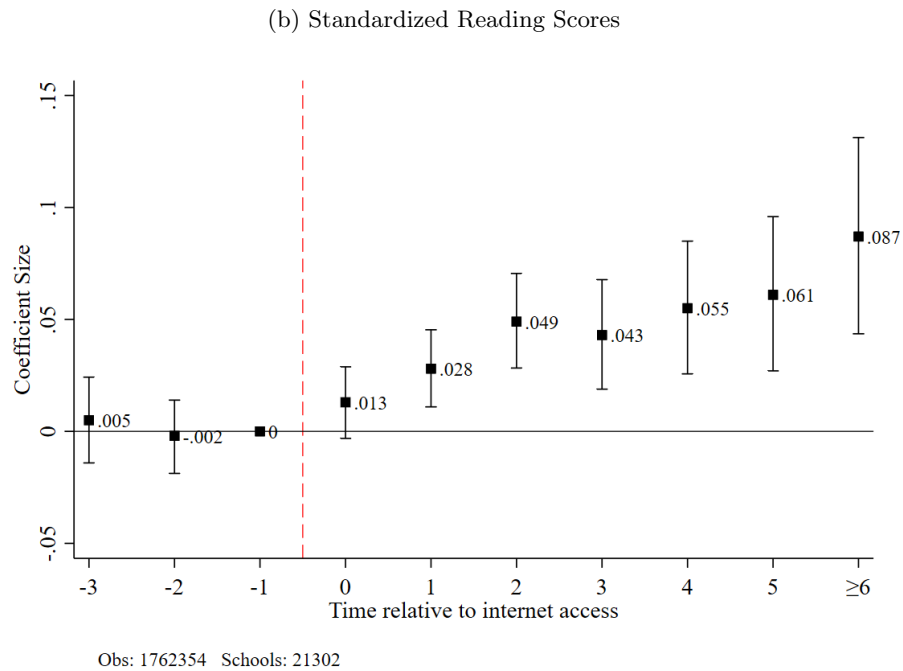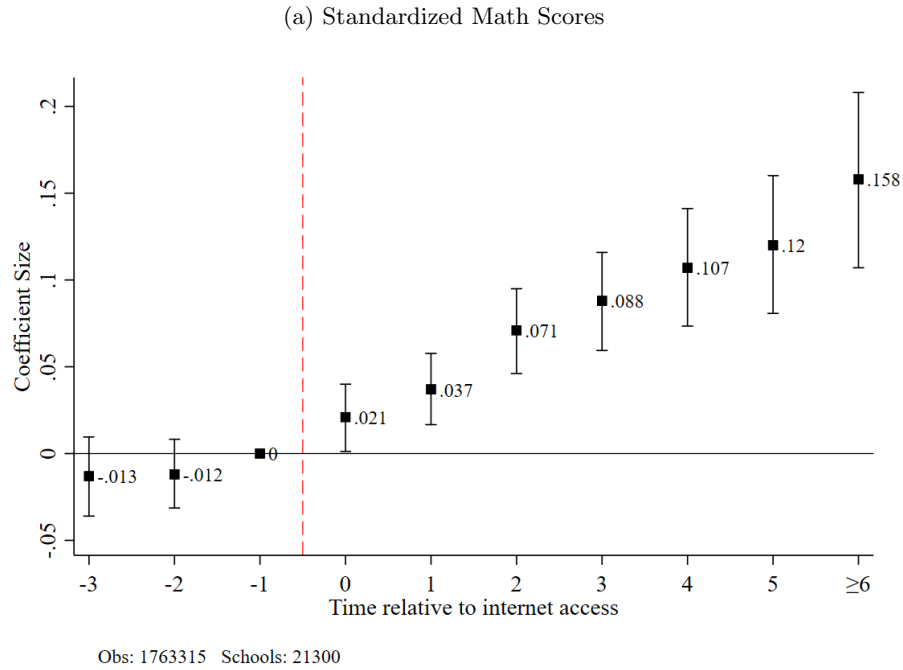
(a) Standardized Math Scores

Obs: 1763315   Schools: 21300

(b) Standardized Reading Scores

Obs: 1762354   Schools: 21302

The sample includes all grade 2 students from all public schools that gain internet between 2009 and 2015 (i.e. observed at least twice prior to and twice after installing internet) or remain unconnected by 2020. Scores are standardized within each calendar year to have mean zero and standard deviation of one across the universe of test takers in public schools. Due to the timing of the *Censo Escolar* relative to the ECE exam, some schools receive internet access in $t = 0$ and some receive it in $t = 1$. Control variables include sex, class size, indicator variabes for the number of 2nd grade classes at the school, total school enrollment, number of second grade students that took the ECE, facilities (computer room, library, administrative offices), resources per student (classrooms, computers, and teachers), UGEL-specific enrollment tercile by year fixed effects, and school fixed effects. Standard errors are clustered by school.

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Figure A.10: Effect of Internet Access in the Sample of Schools Observed in All Calendar Years
2007-2016: Event Study Results

(a) Standardized Math Scores

Obs: 985819   Schools: 3868

(b) Standardized Reading Scores
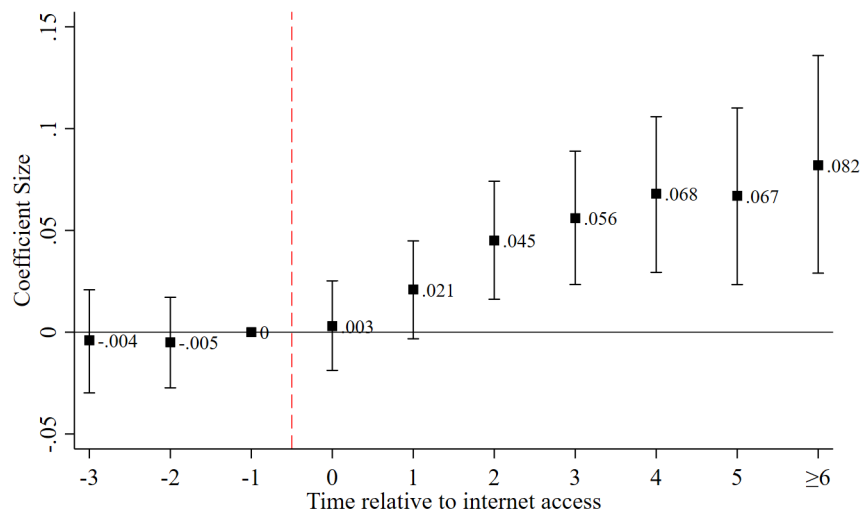
Obs: 988337   Schools: 3875

