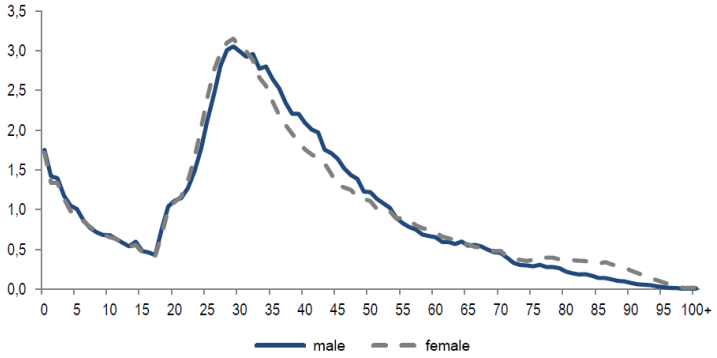
Appendix

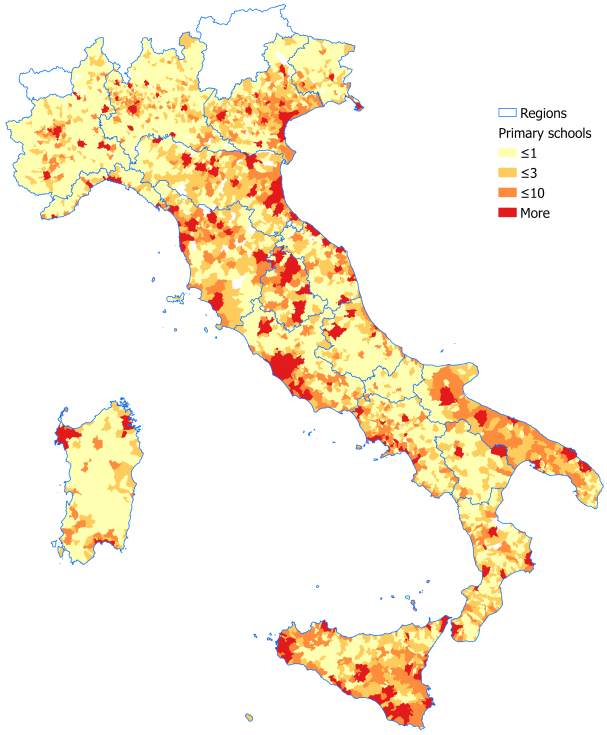
A Descriptive statistics and Data

Figure A1: Percentage of internal migrants by age in Italy



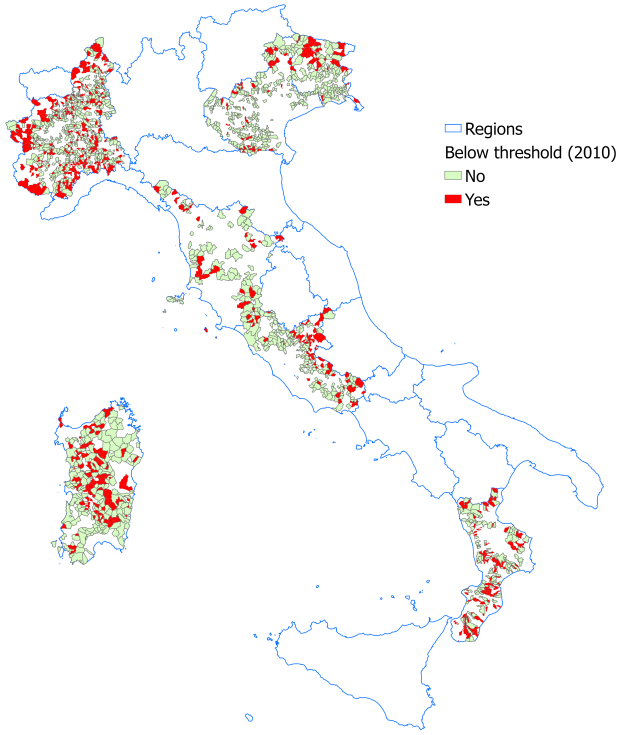
The Figure shows the distribution of internal migrations (i.e. changes of residence across Italian Provinces) in percentage values by age class (horizontal axis). Data refer to 2017. Source: ISTAT (2018).

Figure A2: Primary school endowments by municipality in school year 2007/08



The map shows the distribution of public primary schools among municipalities in school year 2007-08 (i.e. first year in our sample).

Figure A3: Single-primary-school municipalities above/below the regional school-sizing threshold, in regions adopting a threshold



The map shows single-primary-school municipalities in regions adopting thresholds over the period considered. The Figure reports in green/red municipalities above/below the threshold according to school characteristics over the period 2008-10.

Table A1: Summary statistics: all single-primary-school municipalities

Variable	Obs.	Mean	Std. Dev.
School-age population	50,832	239.1	222.1
Population of potential parents	50,832	597.8	531.4
Elder population	50,832	335.9	272.6
Total population	50,832	2603.5	2173.9
Total income	50,809	32997.3	32549.7
Numb. of taxpayers	50,809	1806.7	1507.1
Per-capita income	50,809	17007.4	4077.2
Numb. of low income taxpayers	50,809	578.2	446.3
Public pre-school	50,832	0.822	0.568
Public primary schools	50,832	0.963	0.187
Public lower secondary schools	50,832	0.646	0.478
Private pre-schools	50,832	0.388	0.616
Private primary schools	50,832	0.0174	0.149
Private lower secondary schools	50,832	0.00857	0.0936
Variables at start-of-period values (2008):			
Distance to next school	50,004	3040.2	2201.5
Distance to LLM centre	50,832	7931.3	5301.9
Total population	50,832	2577.7	2079.9

