Maimonides goes to Norway: Class size in primary and lower secondary schools and student achievement*

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[IN PROGRESS - DO NOT QUOTE - COMMENTS INVITED]

Abstract

This paper uses maximum class-size rules as well as demographic variation to estimate the effect of class-size on achievement in Norway. Achievement is measured by test scores for math, English and Norwegian in grade 9 and we relate these outcomes to the average class-size students were exposed to during primary school (grades 1-6) and during lower secondary school (grades 7-9). The results show that class-size has no impact on achievement; even effects as small as 1.5 percent of a standard deviation for a one student change in class-size during 6 (or 3) years, can be ruled out. This is true for both identification methods and for both school levels. There is also no evidence of class-size effects for specific subgroups (boys versus girls and low versus high social background) or for different teacher characteristics.

1 Introduction

One of the big unsettled issues in education research concerns the effects of class size reduction on students' achievement. It is by now well-understood that endogeneity problems may severely bias naive OLS-estimates of the class-size effect, and that exogenous sources of variation in class-size are key for a credible identification of the causal effect of class-size reduction. While various recent studies acknowledge this and apply sometimes very ingenious identification methods, this has not led to a definite conclusion about the magnitude and even the sign of the class-size effect.

While most of the more recent experimental and quasi-experimental studies conclude that a reduction in class size boosts achievement (Angrist and Lavy, 1999; Krueger,

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1999; Urquiola, 2000; Browning and Heinesen, 2003; Boozer and Rouse, 2001), other studies which also exploit credible identification strategies conclude the opposite (Hoxby (2000)). Moreover, the studies reporting negative class-size effects vary considerably in the size of this effect thereby limiting the relevance of these results for policy conclusions.

Of course there need not be a universal effect of class size reduction on achievement. Effects may vary with characteristics of the students affected by the policy, or by contextual factors such as remedial instruction for low performing students or the quality of teachers' education (cf. Woessmann and West (2005)).

This paper provides fresh evidence about the effect of class size in Norwegian primary schools and lower secondary schools on achievement. This evidence is obtained from two identification approaches. The first approach uses exogenous variation due to maximum class-size rules in Norwegian primary and lower secondary education. This approach is related to the one adopted by Angrist and Lavy (1999); Browning and Heinesen (2003); Urquiola (2000); Bingley et al. (2004). The second approach exploits variation in actual class-size that is attributable to demographic variation. This approach was applied previously in Hoxby (2000) and Urquiola (2000).

The first approach uses the fact that the relation between cohort size enrollment and class-size in Norway exhibit discontinuities around multiples of 28 students in primary schools and around 30 students in lower secondary schools. These discontinuities are due to official guidelines which specify that an extra teacher is assigned to the grade level within a school when the size of a cohort enrolling in that school exceeds 28 (in primary school) or 30 (in lower secondary school), or multiples thereof. As will be shown in Section 5, actual class-size almost perfectly reflects this allocation rule. This allows us to apply the "Maimonides"-approach proposed by Angrist and Lavy (1999).

In comparison to Angrist and Lavy's study, a number of differences are worthwhile to point out. First, we have access to test score data from individuals students rather than school average test scores as Angrist and Lavy do. Second, the relation between predicted class-size and actual class-size is much stronger in Norway than in Israel. These two differences result in greater precision in the estimates.

Third, in the Israeli data outcomes and class-size information are measured contemporaneously. That is: test scores and class-size are both for the same grade (3 or 4 or 5, in their case). For the tested students it is unknown what the sizes of their classes were during previous grades. This hinders the interpretation of the results. Do the estimates reflect effects of current class-size, or do they capture the cumulative effect of class-size during a sequence of years? The structure of the Norwegian data is different. Test scores are measured in the end of grade 9. For students in schools that combine primary school and lower secondary school (so-called combined schools), information on class-size is available for all previous grade levels that the tested cohort went through. That is, for combined schools whose 9th grade students are tested in 2002, the dataset includes information about class size in grade $9-t$ in year $2002-t$ (with $0 \leq t \leq 2$). For schools that only offer a lower secondary program, information on class-size is available for grades 7 to 9. We use this additional information to estimate the effects of average class-size students were exposed to during their primary school period (grades 1-6) and average class-size they faced during the lower secondary school period (grades 7-9). These results have a clear-cut interpretation.

A substantial number of schools in Norway have less than 15 students in their 9th grade. Some rural districts have only one school offering lower secondary education. Class-size in these schools is likely to be determined mainly by demographic variation in the district. The second approach applied in this paper uses the idiosyncratic component of districts demographic variation as an instrument for actual class-size in these small schools. This approach is akin to the use of population variation in Hoxby (2000).

While the Nordic countries (Denmark, Finland, Norway and Sweden) are famous for their often incredibly rich datasets, analyses of the kind presented in this paper were until very recently impossible for all of these countries due to a lack of nationwide tests. This situation changed in 2001 in Norway with the introduction of national test programs in the highest grade of lower secondary schools.