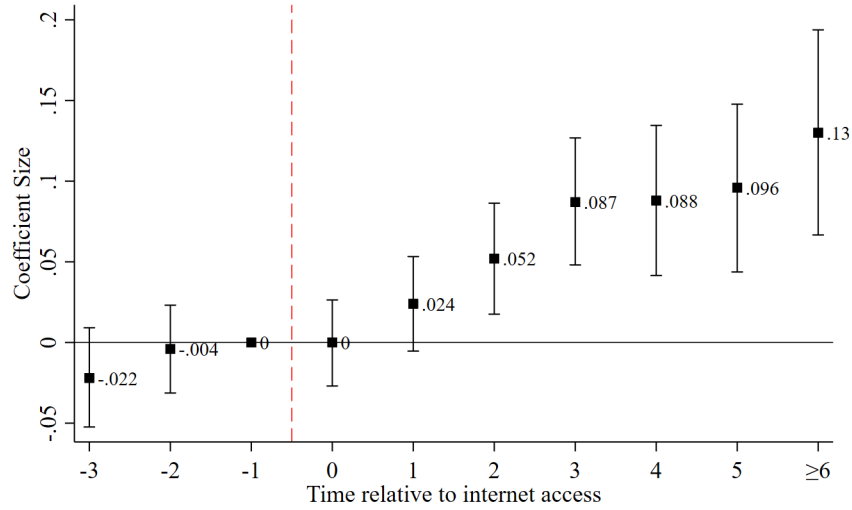The sample includes all grade 2 students in all public schools that gain internet between 2007 and 2020 or remain unconnected by 2020 *and* that are observed for the entire sample period, i.e. for each year 2007-2016 (non-attritors). Coefficients capture the increase in test scores relative to the year prior to a school receiving internet access ($t = -1$). Note that due to the timing of the *Censo Escolar* relative to the ECE exam, some schools receive internet access in $t = 0$ while some receive it in $t = 1$. Control variables include sex, class size, indicator variables for the number of 2nd grade classes at the school, total school enrollment, number of second grade students that took the ECE, facilities (computer room, library, administrative offices), resources per student (classrooms, computers, and teachers), UGEL-specific enrollment tercile by year fixed effects, and school fixed effects. Standard errors are clustered by school.

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Figure A.11: Balanced Panel Estimates

(a) Standardized Math Scores
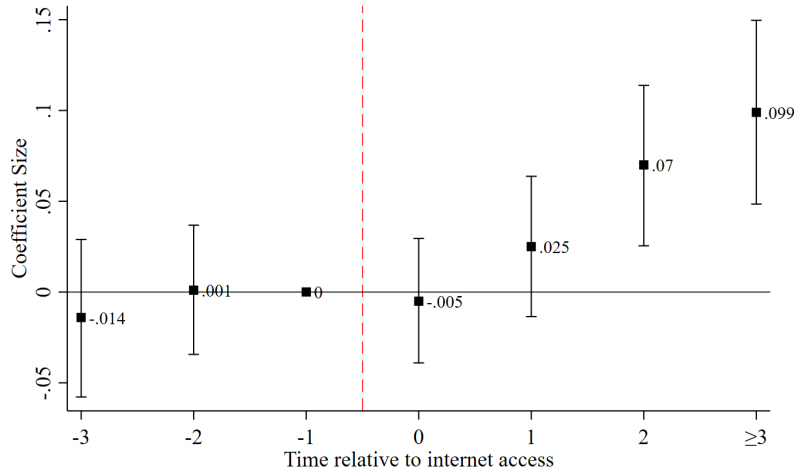
Total Student Obs: 578888 Connected Schools: 1433 Never-connected Schools: 1082

(b) Standardized Reading Scores

Total Student Obs: 580542 Connected Schools: 1437 Never-connected Schools: 1082

The sample includes all grade 2 students from all public schools using only internet-connected schools that appear in all event periods and non-connected schools that appear in all calendar years of the sample period. Scores are standardized within each calendar year to have mean zero and standard deviation of one across the universe of test takers in public schools. Due to the timing of the *Censo Escolar* relative to the ECE exam, some schools receive internet access in $t = 0$ and some receive it in $t = 1$. Control variables include sex, class size, indicator variables for the number of 2nd grade classes at the school, total school enrollment, number of second grade students that took the ECE, facilities (computer room, library, administrative offices), resources per student (classrooms, computers, and teachers), UGEL-specific enrollment tercile by year fixed effects, and school fixed effects. Standard errors are clustered by school.

Figure A.12: Sun and Abraham Estimates

(a) Math

(b) Reading
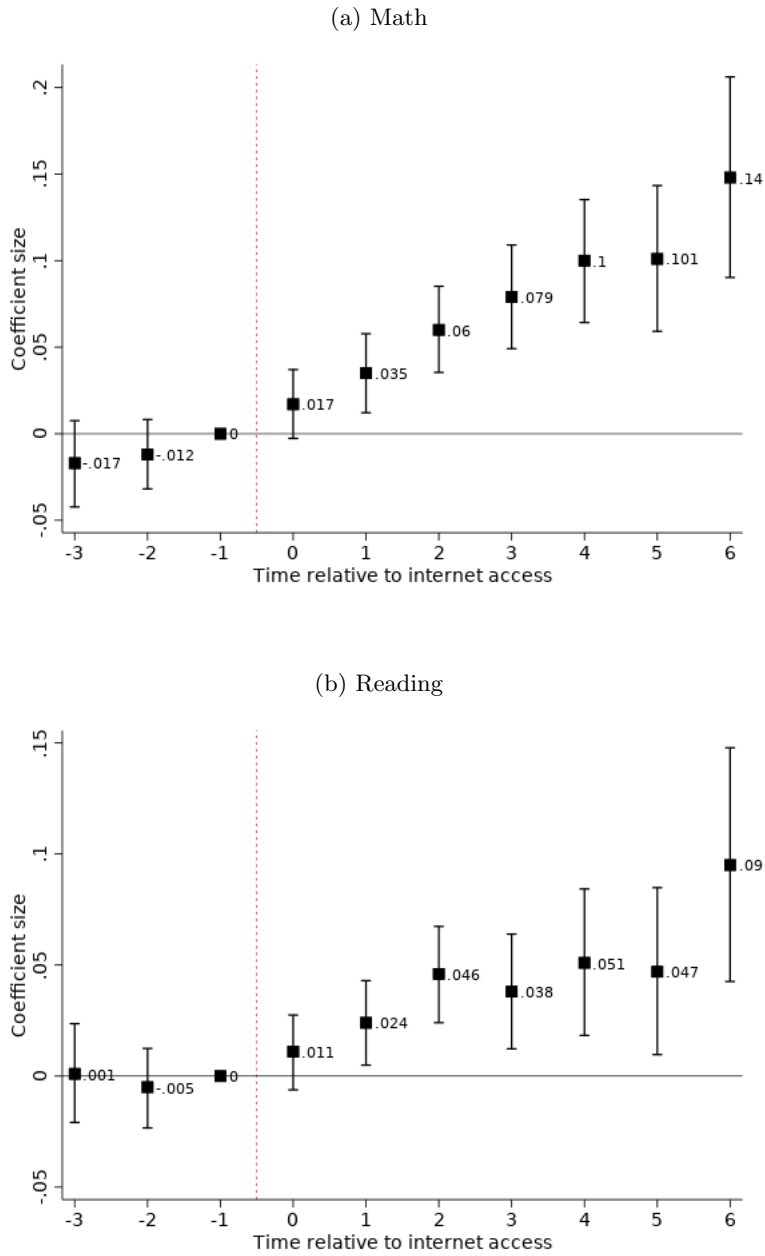
These estimates are calculated using the method described in Sun and Abraham (forthcoming). The sample includes all grade 2 students from a restricted set of cohorts that first installed internet between 2010 and 2018, as required by the estimation procedure. The standard errors are bootstrapped and are estimated with 500 replications. Control variables include sex, class size, indicator variables for the number of 2nd grade classes at the school, total school enrollment, number of second grade students that took the ECE, facilities (computer room, library, administrative offices), resources per student (classrooms, computers, and teachers), UGEL-specific enrollment tercile by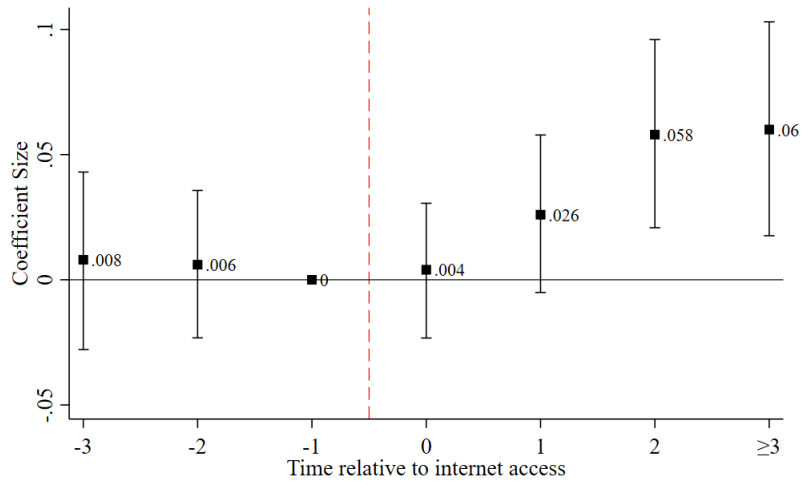 year fixed effects, and school fixed effects. Scores are standardized within each calendar year to have mean zero and standard deviation of one across the universe of test takers in public schools.

