Supplementary material to:
Long term impacts of class size in compulsory school

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Contents

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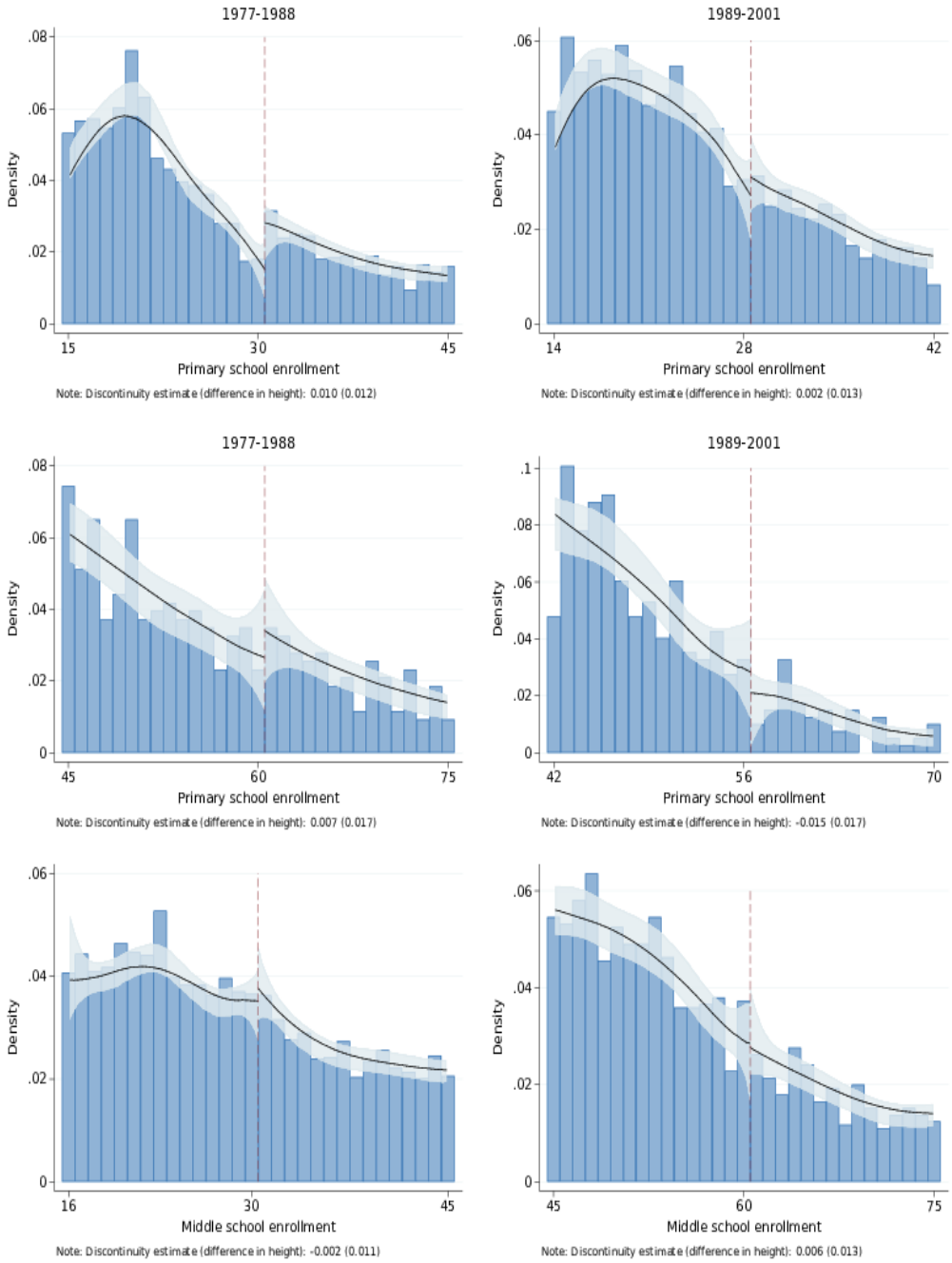
1 Manipulation of the running variable