Table A2: Summary statistics: single-primary-school municipalities in regions with thresholds

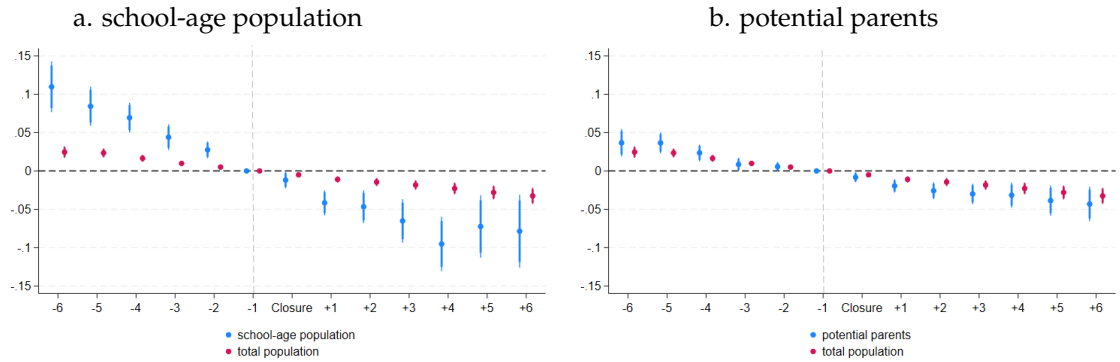
Variable	Obs	Mean	Std. Dev.
School-age population	22,428	196.1	178.8
Population of potential parents	22,428	508.4	453.2
Elder population	22,428	298.1	242.7
Total population	22,428	2236.9	1869.6
Total income	22,414	28113.5	26481.5
Numb. of taxpayers	22,414	1569.3	1306.2
Per-capita income	22,414	17030.8	3657.8
Numb. of low income taxpayers	22,414	504.5	399.4
Public pre-school	22,428	0.801	0.533
Public primary schools	22,428	0.954	0.207
Public lower secondary schools	22,428	0.602	0.490
Private pre-schools	22,428	0.326	0.548
Private primary schools	22,428	0.00838	0.0921
Private lower secondary schools	22,428	0.00673	0.0817
Variables at start-of-period values (2008):			
Primary school students	22,428	95.60	80.39
Primary school classes	22,428	6.023	3.537
Multi-grade classes	22,428	0.421	0.741
Distance to next school	22,044	3224.1	2199.5
Distance to LLM centre	22,428	8464.8	6095.9
Total population	22,428	2231.6	1794.4

Table A3: Summary statistics: variables description and source

Variable	Description	Source
School-age population	resident population between 5 and 14 years old	ISTAT
Population of potential parents	resident population between 35 and 49 years old	ISTAT
Elder population	resident population between 55 and 65 years old	ISTAT
Total population	total resident population	ISTAT
Total income	total taxable income	MEF
Numb. of taxpayers	number of taxpayers	MEF
Per-capita income	total taxable income/ number of taxpayers	MEF
Numb. of low income taxpayers	number of taxpayers with an annual income below 10,000 euros	MEF
Current expenditures	euros of current expenditures per-capita for primary school	MI
Capital expenditures	euros of capital expenditures per-capita for primary school	MI
Public pre-school	numb. of public pre-schools	MIUR
Public primary schools	numb. of public primary schools	MIUR
Public lower secondary schools	numb. of public lower secondary schools	MIUR
Private pre-schools	numb. of private pre-schools	MIUR
Private primary schools	numb. of private primary schools	MIUR
Private lower secondary schools	numb. of private lower secondary schools	MIUR
Variables at start-of-period values (2008):		
Primary school students	numb. of primary school students in school year 2007-08	MIUR
Primary school classes	numb. of primary school classes in school year 2007-08	MIUR
Multi-grade classes	numb. of primary multi-grade classes in school year 2007-08	MIUR
Distance to next school	meter distance to the next available public primary school in 2008	MIUR
Distance to LLM centre	meter distance to the boundary of the closest LLM centre	ISTAT
Total population	total resident population in 2008	ISTAT

ISTAT: Italian Institute for Statistics; MIUR: Italian Ministry of Education; MEF: Italian Ministry of Economy and Finance

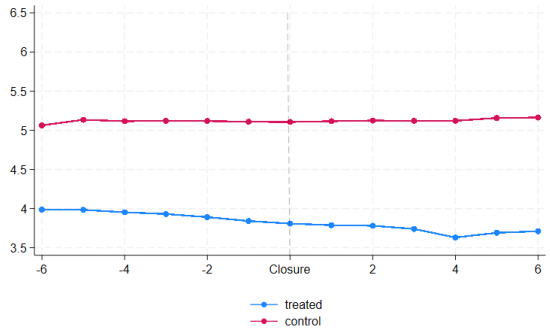
Figure A4: Population by age classes around school closure - Sun and Abraham (2021) estimator



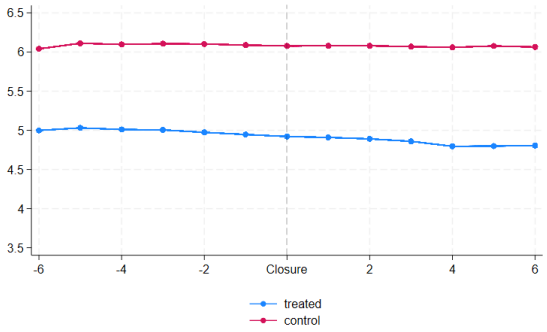
The Figure shows event study plots employing the estimator proposed by Sun and Abraham (2021), which corrects for possible heterogeneous treatment effects across cohorts. Plotted coefficients relate to equation 2, where dependent variable are total and school-age population (Panel a) or total population and potential parents, i.e. residents between 35 and 49 years old (Panel b). Event time corresponds to the year of primary school closure. Thicker confidence intervals refer to 90% level, thinner ones to 95%.