Figure A.13: Internet Access and Grade 2 Transfers, Re-entry, Enrollment, Test Taking, and Student Composition

(a) Transfers

Pre-internet mean of dependent variable: 2.783
Obs: 2253853   Schools: 23318

(b) Re-entrants

Pre-internet mean of dependent variable: .417
Obs: 2253853   Schools: 23318

(c) Enrollment

Pre-internet mean of dependent variable: 33.177
Obs: 2253853   Schools: 23318

(d) Proportion of Students Taking the ECE

Pre-internet mean of dependent variable: .894
Obs: 2253219   Schools: 23310

(e) Proportion of Native Spanish Speakers

Pre-internet mean of dependent variable: .845
Obs: 2253219   Schools: 23310

Transfers are total (net) grade 2 transfers from other schools. Re-entrants are total grade 2 students entering school after not being enrolled in any school the previous year. Enrollment includes all grade 2 students at the school except the individual. Proportion of students taking the ECE is the proportion of enrolled grade 2 students that take the ECE exam. Proportion of Native Spanish Speakers is the proportion of grade 2 students that speak Spanish at home. Each of the above figures plots the coefficients and 95% confidence intervals from estimating equation 1. Coefficients capture the change in outcomes relative to the year before internet installation ($t = -1$). Control variables include sex, class size, indicator variables for the number of 2nd grade classes at the school, total school enrollment, number of second grade students that took the ECE, facilities (computer room, library, administrative offices), resources per student (classrooms, computers, and teachers), UGEL-specific enrollment tercile by year fixed effects, and school fixed effects. The sample includes all grade 2 students in public schools that gain internet after 2007 or remain unconnected by 2020. Standard errors are clustered by school.

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Table A.1: Predictors of Internet Access

	Dependent Variable: School Has Gained Internet Access		
	Including Characteristics Prioritized by *Plan Huascarán*	Adding a Control for for Fencing (2010 and Later)	Adding Characteristics in School Data Sheets
	(1)	(2)	(3)
School has a computer room	0.101***	0.071***	0.098***
	(0.005)	(0.005)	(0.006)
School has electricity	0.071***	0.115***	0.059***
	(0.006)	(0.008)	(0.006)
Total Enrollment, in 100s of students	0.029***	0.027***	0.024***
	(0.001)	(0.002)	(0.003)
School is in an urban area	0.150***	0.171***	0.139***
	(0.009)	(0.010)	(0.009)
School has a full perimeter fence		0.036***	
		(0.006)	
Number of computers for instruction			0.001***
			(0.000)
Number of computers for administration			0.001*
			(0.001)
Total number of staff with teaching responsibilities			0.002***
			(0.001)
Observations	2,251,550	1,720,338	1,978,997
Number of Schools	23314	20714	22934

 The sample includes all grade 2 students in all public schools that gain internet between 2007 and 2020 or remain unconnected by 2020. Standard errors are clustered at the school level. Prioritized characteristics include enrollment and facilities (computer room, electricity), district fixed effects (to capture poverty status) and UGEL-specific enrollment tercile by year fixed effects. Information on the existence of a perimeter fence is only available for 2010 and later. Additional characteristics on school data sheets include number of computers used for instruction, number of computers used for administrative purposes, and number of teachers. Significance levels denoted by: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A.2: Summary Statistics (2007 or Earliest Available Year) of Public Primary Schools