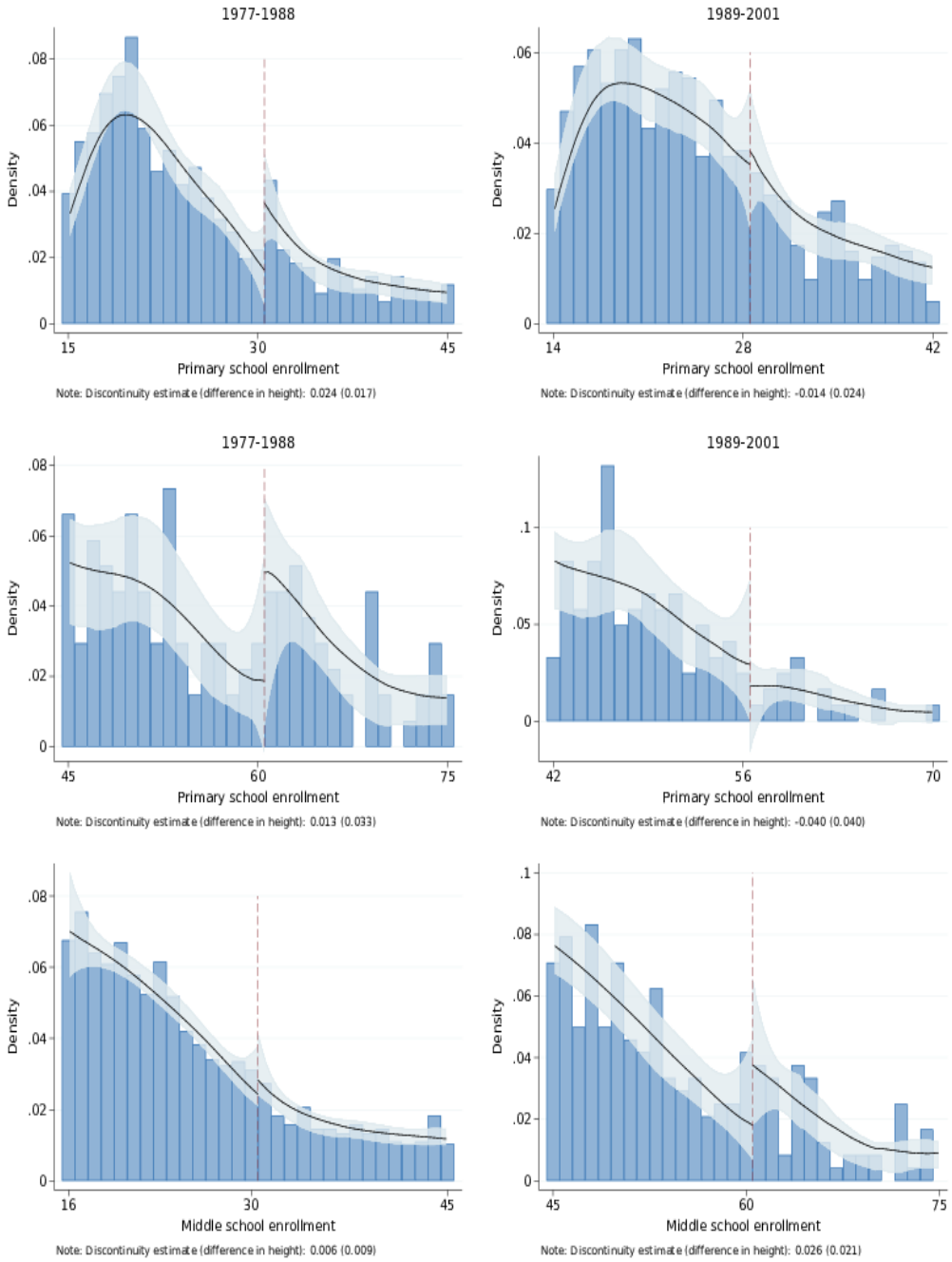
1.1 Bunching

We formally test for bunching following Cattaneo, Jansson and Ma (2017b; 2017a). This method is robust to bin size selection issues with discrete running variables that is common in the popular McCrary density test described in McCrary (2008). While there are visible signs of bunching around some of the discontinuities, we fail to reject the null hypothesis of no bunching. These tests are all preformed on the full sample, while in our main analysis use a donut strategy that excludes observations close to the thresholds and thus removes any visible signs of bunching. Note also that the *rddensity* test requires a higher order local polynomial for the standard errors than for the point estimate (quadratic and cubic are standard), which means that the point estimates on the figures below are not necessarily exactly in the center of the 95 percent confidence interval.



Notes: These figures and tests were generated by the *rddensity* package for Stata using default settings on the sample of students who graduated between 1978 and 2001 from a combined school.

Figure W1. Nonparametric density tests of enrollment manipulation – Combined schools sample



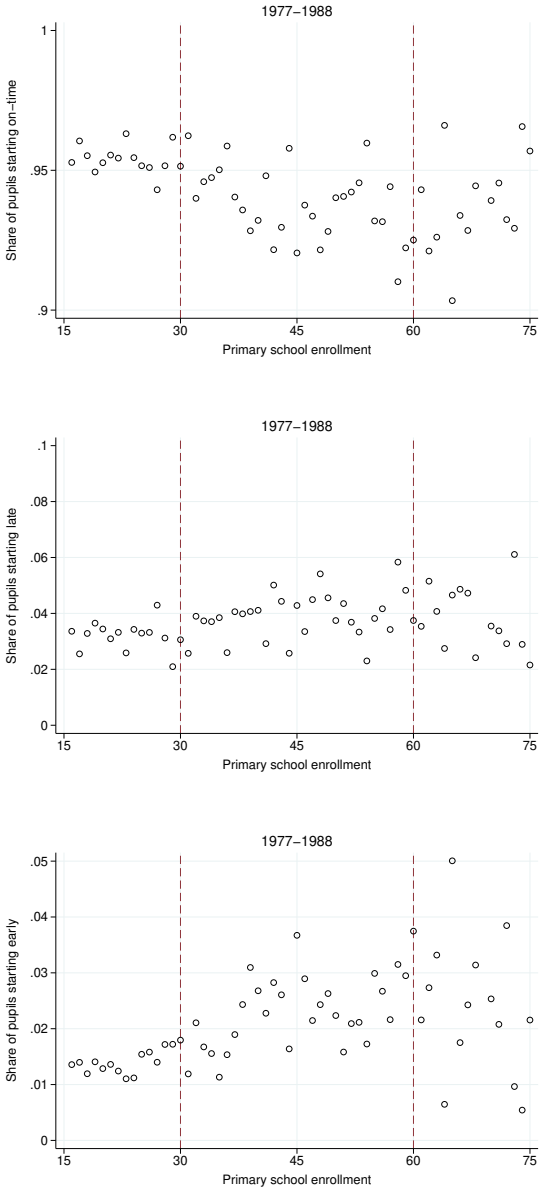
Notes: These figures and tests were generated by the *rddensity* package for Stata using default settings on the baseline sample of students who graduated between 1978 and 2001 from a combined school that does not take-up students from other primary schools.

Figure W2. Nonparametric density tests of enrollment manipulation – Baseline school sample

1.2 Manipulation by the school administrator

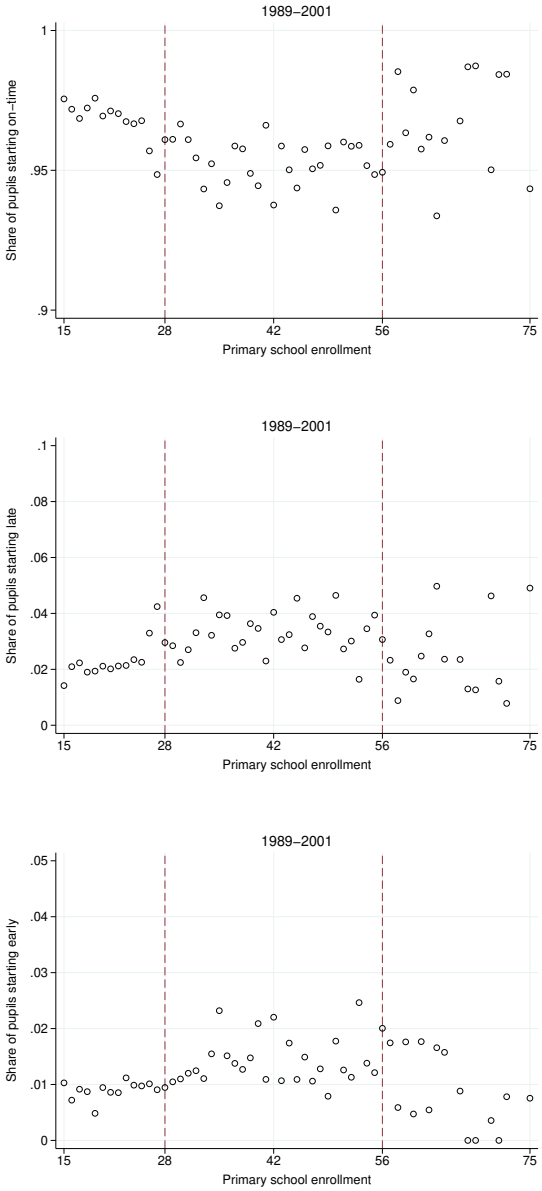
One potential source of bunching may arise from strategic behavior on part of school administrators. Angrist et al. (2017) point out that school administrators in Israel have considerable discretion whether or not to approve applications from families who want to advance or delay the school starting age of their child. If school administrators use this discretion strategically they are able to manipulate the maximum class size running variable in such a way that minimizes the number of classes. This sort of manipulation can be a threat to the validity of the regression discontinuity design. To address this issue Angrist et al. (2017) use a donut strategy which excludes observations of enrollment close to the discontinuity.