Figure A5: Average population in treated and control municipalities since school closure

a. school-age population

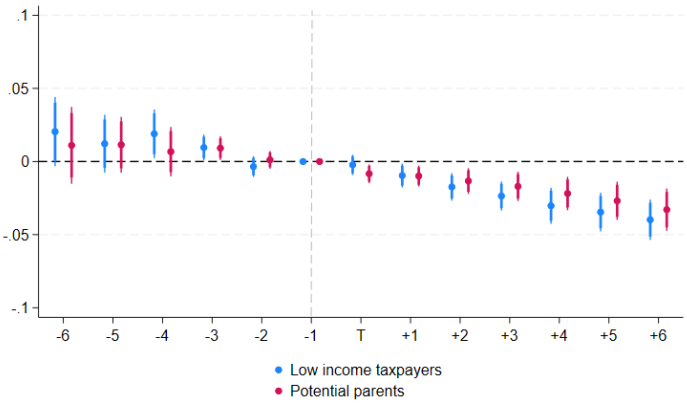


b. potential parents



The Figure shows average population - school-age children (Panel a) and potential parents (Panel b) - across treated and control municipalities within the same LLM in each year before / after school closure. Treated: single-primary-school municipalities in LLMs where only one school closure occurs. Controls: municipalities with no school closures within the same LLMs. For control municipalities, years before / after closure are determined on the basis of the time of closure of the school in the treated municipality in their same LLM.

Figure A6: Event study plot of the reduced-form estimation: low income taxpayers and potential parents



The Figure shows the event study plot corresponding to the reduced form of equation 2, where dependent variable is (log) population of potential parents (i.e. residents between 35 and 49 years old) or (log) of low income taxpayers (below 10,000 euros per year). Those outcome variables are regressed on leads and lags of the instrument defined in equation 3. The sample is restricted to schools with up to 50 students above or below the regional threshold as of s.y. 2008-10. Thicker confidence intervals refer to 90% level, thinner ones to 95%.

Table A4: Municipalities by distance to LLM centres and next available school

Next school	LLM centre *close*	*far*	Total
close	668	385	1,053
far	380	304	684
Total	1,048	689	1,737

The Table reports the number of municipalities respectively below (close) or above (far) the mean distance to centres of LLM and next available public primary school.

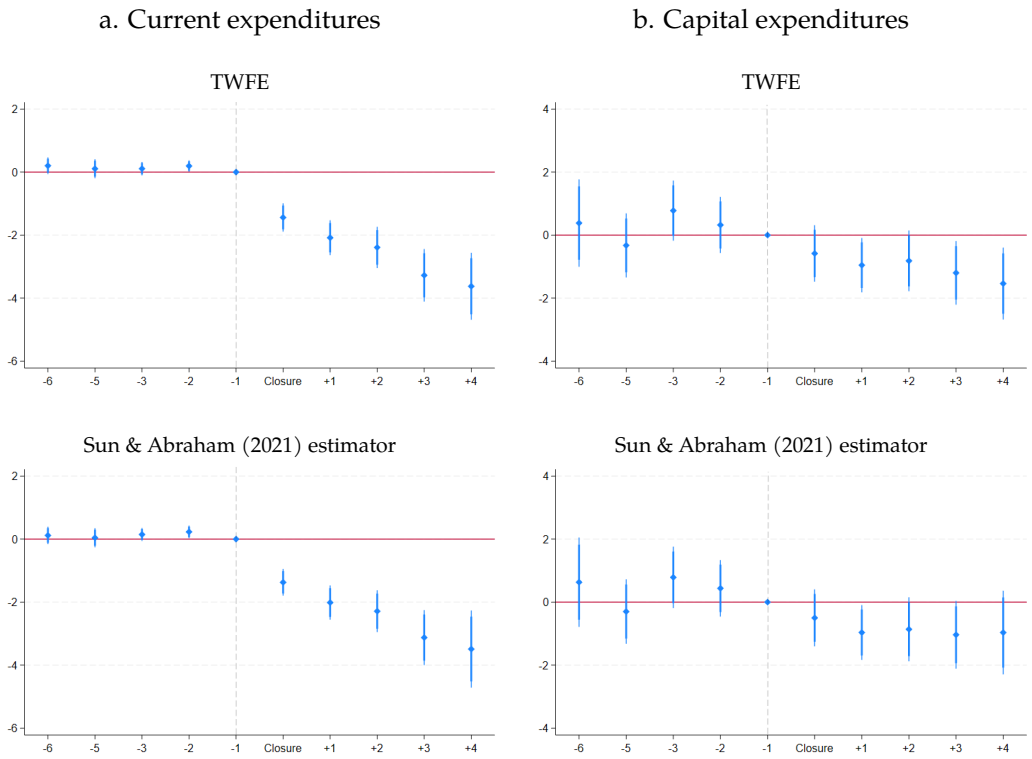
B Fixed costs of primary schools

School rationalisation policies were intended to reduce the number of undersized primary schools, and in doing so cut public expenses. Every school has fixed costs of maintenance and the closure of schools would entail saving public resources. Using the same kind of event study model of equation 2, we can also visualise the evolution of fixed costs in primary schools experiencing closures. Exploiting data on municipal public accounts, available until 2015, we can look specifically at primary school spending at the municipal level and observe its variation year-by-year before and after school closure. Hence, we re-estimate model 2 using (log) current and capital expenditures for primary school per-inhabitant as outcomes, for our sample of single-primary-school municipalities.