	A. All Public Schools			B. Public Schools in ECE 2007-2016			C. Estimation Sample
	Internet before 2007	Internet 2007-2020	No Internet by 2020	Internet before 2007	Internet 2007-2020	No Internet by 2020	Internet 2007-2020 or No Internet by 2020 Matched to ECE, All Covariate Info.
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Standardized math score				0.19	-0.04	-0.29	-0.11
				(0.43)	(0.63)	(0.93)	(0.74)
Standardized reading score				0.42	-0.04	-0.59	-0.20
				(0.41)	(0.64)	(0.85)	(0.75)
Rural school	0.07	0.61	0.94	0.07	0.58	0.94	0.78
	(0.25)	(0.49)	(0.23)	(0.25)	(0.49)	(0.24)	(0.41)
One teacher per grade	0.94	0.44	0.06	0.94	0.47	0.06	0.24
	(0.24)	(0.50)	(0.23)	(0.24)	(0.50)	(0.24)	(0.43)
Total enrollment	551.30	156.05	45.13	553.44	166.31	50.81	102.80
(Grades 1-6)	(348.57)	(196.76)	(48.56)	(347.83)	(201.01)	(47.12)	(150.10)
Enrollment in 2nd Grade	89.32	27.28	8.89	89.66	29.04	10.00	18.59
	(58.75)	(33.71)	(9.21)	(58.65)	(34.41)	(8.88)	(25.70)
Schools connected to public	0.87	0.51	0.27	0.87	0.52	0.29	0.39
water drinking network	(0.34)	(0.50)	(0.45)	(0.34)	(0.50)	(0.45)	(0.49)
School has library	0.70	0.34	0.24	0.70	0.35	0.24	0.29
	(0.46)	(0.47)	(0.42)	(0.46)	(0.48)	(0.43)	(0.45)
School has administrative	0.80	0.41	0.22	0.80	0.43	0.24	0.32
office(s)	(0.40)	(0.49)	(0.42)	(0.40)	(0.49)	(0.43)	(0.47)
Total number of textbooks	359.85	112.32	37.96	360.61	118.78	41.87	78.56
in school	(269.55)	(156.47)	(44.08)	(269.45)	(160.27)	(45.03)	(121.40)
Number of teachers	6.12	5.52	5.08	6.13	5.54	5.15	5.32
	(7.87)	(7.92)	(7.76)	(7.88)	(7.94)	(7.68)	(7.78)
Number of classrooms	20.47	6.82	2.57	20.54	7.17	2.78	4.75
	(11.62)	(6.08)	(2.10)	(11.60)	(6.11)	(2.21)	(4.92)
Computers in school	17.89	2.33	0.31	17.95	2.44	0.34	1.28
	(19.58)	(6.89)	(2.23)	(19.60)	(6.56)	(2.40)	(4.88)
Number of schools	1,366	11,310	18,435	1,360	10,438	14,278	23,318

Panel A includes all public schools in the CE from 2007 to 2020. Panel B restricts the sample to schools that participated in the ECE at least once between 2007 and 2016. Panel C includes all schools that either received internet in 2007-2020 or had not received internet by 2020 and that contain all necessary covariate information for the baseline specification (see Section 3.1). We present data for 2007 (or the earliest available year with information in the sample, when data for 2007 is not available). Scores are standardized within each calendar year to have mean zero and standard deviation of one across the universe of test takers in public schools. In the Peruvian school system, schools might be *unidocente* (only one teacher in the school teaches all grades), *multigrado* (more than one teacher, but each might teach more than one grade in the same classroom), or *polidocente completo* (there is one teacher per grade in the school). Standard deviations in parentheses.

Table A.3: Effect of Internet Access on Standardized Test Scores

	Dependent Variable: Standardized Test Scores	
	Math	Reading
	(1)	(2)
t=-3	-0.012	0.002
	(0.011)	(0.009)
t=-2	-0.011	-0.005
	(0.010)	(0.008)
t=0	0.014	0.006
	(0.009)	(0.008)
t=1	0.028***	0.017**
	(0.010)	(0.008)
t=2	0.056***	0.037***
	(0.012)	(0.010)
t=3	0.082***	0.042***
	(0.013)	(0.011)
t=4	0.090***	0.052***
	(0.015)	(0.013)
t=5	0.110***	0.063***
	(0.017)	(0.014)
t¿=6	0.141***	0.076***
	(0.021)	(0.018)
p-value for Test of Joint Significance for All $t < 0$:	0.405	0.651
p-value for Test of Joint Significance for All $t \geq 0$:	0.000	0.001
Observations	2,253,853	2,252,368
Number of schools	23,318	23,320

Scores are standardized within each calendar year to have mean zero and standard deviation of one across the universe of test takers in public schools. Note that due to the timing of the *Censo Escolar* relative to the ECE exam, some schools receive internet access in $t = 0$ while some receive it in $t = 1$. Control variables include sex, class size, indicator variables for the number of 2nd grade classes at the school, total school enrollment, number of second grade students that took the ECE, facilities (computer room, library, administrative offices), resources per student (classrooms, computers, and teachers), UGEL-specific enrollment tercile by year fixed effects, and school fixed effects. The sample includes all grade 2 students in all public schools that gain internet between 2007 and 2020 or remain unconnected by 2020. Standard errors are clustered by school. Significance levels denoted by: *** p< 0.01, ** p< 0.05, * p< 0.1.

Table A.4: Summary Statistics for Alternate Estimation Samples

	Baseline Sample (1)	Observed at least Twice Before and After Installation (2)	ECE Scores in All Years (3)
Standardized Math Score	-0.085	-0.143	-0.006
	(0.994)	(0.989)	(0.979)
Standardized Reading Score	-0.122	-0.206	0.012
	(0.987)	(0.977)	(0.965)
Years of internet access	1.793	0.214	2.184
	(2.540)	(2.682)	(2.678)
Number of Students Scheduled for the Test	55.101	43.590	66.680
	(53.861)	(43.251)	(53.825)
School has library	0.463	0.407	0.515
	(0.499)	(0.491)	(0.500)
School has administrative office(s)	0.451	0.436	0.507
	(0.498)	(0.496)	(0.500)
Ratio of Classrooms to Students	0.060	0.061	0.052
	(0.053)	(0.054)	(0.036)
Ratio of Computers to Students	0.135	0.127	0.117
	(0.231)	(0.240)	(0.165)
Ratio of Teachers to Students	0.050	0.050	0.045
	(0.045)	(0.051)	(0.022)
Total School Enrollment	342.903	270.805	416.786
	(336.259)	(269.899)	(335.861)
Observations	2,245,933	2,042,249	982,734
Number of Schools	23303	21855	3868

Column 1: The baseline sample includes students from all public schools that gained internet access between 2007 and 2020 or that remained unconnected by 2020. Column 2: The sample includes grade 2 students from schools observed at least twice prior to and twice after internet access, i.e. that installed internet between 2009 and 2015. Column 3: The non-attritor sample are schools that are observed for each year 2007-2016. Scores are standardized within each calendar year to have mean zero and standard deviation of one across the universe of test takers in public schools.