In Norway the school starting age is not often postponed or advanced, but if this decision is taken it is by the municipality and not the school administration, probably reducing the likelihood of the strategic behavior observed in for example Israel. However, manipulation of this type can potentially be difficult to uncover using standard balancing tests. Investigating whether the share of pupils that start compulsory school at the stipulated time is discontinuous at the maximum class size thresholds will provide a clear indication that the administrators are manipulating the running variable. Figures W3 and W4 show how the average probability of finishing at the stipulated time change with primary school enrollment. We find no indications of manipulation of the school enrollment by discretionary enforcement of the school starting age rule.



Notes: This figure show the share of students in the sample of students who graduated from a combined school between 1978 and 1988 who start primary school at the stipulated age (top), start school late (middle), or start school early (bottom). Administrators can control the number of classes by using discretion when approving applications of early or delayed school entry. If this is happening we would expect to see bunching on the right side of the maximum class size cut-offs (and possibly missing mass on the left side).

Figure W3. Primary school starting age (1977-1988)



Notes: This figure show the share of students in the sample of students who graduated from a combined school between 1989 and 2001 who start primary school at the stipulated age (top), start school late (middle), or start school early (bottom).If administrators control the number of classes by using discretion when approving applications of early or delayed school entry we would expect to see bunching on the right side of the maximum class size cut-offs (and possibly missing mass on the left side).

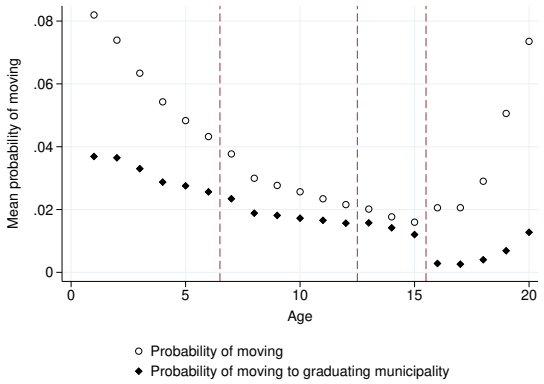
Figure W4. Primary school starting age (1989-2001)

1.3 Manipulation by the family

Another possible form of running variable manipulation arise from families moving strategically. If well-informed families, at least partly, base their choice to move on expected change in class size this could potentially threaten our identification strategy. Manipula-

tion of this type should show up in balancing checks if high ability type families are more likely to move strategically.

Movers identified by change in municipality of residency Figure W5 shows the average probability at each age that the pupil resides in the same municipality of as that of the compulsory school from which it graduates at age 15[3]. The probability of living in the same municipality as the school municipality reach 98.2 percent at age 15, which is the stipulated year of graduation. The main reason why this number of is below 100 is that a small number of children go to school in a different municipality than that which they currently reside.

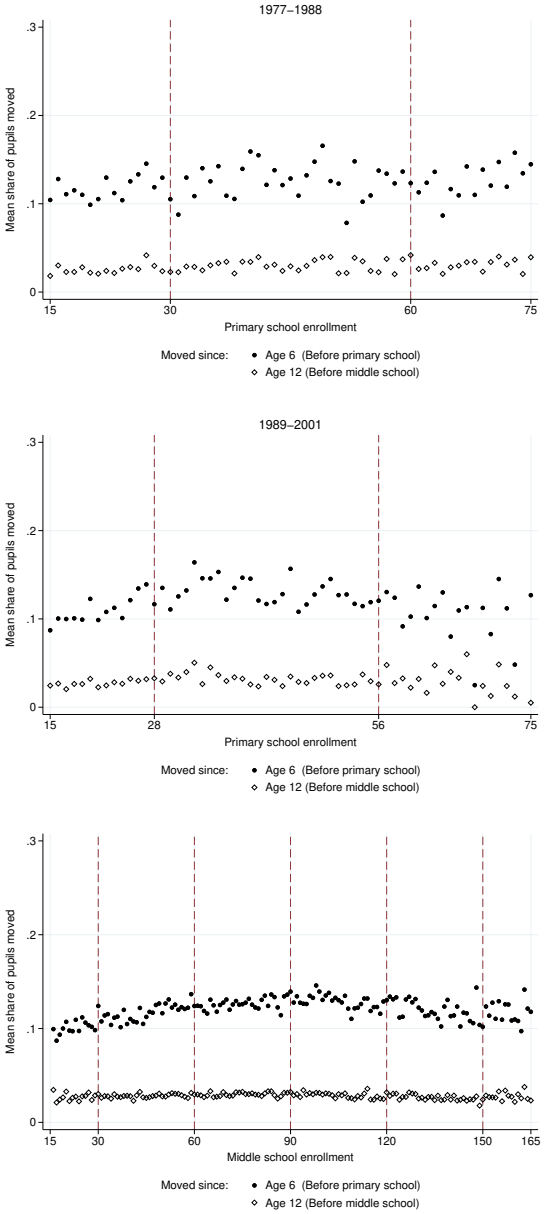


Notes: This Figure shows the probability of moving between municipalities by age for the sample of students who graduated between 1978 and 2001 from a combined school. The black diamonds represent the probability of a student moving to the municipality from which they graduate. The vertical lines separate the ages in which the pupils are enrolled in primary and middle school.

Figure W5. Residential moves by age – Combined schools

The following figures show the probability that a child will be living in the same municipality of the school the will be graduating from at different ages, as a function of school enrollment.

[3]Age is measured at the start of the year. Some students can be 16 when they graduate at the end of the spring semester



Notes: These Figures show the probability that students graduating from compulsory school were living in a different municipality at earlier ages.