Current expenditures refer to spending for ordinary management (e.g. public employees' salaries, maintenance, rents for public buildings) and it is generally low-changing or constant, while capital expenditures refer to public investments (e.g. public procurement tenders, building acquisition) and it is more likely to be fluctuating and characterised by peaks and lows. The estimates are reported in Panels a and b of Figure B1.

No coefficient of dummy variables referring to the pre-closure period emerges as statistically significant, suggesting that spending patterns of treated and control municipalities are very similar prior to school closures. Primary school budgets of municipalities mainly concern school infrastructure maintenance and utility bills, while school personnel is financed by the central government. As infrastructure maintenance and utilities represent fixed costs independent of school size, it comes as no surprise that pre-closure spending appears to be evolving similarly across treatment and control units. Even if school population is decreasing in the years preceding closure, these expenditures are constant as long as the only primary school in the municipality is active. As expected, we observe a very sharp reduction of expenditures for primary schools following the closures, both in the current and the capital expenditures of the treated municipalities. The fact that some municipalities exhibit non-zero expenditures after the closing year does not imply that schools remain open for some time after the official closing date. Rather, it refers to some outstanding municipal transfers to be paid to other entities (*Trasferimenti*), or other forms of services to primary school-age pupils (*Fornitura di servizi*).

Figure B1: Municipal expenditures for primary schools

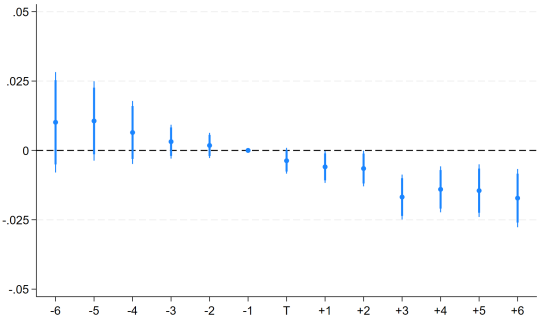


The Figure shows event study plots corresponding to equation 2, using as dependent variable (log) current expenditures for primary schools per inhabitant (Panel a); (log) capital expenditures for primary schools per inhabitant (Panel b). Top plots are obtained with Two-Way-Fixed-Effects estimator, bottom plots are obtained employing the estimator proposed by Sun and Abraham (2021), which corrects for possible heterogeneous treatment effects across cohorts. Event time corresponds to the year of primary school closure. Thicker confidence intervals refer to 90% level, thinner ones to 95%.

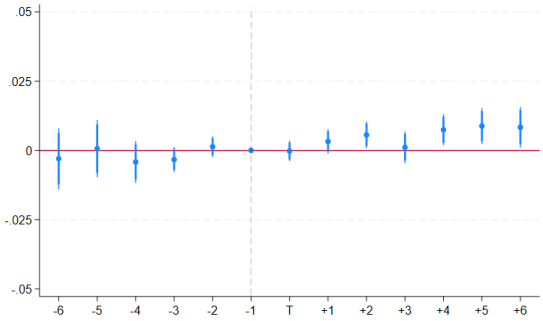
C Additional results

Figure C1: Event study plots of the reduced-form estimation: income

a. Total income

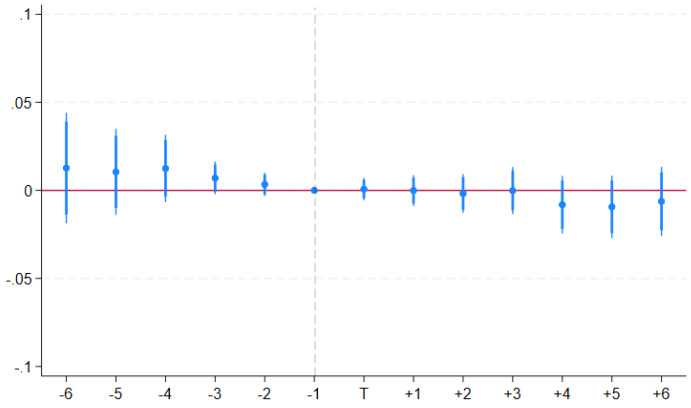


b. Income per-capita



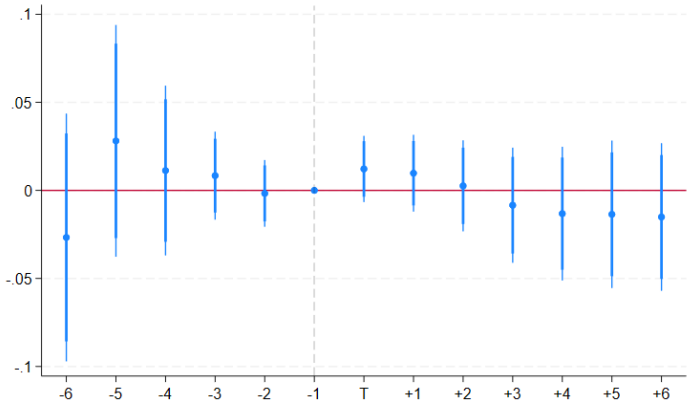
The Figure shows the event study plots corresponding to the reduced form of equation 2, where dependent variable is (log) total (Panel a) or (log) per-capita income (Panel b). Those outcome variables are regressed on leads and lags of the instrument. The sample is restricted to schools with up to 50 students above or below the regional threshold as of s.y. 2008-10. Thicker confidence intervals refer to 90% level, thinner ones to 95%.