Table A.5: Understanding the Role of School-level Compositional Changes: Trend Break Results

	Dependent Variable: Standardized Test Score					
	Math			Reading		
	Baseline Sample	Observed at least Twice Before and After Installation	Observed in All Years	Baseline Sample	Observed at least Twice Before and After Installation	Observed in All Years
	(1)	(2)	(3)	(4)	(5)	(6)
Post-internet Access	0.008	0.015	-0.006	0.010	0.021**	0.010
	(0.011)	(0.012)	(0.016)	(0.009)	(0.010)	(0.013)
Post-internet Access X Event Time	0.015***	0.015**	0.010	0.012***	0.013**	0.011*
	(0.005)	(0.006)	(0.008)	(0.005)	(0.005)	(0.006)
p-val for PostXEventTime:	0.007	0.016	0.187	0.008	0.017	0.094
Observations	2,253,853	1,763,315	985,819	2,252,368	1,762,354	988,337
Number of Schools	23318	21300	3868	23320	21302	3875

Columns 1 and 4 reproduce the baseline results using all public schools that gained internet access between 2007 and 2020 or that remained unconnected by 2020. Columns 2 and 5 present results using the restricted sample of schools that gained internet access between 2009 and 2015 (i.e. observed at least twice prior to and twice after installing internet) or that remained unconnected by 2020. Columns 3 and 6 present results using all schools that gained internet access between 2007 and 2017 or that remained unconnected by 2017 *and* that are observed for the entire sample period, i.e. for each year 2007-2016 (non-attritors). Standard errors are clustered by school. Scores are standardized within each calendar year to have mean zero and standard deviation of one across the universe of test takers in public schools. Post-internet access is a dummy variable for whether a school has gained internet access (i.e. $t >= 0$). Event time is years relative to internet access. ontrol variables include sex, class size, indicator variables for the number of 2nd grade classes at the school, total school enrollment, number of second grade students that took the ECE, facilities (computer room, library, administrative offices), resources per student (classrooms, computers, and teachers), UGEL-specific enrollment tercile by year fixed effects, and school fixed effects. Significance levels denoted by: *** p< 0.01, ** p< 0.05, * p< 0.1.

Table A.6: Attrition (Number of School-Year Observations)

	N	%
All Information Observed (Not Attrited)	123,478	59.26
Attrited	84,898	40.74
School Permanently Closed	5,375	2.58
Missing ECE Scores		
Second Grade Enrollment less than 5	47,675	22.88
Second Grade Enrollment between 5 and 8	15,538	7.46
Other	10,627	5.10
Missing Census (CE) Information	5,683	2.73

Based on each school's initial year of internet connection and our event study window, we determine all the periods that each should be included in our panel dataset. Enrollment is measured from the CE (reported at the beginning of each year). Only schools with five or more second graders by the end of each year are tested in the ECE. Schools that have 5-7 students at the beginning of the year might not have been included in the ECE if they fell below the 5-student threshold by the end of the year. CE information is used to calculate infrastructure (and, importantly, internet access) and school resources (control variables in our regressions).

Table A.7: Effect of Internet Access on Transfers, Re-entry, Test Taking, and Student Composition

	Grade 2 Transfers (1)	Grade 2 Re-entry (2)	Grade 2 Enrollment (3)	Proportion of Enrolled Students that Took Test (4)	Proportion of Native Spanish Speakers in Grade 2 (5)
Post-internet Access	0.176	0.048	0.404	0.005	-0.002
	(0.253)	(0.062)	(0.353)	(0.004)	(0.003)
Post-internet Access X Event Time	-0.248**	-0.015	-0.097	-0.003	-0.001
	(0.108)	(0.032)	(0.176)	(0.002)	(0.001)
p-val for PostXEventTime:	0.0220	0.629	0.581	0.299	0.442
Pre-internet					
Mean of dependent variable	2.783	0.417	33.18	0.894	0.845
Observations	2,253,853	2,253,853	2,253,853	2,253,219	2,253,219
Number of Schools	23318	23318	23318	23310	23310

Transfers are students enrolled in the current year who were enrolled in a different school in the previous year. Re-entrants are students that are currently enrolled but who were not enrolled in the previous year. The sample includes all grade 2 students in all public schools that gain internet between 2007 and 2020 or remain unconnected by 2020. Standard errors are clustered by school. Post-internet access is a dummy variable for whether a school has gained internet access (i.e. $t >= 0$). Event time is years relative to internet access. Control variables include sex, class size, indicator variables for the number of 2nd grade classes at the school, total school enrollment, number of second grade students that took the ECE, facilities (computer room, library, administrative offices), resources per student (classrooms, computers, and teachers), UGEL-specific enrollment tercile by year fixed effects, and school fixed effects. Columns 1-3 controls for both second grade enrollment and enrollment in other grades separately, not including transfers or re-entrants when specified as an outcome variable. Column 4 also controls for the number of second grade students scheduled to take the test.

Table A.8: Assessing the Role of Covariates: Trend Break Results

	Dependent Variable: School Average Standardized Test Score					
	Math			Reading		
	No Controls	Only Enrollment	Adding Resources (Baseline)	No Controls	Only Enrollment	Adding Resources (Baseline)
	(1)	(2)	(3)	(4)	(5)	(6)
Post-internet Access	0.007	0.007	0.008	0.010	0.009	0.010
	(0.011)	(0.011)	(0.011)	(0.009)	(0.009)	(0.009)
Post-internet Access X Event Time	0.015***	0.015***	0.015***	0.012***	0.013***	0.012***
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
p-val for PostXEventTime:	0.005	0.005	0.007	0.006	0.006	0.008
Observations	2,253,853	2,253,853	2,253,853	2,252,368	2,252,368	2,252,368
Number of Schools	23318	23318	23318	23320	23320	23320

The sample includes all grade 2 students in all public schools that gain internet between 2007 and 2020 or remain unconnected by 2020. All columns include UGEL-specific enrollment tercile by year fixed effects and school fixed effects. Columns 1 and 4 do not include any time-varying controls. Columns 2 and 5 add in controls for total student enrollment and number of second grade students that took the ECE. Columns 3 and 6 add in facilities (computer room, library, administrative offices) and resources per student (classrooms, computers, and teachers) and sex, class size, indicator variables for the number of 2nd grade classes at the school. This is our baseline specification. Scores are standardized within each calendar year to have mean zero and standard deviation of one across the universe of test takers in public schools. Post-internet access is a dummy variable for whether a school has gained internet access (i.e. $t >= 0$). Event time is years relative to internet access. Significance levels denoted by: *** p< 0.01, ** p< 0.05, * p< 0.1.