Figure W6. Residential moves by school enrollment – Compulsory schools

The following tables shows the first stage estimates of the maximum class size rule on probability that a child will be living in the same municipality of the school the will be graduating from at different ages.

Table W1. Reduced form of class size rule threshold on residential moves – Combined schools

	Not moved since:					
	Age 4	Age 6	Age 7	Age 10	Age 11	Age 13
Above PS threshold	0.0007	0.0005	0.0058	0.0064	0.0064	-0.0027
	(0.0123)	(0.0107)	(0.0097)	(0.0075)	(0.0070)	(0.0066)
Above MS threshold	-0.0030	-0.0024	-0.0058	-0.0052	-0.0020	0.0048
	(0.0085)	(0.0073)	(0.0071)	(0.0056)	(0.0051)	(0.0045)
N schools	682	682	682	682	682	682
N pupils	163,785	163,785	163,785	163,785	163,785	163,785

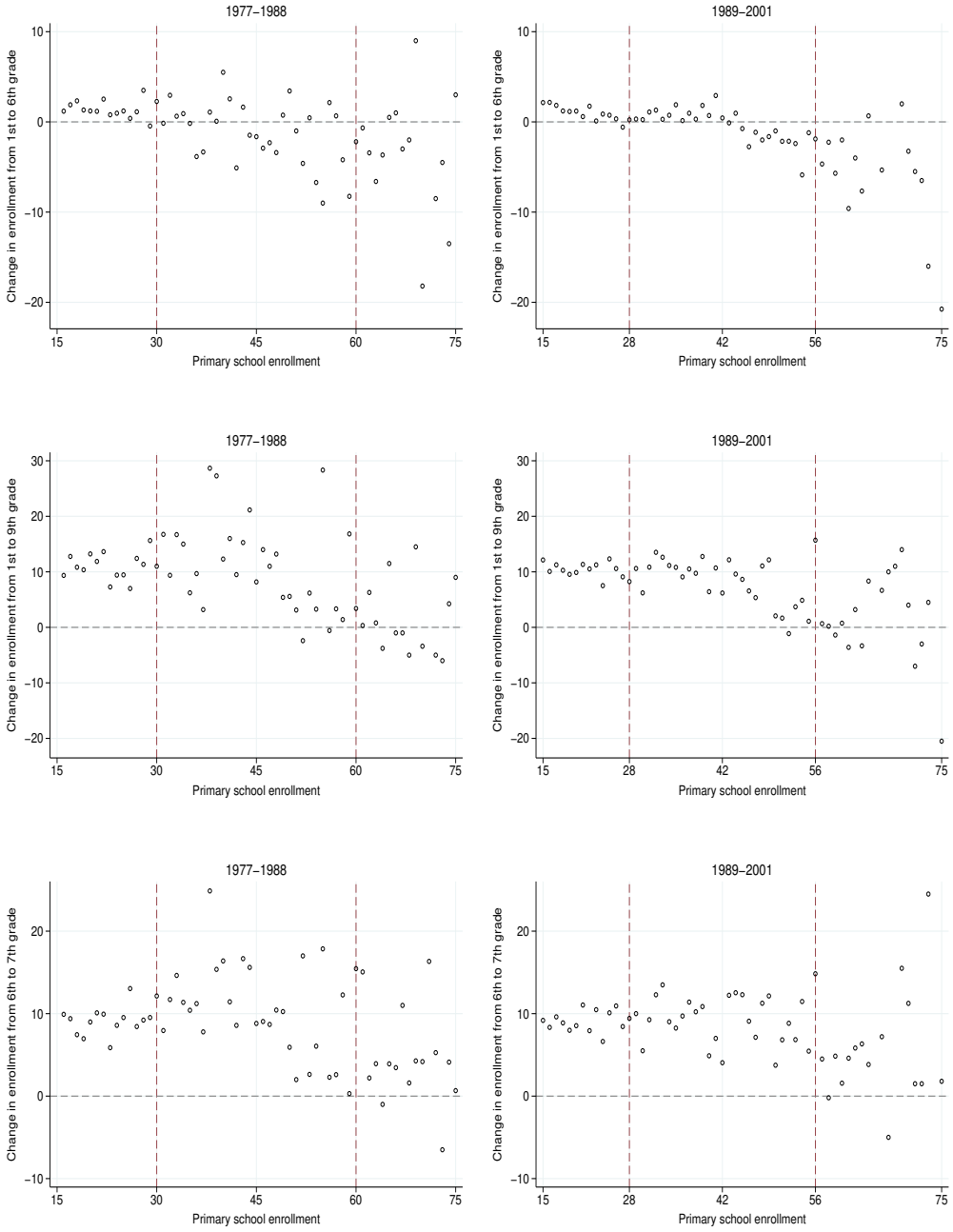
Notes: Estimates for the baseline sample of students who graduated between 1978 and 2001 from a combined school. Each column show the reduced form effect of being above the maximum class size threshold on not having moved at different ages. The indicator function is equal to one if the pupil lives in the same municipality at the specified age as the school from which they graduate at the age of 15. Age is measured at the start of the year. The regressions control for segment and segment specific linear splines in primary school enrollment interacted with maximum class-size regime. All regressions also include year of graduation fixed effects, individual background controls for gender, parental education, immigrant background, month of birth, and age at graduation. Standard errors clustered at the school level are reported in parentheses.

Table W2. Reduced form of class size rule threshold on residential moves – Baseline sample

	Not moved since:					
	Age 4	Age 6	Age 7	Age 10	Age 11	Age 13
Above PS threshold	0.0079	0.0082	0.0053	0.0191	0.0123	-0.0026
	(0.0224)	(0.0191)	(0.0177)	(0.0136)	(0.0133)	(0.0114)
Above MS threshold	-0.0144	-0.0139	-0.0151	-0.0170	-0.0129	-0.0003
	(0.0196)	(0.0168)	(0.0154)	(0.0112)	(0.0108)	(0.0093)
N schools	395	395	395	395	395	395
N pupils	43,765	43,765	43,765	43,765	43,765	43,765