Figure C2: Event study plot of the reduced-form estimation: elder population



The Figure shows the event study plot corresponding to the reduced form of equation 2, where dependent variable is (log) population between 55 and 64 years old. The outcome variables is regressed on leads and lags of the instrument. We interpret the plot as a sort of placebo, since we do not expect residents in that age class to be affected by school closures, while they are plausibly still in the labour market. The sample is restricted to schools with up to 50 students above or below the regional threshold as of s.y. 2008-10. Thicker confidence intervals refer to 90% level, thinner ones to 95%.

Figure C3: Event study plot of the reduced-form estimation: population 0 to 5 years old



The Figure shows the event study plot corresponding to the reduced form of equation 2, where dependent variable is (log) population below 5 years old. The outcome variables is regressed on leads and lags of the instrument. The instrument achieves parallel trends also for this population group, on which local authorities might base school sizing decisions. The sample is restricted to schools with up to 50 students above or below the regional threshold as of s.y. 2008-10. Thicker confidence intervals refer to 90% level, thinner ones to 95%.

Table C1: OLS estimates (TWFE model)

	School-age population	Potential parents	Total income	Per-capita income	Elder population
Panel a: full sample of all regions					
School closure	-0.096***	-0.041***	-0.019***	0.007***	-0.011
	(0.0124)	(0.0063)	(0.0038)	(0.0024)	(0.0079)
Other school endowments	✓	✓	✓	✓	✓
Municipality fe	✓	✓	✓	✓	✓
LLM-year fe	✓	✓	✓	✓	✓
N	49,932	49,932	49,909	49,909	49,932
Panel b: regions with school-sizing threshold					
School closure	-0.085***	-0.035***	-0.016***	0.008**	-0.004
	(0.0170)	(0.0090)	(0.0052)	(0.0032)	(0.0107)
Other school endowments	✓	✓	✓	✓	✓
Municipality fe	✓	✓	✓	✓	✓
LLM-year fe	✓	✓	✓	✓	✓
N	21,552	21,552	21,538	21,538	21,552

Standard errors clustered at municipal level in parentheses. * p<0.10, ** p<0.05, *** p<0.01. Results of the OLS estimation of equation 1 on the sample of single-primary-school municipalities in regions adopting thresholds for school sizing. We regress school-age population, potential parents, total income, per-capita income and elder population on school closure. All specifications include controls for other school endowments, municipality and LLM-year fixed effects. Panel a: full sample of all single-primary-school municipalities; Panel b: sample of all single-primary-schools in regions with thresholds.

Table C2: OLS and IV estimation without including LLM fixed effects

	School-age population	Potential parents	Total income	Per-capita income	Elder population
Panel a: OLS estimation					
School closure	-0.100***	-0.040***	-0.029***	0.004	-0.002
	(0.0163)	(0.0091)	(0.0056)	(0.0034)	(0.0116)
Other school endowments	✓	✓	✓	✓	✓
Municipality fe	✓	✓	✓	✓	✓
Year fe	✓	✓	✓	✓	✓
N	21,928	21,928	21,914	21,914	21,928
Panel b: IV estimation - Dummy instrument					
School closure	-0.295***	-0.273***	-0.227***	0.054***	-0.121***
	(0.0593)	(0.0391)	(0.0286)	(0.0137)	(0.0438)
Other school endowments	✓	✓	✓	✓	✓
Municipality fe	✓	✓	✓	✓	✓
Year fe	✓	✓	✓	✓	✓
N	21,928	21,928	21,914	21,914	21,928
Panel c: IV estimation - Kink instrument					
School closure	-0.231***	-0.121***	-0.168***	0.004	-0.014
	(0.0498)	(0.0284)	(0.0217)	(0.0102)	(0.0373)
$(Students - c)_{icr,2008-10} \cdot T_{rt}$	✓	✓	✓	✓	✓
Other school endowments	✓	✓	✓	✓	✓
Municipality fe	✓	✓	✓	✓	✓
Year fe	✓	✓	✓	✓	✓
N	21,928	21,928	21,914	21,914	21,928

Clustered standard errors at municipal level in parentheses; * p<0.10, ** p<0.05, *** p<0.01. The Table reports OLS (Panel a) and IV - second stage (Panel b and c) results, respectively from equations 1, 4, and 7, but taking out from these specification LLM dummies. The estimation sample is that of all single-primary-schools in regions adopting thresholds.

Table C3: Dummy IV, second stage results: all single-primary-school municipalities in regions with thresholds

	School-age population	Potential parents	Total income	Per-capita income	Elder population
School closure	-0.222***	-0.228***	-0.110***	0.077***	-0.052
	(0.0594)	(0.0364)	(0.0212)	(0.0143)	(0.0420)
N	21,552	21,552	21,538	21,538	21,552
Other school endowments	✓	✓	✓	✓	✓
Municipality fe	✓	✓	✓	✓	✓
LLM-year fe	✓	✓	✓	✓	✓

Clustered standard errors at municipal level in parentheses; * p<0.10, ** p<0.05, *** p<0.01. Second stage results from the TSLS estimation of equation 4, regressing school-age population, potential parents, total income, per-capita income and elder population on school closure. School closure is instrumented with a dummy indicator for the school being below the regional threshold in 2008-10, from the year of its introduction. All specifications include controls for other school endowments, municipality and LLM-year fixed effects. All single-primary-schools in regions adopting thresholds.