Table A.9: Effect of Internet Access on School Resources

	Classrooms per Student (1)	Textbooks per Student (2)	(Non-computer) Teachers per Student (3)	Qual. Teachers per Student (4)	Computers per Student (5)
Post-internet Access	-0.001	0.029	-0.0000	-0.0004	0.008***
	(0.001)	(0.075)	(0.000)	(0.000)	(0.002)
Post-internet Access X Event Time	-0.000	-0.029	-0.0003***	-0.0004*	-0.002**
	(0.000)	(0.034)	(0.000)	(0.000)	(0.001)
p-value for PostXEventTime	0.562	0.389	0.004	0.055	0.048
Pre-internet mean					
of dep. variable	0.0667	3.878	0.0504	0.0413	0.118
Observations	2,253,853	1,703,333	1,836,738	2,253,853	2,253,853
Number of Schools	23318	21866	21773	23318	23318

In column 2, the dependent variable is the number of 2nd grade textbooks per 2nd grade student. Textbook information is not available for 2012. In column 3, the number of teachers per students excludes computer teachers (discussed separately in Section 5.3.1). In column 4, the dependent variable is the number of teachers with a pedagogical or university degree per student. In column 5, the dependent variable is the number of instructional computers per student. The sample includes all grade 2 students in all public schools that gain internet between 2007 and 2020 or remain unconnected by 2020. Standard errors are clustered by school. Post-internet access is a dummy variable for whether a school has gained internet access (i.e. $t >= 0$). Event time is years relative to internet access. Control variables include (excluding the dependent variable) sex, class size, indicator variables for the number of 2nd grade classes at the school, total school enrollment, number of second grade students that took the ECE, facilities (computer room, library, administrative offices), resources per student (classrooms, computers, and teachers), UGEL-specific enrollment tercile by year fixed effects, and school fixed effects.
Significance levels denoted by: *** p< 0.01, ** p< 0.05, * p< 0.1.

Table A.10: Effects of Computers in Non-internet Schools

	Standardized Math Score						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Computers per Student	0.011	0.016	-0.003	-0.004	0.004	0.005	0.000
	(0.012)	(0.014)	(0.014)	(0.015)	(0.016)	(0.018)	(0.023)
Computers per Student (1 Year Lag)		-0.001	-0.008	-0.020	-0.022	-0.015	-0.012
		(0.014)	(0.015)	(0.016)	(0.016)	(0.018)	(0.022)
Computers per Student (2 Year Lag)			0.019	0.023	0.023	0.017	0.028
			(0.017)	(0.019)	(0.020)	(0.021)	(0.023)
Computers per Student (3 Year Lag)				-0.023	-0.012	-0.011	-0.007
				(0.022)	(0.023)	(0.024)	(0.026)
Computers per Student (4 Year Lag)					-0.019	-0.012	-0.021
					(0.025)	(0.026)	(0.029)
Computers per Student (5 Year Lag)						0.043	0.062
						(0.044)	(0.045)
Computers per Student (6 Year Lag)							0.068
							(0.104)
Observations	607,115	586,759	487,860	400,091	327,028	264,851	207,295
Number of Schools	13791	13588	12350	11222	9918	8979	7587

	Standardized Reading Score						
	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Computers per Student	-0.000	0.003	-0.009	-0.009	-0.006	-0.007	-0.010
	(0.011)	(0.012)	(0.013)	(0.013)	(0.014)	(0.017)	(0.021)
Computers per Student (1 Year Lag)		0.001	-0.004	-0.016	-0.019	-0.015	-0.017
		(0.012)	(0.013)	(0.014)	(0.015)	(0.016)	(0.019)
Computers per Student (2 Year Lag)			0.017	0.018	0.018	0.018	0.030
			(0.015)	(0.017)	(0.018)	(0.019)	(0.021)
Computers per Student (3 Year Lag)				-0.021	-0.011	-0.009	-0.003
				(0.020)	(0.021)	(0.022)	(0.024)
Computers per Student (4 Year Lag)					-0.004	0.004	-0.002
					(0.022)	(0.024)	(0.025)
Computers per Student (5 Year Lag)						0.034	0.058
						(0.039)	(0.041)
Computers per Student (6 Year Lag)							-0.025
							(0.098)
Observations	606,198	585,753	488,128	400,206	327,232	265,022	207,394
Number of Schools	13793	13588	12350	11224	9919	8978	7587

The sample includes all schools that report ECE scores during 2007-2016 and that had not gained internet access by 2020. Scores are standardized within each calendar year to have mean zero and standard deviation of one across the universe of test takers in public schools. Control variables include sex, class size, indicator variables for the number of 2nd grade classes at the school, total school enrollment, number of second grade students that took the ECE, facilities (computer room, library, administrative offices), resources per student (classrooms and teachers), UGEL-specific enrollment tercile by year fixed effects, and school fixed effects. Standard errors are clustered by school. Significance levels denoted by: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A.11: Effects of Concurrent Computer Investments: Back of the Envelope Calculations

Math

Time Relative to Internet Access	Total Predicted Rise in Computers per Student	Total Dynamic Effect of Computers on Scores	Estimated Effect of Internet Access on Scores	Share of Total Internet Effect Explained by Computers (%)
(1)	(2)	(3)	(4)	(5)
t=0	0.008	0.00013	0.014	0.91%
t=1	0.006	0.00009	0.028	0.31%
t=2	0.004	0.00028	0.056	0.50%
t=3	0.002	0.00014	0.082	0.17%
t=4	0.000	-0.00003	0.090	-0.03%
t=5	-0.002	0.00042	0.110	0.38%
t=6	-0.004	0.00015	0.141	0.10%

Reading

Time Relative to Internet Access	Total Predicted Rise in Computers per Student	Total Dynamic Effect of Computers on Scores	Estimated Effect of Internet Access on Scores	Share of Total Internet Effect Explained by Computers (%)
(6)	(7)	(8)	(9)	(10)
t=0	0.008	0.00002	0.006	0.40%
t=1	0.006	0.00003	0.017	0.15%
t=2	0.004	0.00026	0.037	0.70%
t=3	0.002	0.00017	0.042	0.40%
t=4	0.000	0.00014	0.052	0.26%
t=5	-0.002	0.00053	0.063	0.84%
t=6	-0.004	0.00063	0.076	0.83%

Columns 2 and 7 give the total predicted rise in computers in each period using the parameter estimates from the trend break regression of resources per student on Post-internet access, event time, and the interaction between the two (from Table A.9). Columns 3 and 8 calculate the total dynamic effect of computers as of time t using (i) the largest positive parameter values from regressing ECE scores on computers per students and lags using the sample of non-internet connected schools (from Appendix Table A.10), without regard to significance level and (ii) the total predicted rise in computers from columns 2 and 7. Columns 4 and 9 display estimated effects of internet access on test scores from the baseline event study specification (Appendix Table A.3). Columns 5 and 10 express the total effect of computers as a percent of the total effect of internet access (column 3 (8) divided by column 4 (9)).