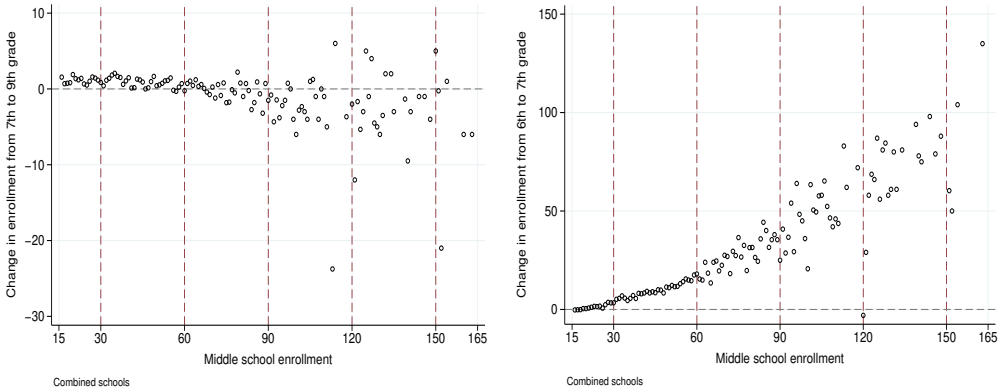
Notes: Estimates for the baseline sample of students who graduated between 1978 and 2001 from a combined school that does not take-up students from other primary schools. Each column show the reduced form effect of being above the maximum class size threshold on not having moved at different ages. The indicator function is equal to one if the pupil lives in the same municipality at the specified age as the school from which they graduate at the age of 15. Age is measured at the start of the year. The regressions control for segment and segment specific linear splines in primary school enrollment interacted with maximum class-size regime. All regressions also include year of graduation fixed effects, individual background controls for gender, parental education, immigrant background, month of birth, and age at graduation. Standard errors clustered at the school level are reported in parentheses.

Movers identified using change in enrollment In this section we use information from compulsory school enrollment to investigate whether student body is shifted over the course of compulsory school in a way that suggests manipulation of class size.



Note: These figures show the average within-grade change in compulsory school enrollment by initial primary school enrollment for the baseline sample of students who graduated between 1978 and 2001 from a combined school that does not take-up students from other primary schools.

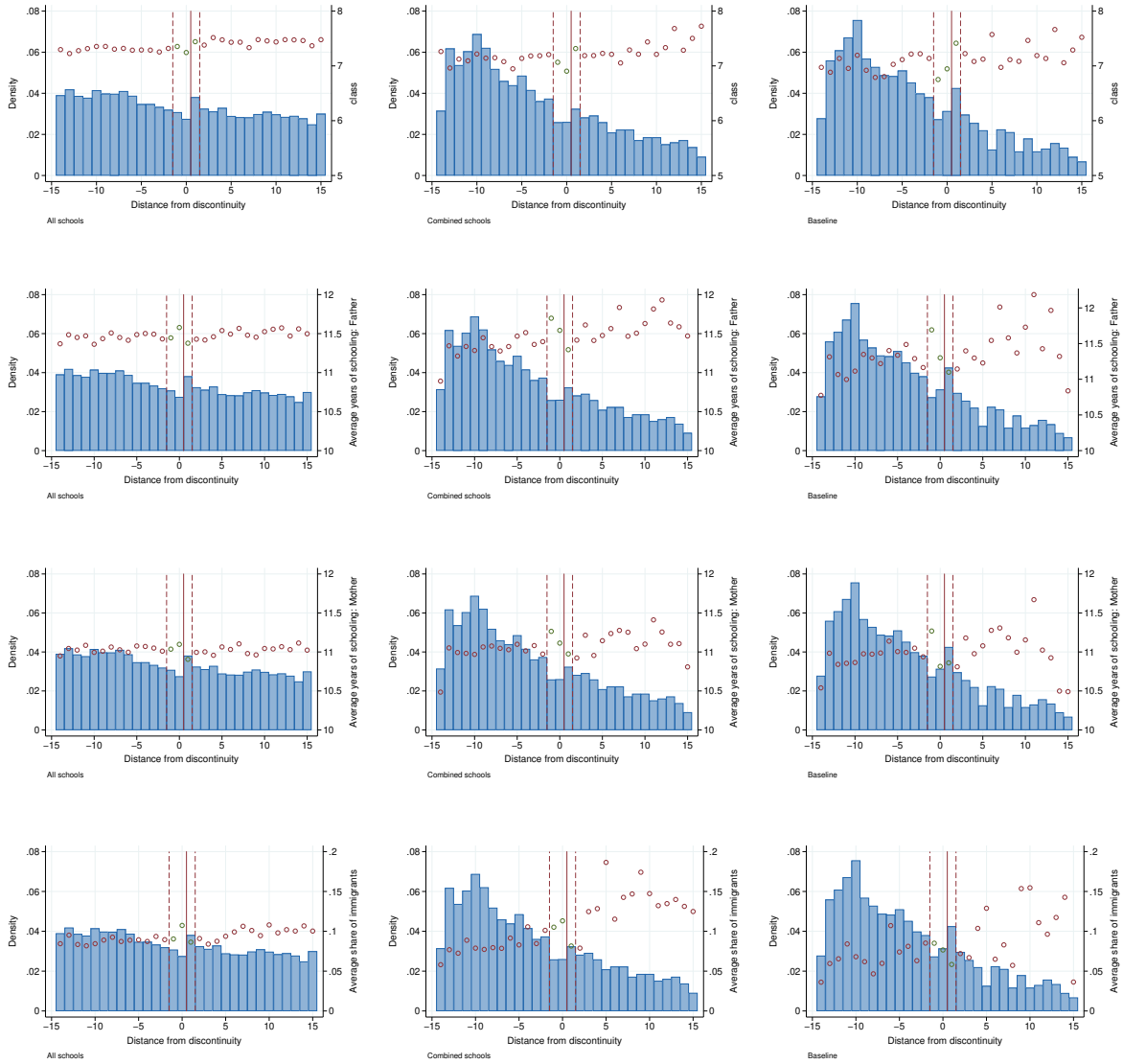
Figure W7. Within-grade change in enrollment by primary school enrollment



Note: These figures show the average within-grade change in compulsory school enrollment by initial middle school enrollment for the baseline sample of students who graduated between 1978 and 2001 from a combined school.

Figure W8. Within-grade change in enrollment by middle school enrollment

1.4 Graphic presentation of balancing tests



Notes: These figures show the distribution of enrollment distance from the discontinuity in primary and middle school, and the mean values of month of birth (first row), years of fathers education (second row), years of mothers education (third row), and immigrant share (fourth row). The figures in the first column are based on the sample of all schools, the second column is based on the sample of all combined schools, while the figures in the last column are based on the baseline sample.

Figure W9. The distribution of enrollment distance from discontinuity – combined schools

2 Measurement error

We only have information on the school from which the pupils graduate at age 15. By assuming that all combined school graduates has been there for the entire compulsory schooling track, we investigate three sources of measurement error.