Table C4: IV estimation, second stage results for alternative placebo outcome

	Resident population between 20 and 35 years old		
	Dummy IV		Kink IV
School closure	-0.066	-0.091	-0.060
	(0.0493)	(0.0646)	(0.0424)
$(Students - c)_{icr,2010} \cdot T_{rt}$			✓
Other school endowments	✓	✓	✓
Municipality fe	✓	✓	✓
LLM-year fe	✓	✓	✓
N	21,552	13,374	21,552

Clustered standard errors at municipal level in parentheses; * p<0.10, ** p<0.05, *** p<0.01. Columns 1 and 2 report second stage estimates corresponding to equation 4 for the resident population between 20 and 35 years old, instrumenting closure with the dummy instrument. Column 1: sample of all single-primary-schools in regions adopting thresholds; column 2: sample of schools with up to 50 students above or below the regional threshold as of s.y. 2008-10. Column 3 repeat the same exercise on the full sample using the kink instrument; namely, it reports second stage estimates from equation 7 employing resident population between 20 and 35 years old as dependent variable. All specifications include controls for other school endowments, municipality and LLM-year fixed effects.

Table C5: IV estimation, second stage results with alternative bandwidth choices: from 55 to 35 students around the threshold

	School-age population	Potential parents	Total income	Per-capita income	Elder population
*Panel a: Schools with up to **55 students** above/below threshold*					
School closure	-0.168**	-0.181***	-0.116***	0.045***	-0.061
	(0.0704)	(0.0423)	(0.0263)	(0.0166)	(0.0517)
N	14,068	14,068	14,064	14,064	14,068
*Panel b: Schools with up to **45 students** above/below threshold*					
School closure	-0.165**	-0.181***	-0.117***	0.034*	-0.070
	(0.0770)	(0.0456)	(0.0286)	(0.0177)	(0.0559)
N	12,640	12,640	12,634	12,634	12,640
*Panel c: Schools with up to **40 students** above/below threshold*					
School closure	-0.182**	-0.199***	-0.125***	0.017	-0.066
	(0.0888)	(0.0527)	(0.0326)	(0.0199)	(0.0645)
N	11,598	11,598	11,590	11,590	11,598
*Panel d: Schools with up to **35 students** above/below threshold*					
School closure	-0.178*	-0.186***	-0.111***	0.026	-0.059
	(0.1006)	(0.0583)	(0.0354)	(0.0219)	(0.0710)
N	10,526	10,526	10,518	10,518	10,526
Other school endowments	✓	✓	✓	✓	✓
Municipality fe	✓	✓	✓	✓	✓
LLM-year fe	✓	✓	✓	✓	✓

Standard errors clustered at municipal level in parentheses. * p<0.10, ** p<0.05, *** p<0.01. Second stage results from the TSLS estimation of equation 4, regressing school-age population, potential parents, total income, per-capita income and elder population on school closure, instrumented with an indicator for the school being below the regional threshold in 2008-10, from the year of its introduction. All specifications include controls for other school endowments, municipality and LLM-year fixed effects. Panel from a to d refer, respectively, to the sample of schools with at most 55 t0 35 students above/below the regional threshold in 2008-10, progressively reducing bandwidths.

Table C6: School closure effect by municipality location: all municipalities in regions with threshold

	School-age population		Potential parents		Total income	
	far	*close*	*far*	*close*	*far*	*close*
Panel a: ***distance from LLM centres***						
School closure	-0.259**	-0.117	-0.261***	-0.138***	-0.146***	-0.037
	(0.1063)	(0.0787)	(0.0613)	(0.0475)	(0.0388)	(0.0257)
N	8,244	12,802	8,244	12,802	8,240	12,792
Panel b: ***distance from the next public school***						
School closure	-0.448***	-0.072	-0.287***	-0.201***	-0.168***	-0.065**
	(0.1125)	(0.0763)	(0.0629)	(0.0478)	(0.0370)	(0.0275)
N	8,016	12,696	8,016	12,696	8,012	12,686
Other school endowments	✓	✓	✓	✓	✓	✓
Municipality fe	✓	✓	✓	✓	✓	✓
LLM-year fe	✓	✓	✓	✓	✓	✓

Standard errors clustered at municipal level in parentheses. * p<0.10, ** p<0.05, *** p<0.01. Second stage results from equation 4, where dependent variables are school-age population, potential parents and total income. School closure instrumented with $Dummy\,IV_{irt}$. In Panel a we subdivide our sample by distance to LLM centres and separately estimate equation 4 for municipalities above (far) or below (close) the mean distance from LLM centres. In Panel b, we follow consider distance from the closest public primary school. Sample of all municipalities with one primary school in regions with threshold.

Table C7: School closure effect by municipality location, interaction term - Dummy instrument

	School-age population	Potential parents	Total income
Panel a: ***distance from LLM centres***			
School closure × *far*	-0.226**	-0.167**	-0.160***
	(0.1143)	(0.0659)	(0.0404)
School closure	-0.009	-0.072	-0.012
	(0.1112)	(0.0645)	(0.0370)
N	13,374	13,374	13,370
Panel b: ***distance from next public school***			
School closure × *far*	-0.409***	-0.265***	-0.193***
	(0.1273)	(0.0786)	(0.0475)
School closure	0.004	-0.085*	-0.046
	(0.0805)	(0.0485)	(0.0285)
N	13,002	13,002	12,998
Other school endowments	✓	✓	✓
Municipality fe	✓	✓	✓
LLM-year fe	✓	✓	✓