Table A.12: Allowing for Differential Linear Pre-trends by Various Groups

		Dependent Variable: Standardized Math Scores		
	Baseline	UGEL-specific Trends	District-specific Trends	Trends by Initial Scoring Decile
	(1)	(2)	(3)	(4)
Post-internet Access	0.008	0.009	0.010	0.013
	(0.011)	(0.011)	(0.011)	(0.011)
Post-internet Access X Event Time	0.015***	0.015***	0.018***	0.020***
	(0.005)	(0.005)	(0.006)	(0.006)
p-value for PostXEventTime	0.007	0.007	0.002	0.000
Observations	2,253,853	2,253,853	2,253,853	1,852,352
Number of Schools	23318	23318	23318	22024
Number of groups	N/A	222	1826	10
		Dependent Variable: Standardized Reading Scores		
	Baseline	UGEL-specific Trends	District-specific Trends	Trends by Initial Scoring Decile
	(5)	(6)	(7)	(8)
Post-internet Access	0.010	0.011	0.010	0.014
	(0.009)	(0.009)	(0.009)	(0.009)
Post-internet Access X Event Time	0.012***	0.012***	0.014***	0.020***
	(0.005)	(0.005)	(0.005)	(0.005)
p-value for PostXEventTime	0.008	0.007	0.003	0.000
Observations	2,252,368	2,252,368	2,252,368	1,851,980
Number of Schools	23320	23320	23320	22028
Number of groups	N/A	222	1826	10

"Number of groups" refers to the number of groups used to create additional controls listed in each column; e.g., in col. 2 including UGEL-specific linear trends adds an additional regressor per UGEL (222). The sample includes all grade 2 students in all public schools that gain internet between 2007 and 2020 or remain unconnected by 2020. In columns 4 and 8, the sample is further restricted to schools that are observed prior to internet access. Initial scoring decile is defined as the school's scoring decile based on pre-internet scoring average; the decile is calculated based on all schools that have pre-internet scores (including those that are not connected by 2020). Scores are standardized within each calendar year to have mean zero and standard deviation of one across the universe of test takers in public schools. Post-internet access is a dummy variable for whether a school has gained internet access. Event time is years relative to internet access. Control variables include sex, class size, indicator variables for the number of 2nd grade classes at the school, total school enrollment, number of second grade students that took the ECE, facilities (computer room, library, administrative offices), resources per student (classrooms, computers, and teachers), UGEL-specific enrollment tercile by year fixed effects, school fixed effects, and the additional trends indicated in each column heading. Standard errors are clustered by school. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A.13: Restricting the Sample to Likely *Plan Huascarán* Compliers: Trend Break Results

	Dependent Variable: Standardized Test Score					
	Math			Reading		
	Baseline Sample	Only Schools in Complier UGELs	Only Schools in Localities w/o Other Sources of Internet	Baseline Sample	Only Schools in Complier UGELs	Only Schools in Localities w/o Other Sources of Internet
	(1)	(2)	(3)	(4)	(5)	(6)
Post-internet Access	0.008	0.016	0.027	0.010	0.018*	0.028*
	(0.011)	(0.013)	(0.017)	(0.009)	(0.011)	(0.015)
Post-internet Access X Event Time	0.015***	0.017***	0.012	0.012***	0.015***	0.013
	(0.005)	(0.006)	(0.009)	(0.005)	(0.005)	(0.008)
pval for PostXEventtime:	0.007	0.008	0.173	0.008	0.006	0.101
Observations	2,253,853	1,600,224	935,415	2,252,368	1,599,007	934,491
Number of Schools	23318	16016	18444	23320	16017	18446

Columns 1 and 4 reproduce the baseline results using all public schools that gained internet access between 2007 and 2020 or that remained unconnected by 2020. Columns 2 and 5 present results excludes all schools in UGELs where more public primary schools become connected than allowed under the official quota under *Plan Huascarán*. We calculate the quotas as follows: first, we obtain annual quotas per UGEL from the Ministry of Education (published in 2004); note that these are only available for 206 out of the 219 UGELs. Second, we multiply the annual quota by 11 (to reflect 11 years between when the quotas were published in 2004 and the end of our sample period, 2014) and then by 0.7 (to reflect that 50% of the quota was for primary (only) schools and 20% was for integrated (primary and secondary) schools). Columns 3 and 6 present results excluding schools in areas that had an alternate source of internet access (i.e. a cyber cafe) prior to schools gaining access. Standard errors are clustered by school. Scores are standardized within each calendar year to have mean zero and standard deviation of one across the universe of test takers in public schools. Post-internet access is a dummy variable for whether a school has gained internet access (i.e. $t >= 0$). Event time is years relative to internet access. Control variables include sex, class size, indicator variables for the number of 2nd grade classes at the school, total school enrollment, number of second grade students that took the ECE, facilities (computer room, library, administrative offices), resources per student (classrooms, computers, and teachers), UGEL-specific enrollment tercile by year fixed effects, and school fixed effects. Significance levels denoted by: *** $p< 0.01$, ** $p< 0.05$, * $p< 0.1$.

Table A.14: Ease of Conducting Teaching Activities and School-based Internet Access

| | Reported Ease of Teaching Activities (1=Very Difficult, 6 = Very Easy) | | | | | |
| | Communicating w/ & Motivating Students | Selecting & Making Good Use of Methods & Materials | Using Class Time Effectively | Teaching at Different Learning Levels | Addressing Students' Academic Problems | Overall Activity Index (Average of 1-5) |
	(1)	(2)	(3)	(4)	(5)	(6)
School has internet in good condition	0.001	0.113*	0.110*	0.063	0.149**	0.087*
	(0.054)	(0.059)	(0.061)	(0.066)	(0.064)	(0.045)
School does not have internet in good condition	0.000	0.037	0.079	0.034	0.022	0.035
	(0.066)	(0.073)	(0.075)	(0.081)	(0.078)	(0.055)
Observations	3,474	3,474	3,474	3,474	3,474	3,474
Mean of dependent variable	4.975	4.644	4.640	4.311	4.442	4.602
Std. dev. of dependent variable	1.061	1.104	1.155	1.263	1.215	0.883
District Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Teacher-level controls	Yes	Yes	Yes	Yes	Yes	Yes

The sample includes teachers in public primary schools that appear in the 2014 ENDO. "School has internet access in "good condition" and is zero for all schools that do not have access or that have access in poor condition. "School does not have internet in good condition" takes the value of 1 if a school has internet access that is not in "good condition". Teacher- and school-level control variables include sex, age, experience, fixed effects for education level, and a dummy variable for urban status. Significance levels denoted by: *** p< 0.01, ** p< 0.05, * p< 0.1.

Table A.15: Heterogeneity in the Impact of Internet Access across Schools by Student to Teacher Ratios and Teacher Qualifications: Trend Break Results

	Dependent Variable: Standardized Test Scores			
	Math	Reading	Math	Reading
	(1)	(2)	(3)	(4)
Post-internet Access	-0.000	0.002	0.017	0.021*
	(0.016)	(0.013)	(0.015)	(0.012)
Post-internet Access	0.006	0.007	0.008	0.012*
× Event Time	(0.008)	(0.007)	(0.007)	(0.006)
Post-internet Access	0.022	0.021		
× High STR	(0.022)	(0.018)		
Post-internet Access	0.005	0.002		
× Event Time × High STR	(0.011)	(0.009)		
Post-internet Access			-0.006	-0.012
× Low Teach. Qual			(0.022)	(0.018)
Post-internet Access			0.006	-0.005
× Event Time			(0.011)	(0.009)
× Low Teach. Qual.				