2.1 Truncated enrollment

Table W3 shows that missing enrollment information is mainly an issue in primary school.

Table W3. Grade where enrollment can be first observed

	# Students		
	Baseline	Combined	All
Primary school:			
1st grade	28,830	106,075	129,006
2nd grade	2,691	10,122	11,554
3rd grade	2,479	8,963	11,275
4th grade	3,892	17,997	19,675
5th grade	2,801	10,868	12,075
6th grade	3,072	9,768	18,644
Sum pupils	43,765	163,785	202,229
Middle school:			
7th grade	43,691	162,040	1,003,762
8th grade	35	1,218	57,778
9th grade	39	527	53,189
Sum pupils	43,765	163,785	1,114,729

Notes: The number of primary school pupils in the all schools sample is larger than in the combined school sample since the combined schools sample exclude observations from school-grades with primary school enrollment lower than 15.

Estimates using the cohorts with complete class size histories Tables W4 through W6 below show the results from different levels of truncation on the baseline subsample.

Table W4. The effect of class size in compulsory school (grades 1-9) on years of schooling – Baseline population

	PS enrollment truncated at:					
	1st grade	2nd grade	3rd grade	4th grade	5th grade	6th grade
A. First Stage						
Above threshold	-7.30**	-7.04**	-6.40**	-7.31**	-7.66**	-7.89**
	(0.47)	(0.50)	(0.57)	(0.50)	(0.53)	(0.47)
F-statistic	242	201	128	216	209	276
B. Reduced Form						
Above threshold	0.094	0.095	0.026	-0.021	0.054	0.079
	(0.072)	(0.072)	(0.065)	(0.066)	(0.065)	(0.063)
C. 2SLS						
Average class size	-0.0080	-0.0024	0.0031	0.0028	-0.0045	-0.0087
	(0.0093)	(0.0089)	(0.0093)	(0.0088)	(0.0076)	(0.0074)
N Schools	394	394	394	394	394	393
N Students	43,258	43,258	43,258	43,258	43,258	43,184

Notes: Estimates for the baseline sample of students who graduated between 1978 and 2001 from a combined school that does not take-up students from other primary schools. All outcomes are measured when the individuals are 27–42 years old. The regressions control for segment and segment specific linear splines in primary school enrollment interacted with maximum class size regime. All regressions also include year of graduation fixed effects, individual background controls for gender, parental education, immigrant background, month of birth, and age at graduation. Standard errors clustered at the school level are reported in parentheses. */** = p-value < 0.10/0.05.

Table W5. The effect of class size in compulsory school (grades 1-9) on log-earnings – Baseline population

	PS enrollment truncated at:					
	1st grade	2nd grade	3rd grade	4th grade	5th grade	6th grade
A. First Stage						
Above threshold	-7.26**	-7.05**	-6.45**	-7.32**	-7.69**	-7.89**
	(0.47)	(0.48)	(0.55)	(0.49)	(0.52)	(0.46)
F-statistic	242	214	137	225	218	290
B. Reduced Form						
Above threshold	-0.003	-0.005	-0.007	-0.001	0.0004	-0.002
	(0.013)	(0.012)	(0.011)	(0.011)	(0.0107)	(0.010)
C. 2SLS						
Average class size	0.0004	0.0012	0.0018	0.0002	0.0003	-0.00004
	(0.0018)	(0.0016)	(0.0017)	(0.0016)	(0.0014)	(0.00134)
N Schools	395	395	395	395	395	394
N Students	43,765	43,765	43,765	43,765	43,765	43,691

Notes: Estimates for the baseline sample of students who graduated between 1978 and 2001 from a combined school that does not take-up students from other primary schools. All outcomes are measured when the individuals are 27–42 years old. The regressions control for segment and segment specific linear splines in primary school enrollment interacted with maximum class size regime. All regressions also include year of graduation fixed effects, individual background controls for gender, parental education, immigrant background, month of birth, and age at graduation. Standard errors clustered at the school level are reported in parentheses. */** = p-value < 0.10/0.05.

Table W6. The effect of class size in compulsory school (grades 1-9) on earnings – Baseline population

	PS enrollment truncated at:					
	1st grade	2nd grade	3rd grade	4th grade	5th grade	6th grade
A. First Stage						
Above threshold	-7.30**	-7.03**	-6.42**	-7.30**	-7.66**	-7.86**
	(0.47)	(0.49)	(0.55)	(0.49)	(0.52)	(0.47)
F-statistic	243	202	134	220	216	283
B. Reduced Form						
Above threshold	-0.017	-0.017	-0.010	-0.011	-0.011	-0.007
	(0.018)	(0.016)	(0.014)	(0.014)	(0.013)	(0.013)
C. 2SLS						
Average class size	0.0020	0.0027	0.0028	0.0013	0.0019	0.0009
	(0.0024)	(0.0021)	(0.0023)	(0.0020)	(0.0018)	(0.0017)
N Schools	398	398	398	398	398	397
N Students	45,668	45,668	45,668	45,668	45,668	45,592

Notes: Estimates for the baseline sample of students who graduated between 1978 and 2001 from a combined school that does not take-up students from other primary schools. All outcomes are measured when the individuals are 27–42 years old. The regressions control for segment and segment specific linear splines in primary school enrollment interacted with maximum class size regime. All regressions also include year of graduation fixed effects, individual background controls for gender, parental education, immigrant background, month of birth, and age at graduation. Standard errors clustered at the school level are reported in parentheses. */** = p-value < 0.10/0.05.

2.2 Exposure to schools for movers

The second source of measurement error comes from pupils who move to the municipality during the compulsory schooling track. By using administrative registry data on person residency we create $e^{PS}_{s(i)}$ and $e^{MS}_{s(i)}$ which measures the share spent in primary school and middle school respectively. If a child moves to the municipality of the school from which he/she will eventually graduate from before 4th grade, then $e^{PS}_{s(i)}$ will be $3/6$ and $e^{MS}_{s(i)}$ will be 1. If the child moves before the start of 8th grade, then $e^{PS}_{s(i)}$ will be 0 and $e^{MS}_{s(i)}$ will be $2/3$.