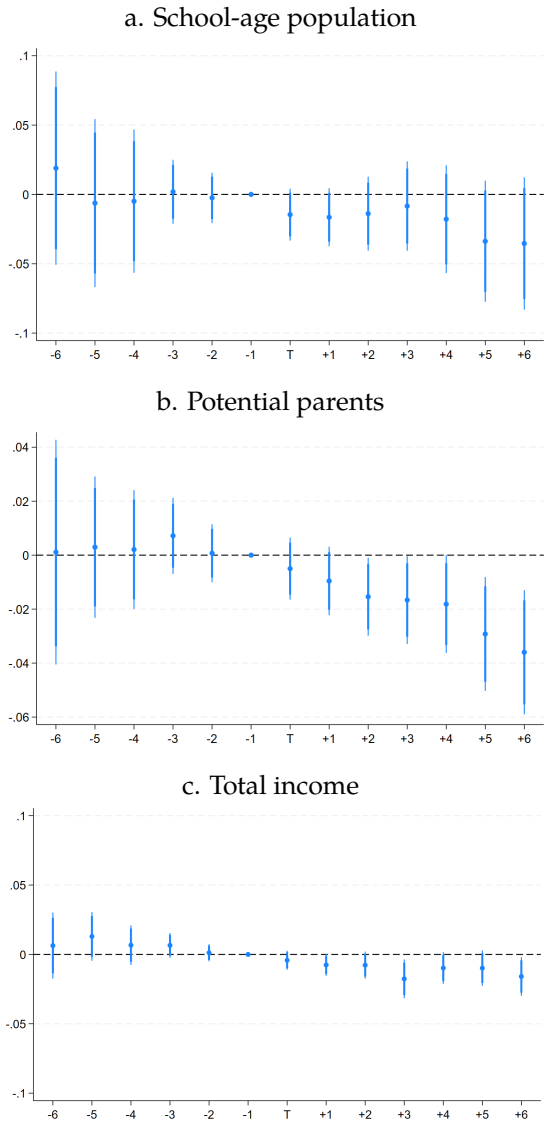
Standard errors clustered at municipal level in parentheses. * p<0.10, ** p<0.05, *** p<0.01. Second stage results from equation 4, where dependent variables are school-age population, potential parents and total income. In Panel a we add to the specification of equation 4 the interaction between school closure and an indicator taking value one if the municipality is above the mean distance from LLM centre. In Panel b we consider distance from the closest public primary school. School closure instrumented with $Dummy\ IV_{irt}$; interaction term instrumented with $Dummy\ IV_{irt}$ × *far*. Sample of schools ± 50 students from regional thresholds.

Table C8: School closure effect by municipality location, interaction term - Kink instrument

	School-age population	Potential parents	Total income
Panel a: ***distance from LLM centres***			
School closure × *far*	-0.205**	-0.122**	-0.088***
	(0.0861)	(0.0475)	(0.0294)
School closure	0.025	-0.042	-0.043*
	(0.0689)	(0.0385)	(0.0227)
N	21,552	21,552	21,538
Panel b: ***distance from next public school***			
School closure × *far*	-0.221***	-0.139***	-0.126***
	(0.0849)	(0.0482)	(0.0305)
School closure	0.005	-0.057*	-0.046**
	(0.0520)	(0.0330)	(0.0195)
N	21,168	21,168	21,154
$(Students - c)_{icr,2008-10} \cdot T_{rt}$	✓	✓	✓
Other school endowments	✓	✓	✓
Municipality fe	✓	✓	✓
LLM-year fe	✓	✓	✓

Standard errors clustered at municipal level in parentheses. * p<0.10, ** p<0.05, *** p<0.01. Second stage results from equation 7, where dependent variables are population of potential parents and total income. In Panel a we add to the specification of equation 7 the interaction between school closure and an indicator taking value one if the municipality is above the mean distance from LLM centre. In Panel b we consider distance from the closest public primary school. School closure instrumented with $Kink\,IV_{irt}$; interaction term instrumented with $Kink\,IV_{irt}$ × *far*. Full sample of single-primary schools in regions with threshold.

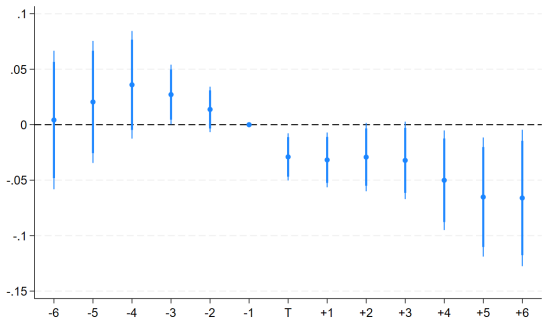
Figure C4: Event study plots of the reduced-form estimation: municipalities far from LLM centres



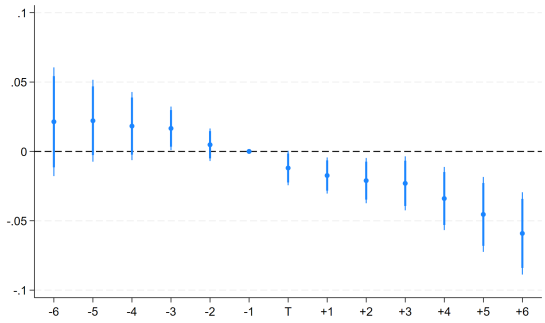
The Figure shows the event study plots corresponding to the reduced form of equation 2. Dependent variables: (log) school-age population (Panel a), (log) potential parents population (Panel b), total income (Panel c). Those outcome variables are regressed on leads and lags of the $Dummy\,IV_{irt}$. The sample is composed of single-primary-school municipalities of regions with school-sizing thresholds above the mean distance from Local Labour Market centres. Sample further restricted to schools with up to 50 students above or below the regional threshold as of s.y. 2008-10. Thicker confidence intervals refer to 90% level, thinner ones to 95%.