	Effects in High STR Schools		Effects in Schools with Low Teacher Qualifications	
...for Post-internet Access	0.022	0.023	0.011	0.009
	[p-value=0.146]	[p-value=0.068]	[p-value=0.517]	[p-value=0.525]
...for Post-internet Access	0.012	0.009	0.014	0.007
× Event Time	[p-value=0.138]	[p-value=0.178]	[p-value=0.121]	[p-value=0.337]
Observations	1,852,352	1,851,980	1,852,352	1,848,798
Number of Schools	22024	22028	22024	21985

High and Low STR schools are defined based on each school's pre-internet average ratio of grade 2 students to total teachers in the school (STR) over the sample period relative to the median of all schools' sample averages (including schools that remained unconnected by 2020). High and Low Teacher Quality schools are defined based on each school's pre-internet average number of teachers with a pedagogical or higher education degree per student over the sample period relative to the median of all schools' sample averages (including schools that remain unconnected by 2020). Note that degree information is not available for all schools. The samples include students from all public schools that gain internet between 2007 and 2020 or remain unconnected by 2020. or that remain unconnected by 2017. Standard errors are clustered by school. Scores are standardized within each calendar year to have mean zero and standard deviation of one across the universe of test takers in public schools. Post-internet access is a dummy variable for whether a school has gained internet access (i.e. $t >= 0$). Event time is years relative to internet access. Control variables include sex, class size, indicator variables for the number of 2nd grade classes at the school, total school enrollment, number of second grade students that took the ECE, facilities (computer room, library, administrative offices), resources per student (classrooms, computers, and teachers), UGEL-specific enrollment tercile by year fixed effects, and school fixed effects. Significance levels denoted by: *** p< 0.01, ** p< 0.05, * p< 0.1.

Table A.16: Cost Effectiveness Calculations

	Present Value of Payment	Cumul. Payment (Pres. Val.)	Math				Reading			
			Learning in 0.01 SD	Disc. Learning	Cumul. Learn (Pres. Val.)	Cost per 0.01 SD	Learning in 0.01 SD	Disc. Learning	Cumul. Learn (Pres. Val.)	Cost per 0.01 SD
					Upper Bound					
Year 1	21.59	21.59	2.82	2.82	2.82	7.65	1.72	1.72	1.72	12.56
Year 2	20.57	42.16	5.65	5.38	8.20	5.14	3.66	3.48	5.20	8.11
Year 3	19.59	61.75	8.16	7.40	15.60	3.96	4.17	3.78	8.98	6.87
Year 4	18.65	80.40	8.97	7.75	23.35	3.44	5.16	4.45	13.44	5.98
Year 5	17.77	98.17	10.98	9.04	32.38	3.03	6.25	5.14	18.58	5.28
					Lower Bound					
Year 1	4.02	4.02	2.82	2.82	2.82	1.42	1.72	1.72	1.72	2.34
Year 2	3.83	7.84	5.65	5.38	8.20	0.96	3.66	3.48	5.20	1.51
Year 3	3.64	11.49	8.16	7.40	15.60	0.74	4.17	3.78	8.98	1.28
Year 4	3.47	14.96	8.97	7.75	23.35	0.64	5.16	4.45	13.44	1.11
Year 5	3.31	18.26	10.98	9.04	32.38	0.56	6.25	5.14	18.58	0.98

Data for the upper bound assumes connection costs provided by the Peruvian Ministry of Education for two recent large contracts (in 2016 and 2019) that would expand internet access to 3,140 educational institutions (e.g., primary and secondary schools, vocational education centers, technical institutes, etc.) across the country for three years. The total sum of the awarded contracts was about $36 million, which yields a yearly average cost of $3,821 per school. If we consider that schools that received access to internet between 2007 and 2020 had an average enrollment of 177 students, this represents a cost of $21.59 per student / year. Data for the lower bound assumes residential connection costs with a bandwidth of 500 Mbps, about $710 per year. Considering again an average enrollment in schools of 177, we calculate an average cost of $4.02 per student / year. The effects for math and reading are those presented in Figure 2 of the paper. We assume a discount rate of 5%.

Table A.17: Cost Effectiveness of Education Interventions (ranked by cost-effectiveness)

Intervention	Evaluation	Country	Effect (in 0.01 SD)	Cost per student	Cost per 0.01 SD
Nonmonetary incentives for students	Nguyen (2008i)	Madagascar	20	1	0.1
Nonmonetary incentives for students	Nguyen (2008ii)	Madagascar	7	3	0.4
Guided technology with extra time	Lai et al (2013ii)	China	21	10	0.5
Funding for materials	Glewwe, Kremer and Moulin (2009)	Kenya	11	6	0.5
Guided technology with extra time	Lai et al (2015)	China	16	9	0.6
Our study (lower bound, Math)		**Peru**	**32**	**18**	**0.6**
Tracking	Duflo, Dupas and Kremer (2011	Kenya	14	10	0.7
Guided technology with extra time	Lai et al (2013i)	China	12	9	0.8
Our study (lower bound, Reading)		**Peru**	**19**	**18**	**1.0**
Guided technology with extra time	Mo et al (2014)	China	16	24	1.5
Nonmonetary incentives for students	Abeberese, Kumler and Linden (2014)	Philippines	6	10	1.7
Funding for materials	Das et al (2013)	India	9	17	1.9
Lesson plans	Bassi et al (2016)	Chile	8	16	2.0
Lesson plans	Ysseldyke and Bolt (2007)	USA	21	46	2.2
Guided technology with extra time	Banerjee et al (2007)	India	19	43	2.3
Tracking	Duflo et al (2015)	India	8	20	2.5
Guided technology with extra time	Linden (2008)	India	25	68	2.7
Lesson plans	Worth et al (2015i)	UK	9	25	2.8
Our study (upper bound, Math)		**Peru**	**32**	**98**	**3.0**
Funding for materials	Pradhan et al (2014)	Indonesia	6	21	3.5
Lesson plans	Leme et al (2012)	Brazil	19	74	3.9
Our study (upper bound, Reading)		**Peru**	**19**	**98**	**5.3**
Lesson plans	Worth et al (2015ii)	UK	2	25	12.5
Funding for materials	Blimpo and Evans (2011)	Gambia	2	50	25.0
Lesson plans	Randel et al (2011)	USA	1	25	25.0

The table was reproduced and adapted from Busso et al. (2017, p. 160). The authors do not disaggregate math and reading results. As they mention in p. 153, "A summary measure of academic achievement on math and reading achievement was used for each evaluation or constructed averaging available effects on math and reading." We ranked the interventions by cost-effectiveness (i.e., expenditure per pupil to achieve an increase of 0.01 SD in test scores). We include upper- and lower-bound estimates of the cost-effectiveness of providing internet access at schools (5 years after gaining access) in the table.