We use these exposure rates to compute class size in primary and middle school:

$$cs^{PS}_i = e^{PS}_{s(i)} cs^{PS}_{s(i)} + (1 - e^{PS}_{s(i)}) cs^{PS}_{\neg s(i)}$$
$$cs^{MS}_i = e^{MS}_{s(i)} cs^{MS}_{s(i)} + (1 - e^{MS}_{s(i)}) cs^{MS}_{\neg s(i)}$$

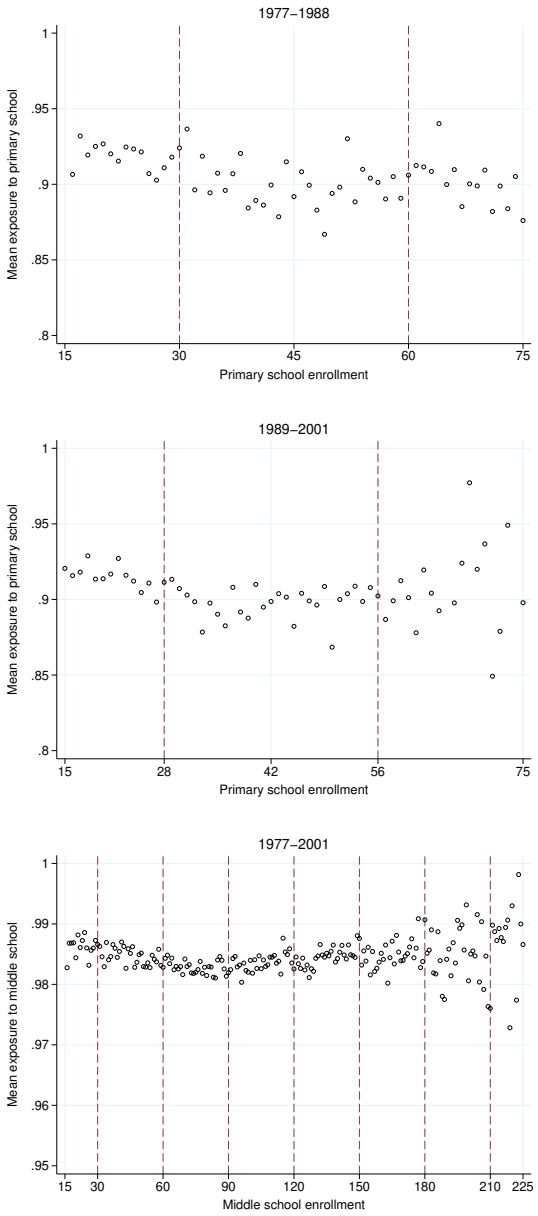


Figure W10. Average share of schooling track spend in graduating combined school

2.3 Inflow from other primary schools

The first source of measurement error comes from combined school graduates that was enrolled in a different primary school. Maximum travel distance restrictions are more restrictive for primary school pupils than for middle school pupils, which means that combined school enrollment is, on average, higher in middle school than in primary school.

We calculate the share of pupil inflow from other school between 6th and 7th grade in combined schools. This relative pupil inflow share is then used to construct the expected primary school class size for the pupils graduating from combined schools.

$$\widehat{cs}^{*} = cs \cdot \hat{p} + \widehat{\tilde{cs}}(1-\hat{p})$$

where $1-\hat{p}$ is the share of pupil inflow in a given combined school. cs is the measured primary school class size in the that school, and $\widehat{\tilde{cs}}$ is the average primary school class size in the municipality that year not including the combined school. If the net inflow of pupils from other primary is negative, meaning that pupils leave for other middle school, we still have complete enrollment histories for the students who graduate and can set the relative inflow coefficient to zero.

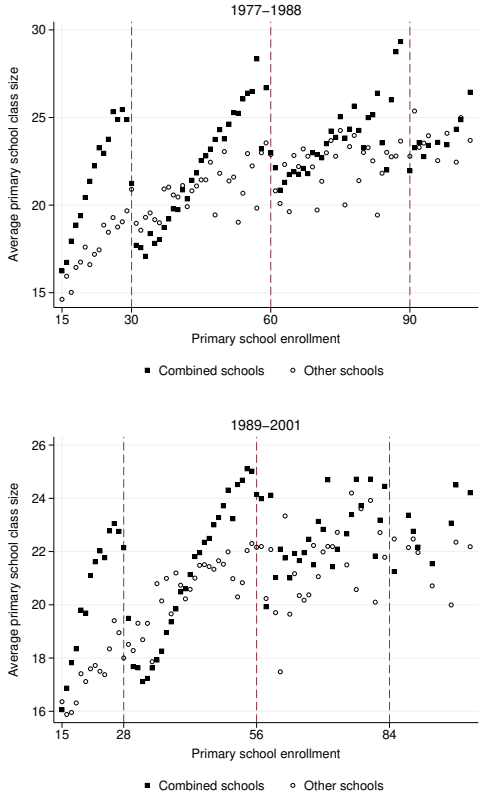


Figure W11. Average class size in combined primary school and other primary schools in municipality

3 Specification checks

3.1 Extended donuts

In this section we provide additional robustness of our donut strategy by excluding schools that fall within a certain proximity to the thresholds.

Tables W7 to W9 below provide results from using symmetric donuts ranging from $\pm$1to $\pm$5 of the thresholds.

Table W7. The effect of class size in compulsory school (grades 1-9) on schooling – Baseline population

	Symmetric donut $\pm n$ from threshold				
	n=1	*n=2*	*n=3*	*n=4*	*n=5*
A. First Stage					
Above threshold	-7.17**	-7.44**	-7.35**	-7.72**	-8.01**
	(0.46)	(0.49)	(0.53)	(0.63)	(0.69)
F-statistic	245	234	191	152	133
B. Reduced Form					
Above threshold	0.101	0.095	0.037	-0.006	-0.046
	(0.072)	(0.083)	(0.087)	(0.089)	(0.106)
C. 2SLS					
Average class size	-0.0090	-0.0097	-0.0023	0.0035	0.0122
	(0.0095)	(0.0106)	(0.0111)	(0.0101)	(0.0115)
N Schools	396	393	388	380	370
N Students	44,206	42,154	39,504	36,691	34,002

Notes: Estimates for the baseline sample of students who graduated between 1978 and 2001 from a combined school that does not take-up students from other primary schools. All outcomes are measured when the individuals are 27–42 years old. The regressions control for segment and segment specific linear splines in primary school enrollment interacted with maximum class size regime. All regressions also include year of graduation fixed effects, individual background controls for gender, parental education, immigrant background, month of birth, and age at graduation. Standard errors clustered at the school level are reported in parentheses. */** = p-value < 0.10/0.05.