Figure C5: Event study plots of the reduced-form estimation: municipalities far from next primary school

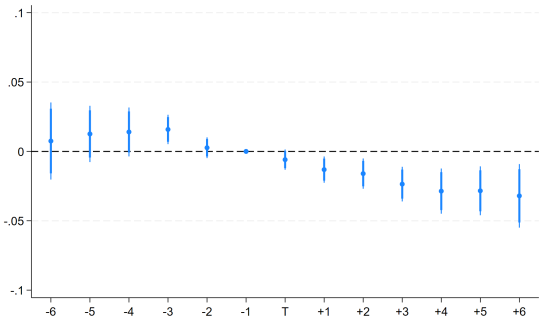
a. School-age population



b. Potential parents

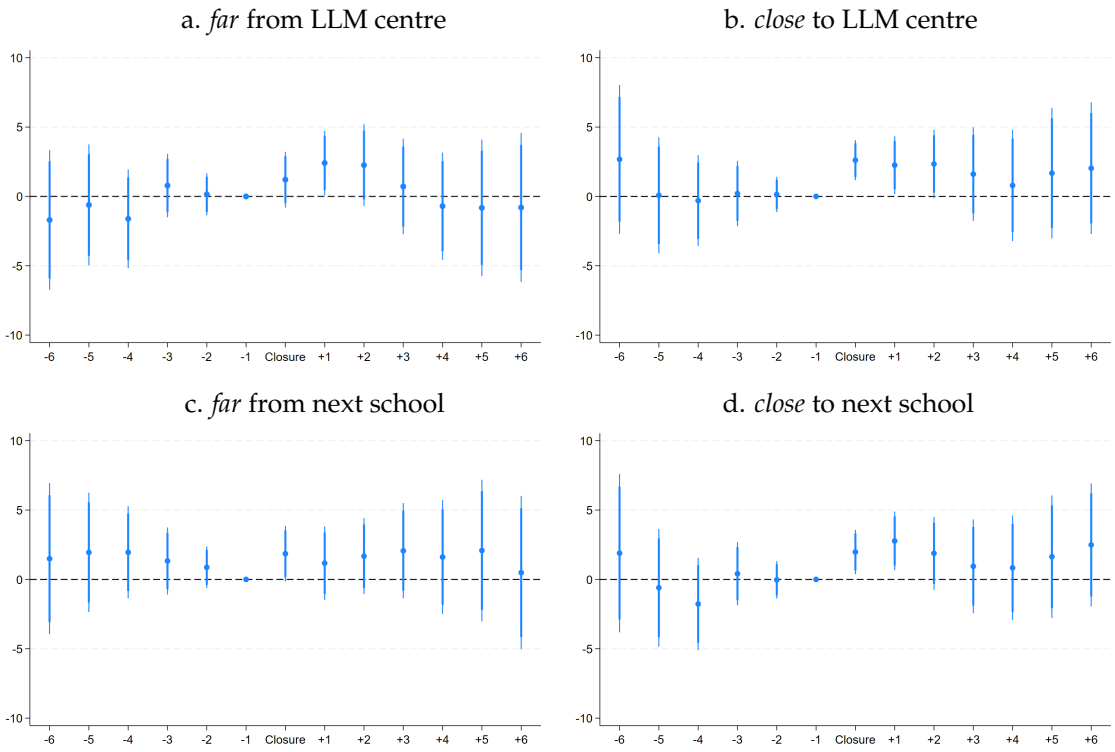


c. Total income



The Figure shows the event study plots corresponding to the reduced form of equation 2. Dependent variables: (log) school-age population (Panel a), (log) potential parents population (Panel b), total income (Panel c). Those outcome variables are regressed on leads and lags of the $Dummy\,IV_{irt}$. The sample is composed of single-primary-school municipalities of regions with school-sizing thresholds above the mean distance from the next available primary school. Sample further restricted to schools with up to 50 students above or below the regional threshold as of s.y. 2008-10. Thicker confidence intervals refer to 90% level, thinner ones to 95%.

Figure C6: Neighbouring enrolment - event study



The Figure shows event study plots corresponding to equation 2, where the dependent variable is the number of students enrolled in primary school per municipality. Sample of municipalities never experiencing school closure. Leads and lags relative to the closure of a school in a neighbouring municipality. Panel a(b) refers to municipalities above(below) the median distance from the centre of the corresponding LLM, Panel c(d) refers to municipalities above(below) the median distance from the next primary school.

Table C9: First stage - analysis at Local Labour Market level

	Number of school closures
Panel a: ***LLMs without provincial city***	
LLM IV	0.185***
	(0.0260)
F-test	50.46
N	2,160
Panel b: ***LLMs with provincial city***	
LLM IV	0.139***
	(0.0422)
F-test	10.85
N	492
Other school endowments	✓
LLM fe	✓
Region-year fe	✓

Clustered standard errors at LLM level in parentheses; * p<0.10, ** p<0.05, *** p<0.01. First stage estimation of equation 10, regressing LLM-level school-age population, potential parents, and total income on the cumulative number of single-primary-school closures occurred in that LLM at any given year over the 2008-19 period. Sample of all LLMs in regions adopting thresholds, excluding cross-region LLMs.