Table W8. The effect of class size in compulsory school (grades 1-9) on log(earnings) – Baseline population

	Symmetric donut $\pm n$ from threshold				
	n=1	*n=2*	*n=3*	*n=4*	*n=5*
A. First Stage					
Above threshold	-7.12**	-7.42**	-7.38**	-7.80**	-8.12**
	(0.46)	(0.48)	(0.52)	(0.62)	(0.68)
F-statistic	243	238	198	160	141
B. Reduced Form					
Above threshold	-0.001	0.010	0.009	0.015	-0.004
	(0.013)	(0.014)	(0.018)	(0.019)	(0.021)
C. 2SLS					
Average class size	0.00001	-0.0010	-0.0004	-0.0007	0.0012
	(0.00182)	(0.0019)	(0.0024)	(0.0024)	(0.0024)
N Schools	396	394	390	382	372
N Students	44,728	42,666	39,966	37,066	34,366

Notes: Estimates for the baseline sample of students who graduated between 1978 and 2001 from a combined school that does not take-up students from other primary schools. All outcomes are measured when the individuals are 27–42 years old. The regressions control for segment and segment specific linear splines in primary school enrollment interacted with maximum class size regime. All regressions also include year of graduation fixed effects, individual background controls for gender, parental education, immigrant background, month of birth, and age at graduation. Standard errors clustered at the school level are reported in parentheses. */** = p-value < 0.10/0.05.

Table W9. The effect of class size in compulsory school (grades 1-9) on earnings – Baseline population

	Symmetric donut $\pm n$ from threshold				
	n=1	*n=2*	*n=3*	*n=4*	*n=5*
A. First Stage					
Above threshold	-7.16**	-7.44**	-7.38**	-7.77**	-8.10**
	(0.46)	(0.48)	(0.53)	(0.63)	(0.69)
F-statistic	245	236	194	154	138
B. Reduced Form					
Above threshold	-0.015	0.0004	-0.005	0.004	-0.012
	(0.017)	(0.0190)	(0.024)	(0.024)	(0.027)
C. 2SLS					
Average class size	0.0018	0.0003	0.0015	0.0005	0.0032
	(0.0024)	(0.0026)	(0.0032)	(0.0029)	(0.0031)
N Schools	399	397	392	384	374
N Students	46,692	44,529	41,704	38,657	35,814

Notes: Estimates for the baseline sample of students who graduated between 1978 and 2001 from a combined school that does not take-up students from other primary schools. All outcomes are measured when the individuals are 27–42 years old. The regressions control for segment and segment specific linear splines in primary school enrollment interacted with maximum class size regime. All regressions also include year of graduation fixed effects, individual background controls for gender, parental education, immigrant background, month of birth, and age at graduation. Standard errors clustered at the school level are reported in parentheses. */** = p-value < 0.10/0.05.

3.2 Two-way clustering

Both 1 and 2 way cluster - using schools and enrollment

Table W10. The effect of class size in compulsory school (grades 1-9) on schooling – Baseline population

	(1)	(2)	(3)
A. First Stage			
Above threshold	-7.32**	-7.32**	-7.32**
	(0.47)	(0.43)	(0.47)
F-statistic	245	289	241
B. Reduced Form			
Above threshold	0.094	0.094	0.094
	(0.072)	(0.079)	(0.080)
C. 2SLS			
Average class size	-0.0080	-0.0080	-0.0080
	(0.0093)	(0.0098)	(0.0102)
Cluster level:			
-School	Yes		Yes
-Enrollment		Yes	Yes
N Clusters	394	61	61+394
N Students	43,258	43,258	43,258

Notes: Estimates for the baseline sample of students who graduated between 1978 and 2001 from a combined school that does not take-up students from other primary schools. All outcomes are measured when the individuals are 27–42 years old. In the first column we cluster at the school level, and in the second column we cluster on enrollment. In the third column we cluster on both school and the enrollment. The regressions control for segment and segment specific linear splines in primary school enrollment interacted with maximum class size regime. All regressions also include year of graduation fixed effects, individual background controls for gender, parental education, immigrant background, month of birth, and age at graduation. Standard errors clustered at the school level are reported in parentheses. */** = p-value < 0.10/0.05.

Table W11. The effect of class size in compulsory school (grades 1-9) on log(earnings) – Baseline population

	(1)	(2)	(3)
A. First Stage			
Above threshold	-7.28**	-7.28**	-7.28**
	(0.47)	(0.43)	(0.47)
F-statistic	244	284	237
B. Reduced Form			
Above threshold	-0.003	-0.003	-0.003
	(0.013)	(0.013)	(0.012)
C. 2SLS			
Average class size	0.0004	0.0004	0.0004
	(0.0018)	(0.0017)	(0.0018)
Cluster level:			
-School	Yes		Yes
-Enrollment		Yes	Yes
N Clusters	395	61	61+395
N Students	43,765	43,765	43,765

Notes: Estimates for the baseline sample of students who graduated between 1978 and 2001 from a combined school that does not take-up students from other primary schools. All outcomes are measured when the individuals are 27–42 years old. In the first column we cluster at the school level, and in the second column we cluster on enrollment. In the third column we cluster on both school and the enrollment. The regressions control for segment and segment specific linear splines in primary school enrollment interacted with maximum class size regime. All regressions also include year of graduation fixed effects, individual background controls for gender, parental education, immigrant background, month of birth, and age at graduation. Standard errors clustered at the school level are reported in parentheses. */** = p-value < 0.10/0.05.

Table W12. The effect of class size in compulsory school (grades 1-9) on earnings – Baseline population

	(1)	(2)	(3)
A. First Stage			
Above threshold	-7.31**	-7.31**	-7.31**
	(0.47)	(0.43)	(0.47)
F-statistic	245	286	239
B. Reduced Form			
Above threshold	-0.017	-0.017	-0.017
	(0.018)	(0.017)	(0.017)
C. 2SLS			
Average class size	0.0020	0.0020	0.0020
	(0.0024)	(0.0023)	(0.0024)
Cluster level:			
-School	Yes		Yes
-Enrollment		Yes	Yes
N Clusters	398	61	61+398
N Students	45,668	45,668	45,668

Notes: Estimates for the baseline sample of students who graduated between 1978 and 2001 from a combined school that does not take-up students from other primary schools. All outcomes are measured when the individuals are 27–42 years old. In the first column we cluster at the school level, and in the second column we cluster on enrollment. In the third column we cluster on both school and the enrollment. The regressions control for segment and segment specific linear splines in primary school enrollment interacted with maximum class size regime. All regressions also include year of graduation fixed effects, individual background controls for gender, parental education, immigrant background, month of birth, and age at graduation. Standard errors clustered at the school level are reported in parentheses. */** = p-value < 0.10/0.05.

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