The results reported in this paper consistently point to a lack of any impact of class-size on achievement. This holds irrespective of level of education (primary or lower secondary), identification method (regression discontinuity or demographic variation), subject tested (math, foreign language and Norwegian) or the control variables included in the regressions. The finding also holds across various subgroups of the population and is also independent of teacher characteristics.[1]

The remainder of this paper is organized as follows. The next section elaborates somewhat more on the methods and results of previous studies. Section **??** describes the relevant institutional features of the Norwegian educational system. Section **??** gives a description of the data employed in the empirical analysis. Section 5 continues with an exposition of the empirical approaches applied in this paper and their limitations. Sections 6 and 8 present and discuss the findings based on the discontinuity approach and the demographic variation approach, respectively. Section 9 investigates the possibility of heterogeneous outcomes, and Section 11 concludes.

2 Related literature

In their well-known paper, Angrist and Lavy exploit the fact that according to official guidelines for Israeli public schools, maximum class-size equals 40. If the size of an enrollment cohort in a school exceeds (a multiple of) 40, an extra class should be

[1] Woessmann and West (2005) report some tentative evidence that small classes are only beneficial when teachers have low levels of qualifications.

created. This informal rule creates discontinuities in the relation between cohort enrollment size and class size, which Angrist and Lavy then use in a regression discontinuity framework to identify the causal effect of class-size on achievement. Their key finding is that whereas estimates that do not correct for endogeneity bias point to a positive relation between class-size and achievement, the reverse is true for the estimates based on the discontinuities.

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3 The Norwegian institutional setting

Compulsory schooling in Norway which is public primary and lower secondary school, is free of user charges and it is the local school districts who are responsible for providing it.[2] The number of public schools within each school district varies to a great extent, from 1 school to 42 schools, depending on the population size and the settlement pattern. Private schools are quite rare and do not provide a realistic alternative to public schools (about 2.78 percent of compulsory schooling are run by private schools). Parental school choice between public schools both within and between the school districts (for given residence) is not allowed, i.e switching school imply changing address as well.

In the period under investigation nine years with schooling was still compulsory in Norway. Hence in the remaining of the paper we refer to the grade levels in public primary and lower secondary as 1th to 6th grade and 7th to 9th grade respectively.[3]

About 25 percent of the schools in Norway are "so-called" comprehensive schools, meaning that they offer both primary and lower secondary education (1th - 9th grade). Students who start with taking their primary education in a comprehensive school also continue taking their lower secondary education there because of lack of school choice for given residence.[4] Comprehensive schools occur more frequently in small rural school districts due to the settlement pattern in Norway.

4 Data

In this paper we use administrative data from Statistics Norway on all 122,281 students finishing public lower secondary school (9th grade) the school year 2001/2002 and

[2] The local school districts in Norway are multipurpose institutions that provide other utility services in addition to education, for instance elderly care, preschool education, and infrastructure. Spending on education consists of about 30% of total spending of the accessible budget. In Norway the names local school district, local government and municipality are used interchangeable.

[3] Until the school year 1996/1997 nine years with schooling was compulsory in Norway, starting the year the children turned 7 years. The children spent the six first years in primary school and the remaining three years in lower secondary school. From the school year 1997/98 it became compulsory to start schooling at the age of 6, and from that on 10 years of schooling was implemented in Norway. The reform was implemented in such a way that the length of primary school was extended with one year.

[4] The school districts are divided into smaller school-areas, and each such area consist of either one primary and lower secondary school or one combined school.

2002/2003. This dataset is merged with test score data on the same students (also from Statistics Norway) and class size data on school level from the Norwegian Ministry of Education (Grunnskolens Informasjonssystem). Available teacher data from the Ministry of labor and Government Administration makes it possible to control for teacher characteristics on school level, and we also include school district controls from the Norwegian Social Science Data Services. The unit of observation is the individual student. In the following subsections we discuss the data we use more in detail.

4.1 Tests

We have access to results from central exit examinations and school based tests for the students who graduate from lower secondary school in the school years 2001/2002 and 2002/2003.

At the lower secondary school (grade 7, 8 and 9) the students are graded by their teachers in all subjects. In addition, at the end of lower secondary school (May/June, 9th grade) they also have to undertake a nationally decided written external exam. Both the exam and grading by teachers matter for further schooling possibilities (which is upper secondary education).[5] Although the curriculum includes many different subjects, both elective and compulsory, written national examination is only undertaken in mathematics, English and Norwegian. Further each student is only examined in one of the subjects, decided centrally shortly before the exam. This means that which subject each student is going to undertake an exam in is outside the scope of both the students themselves and also their teachers until a few days before the exam. It is not a claim that students enrolled in the same school shall be examined in the same subject. In Norway there are two official written languages, main Norwegian and a second Norwegian language (Nynorsk), and a students who is appointed to have an exam in Norwegian has to undertake two exams, one in each language. We will refer to those two languages as ”Norwegian” and ”Nynorsk”.

Since exam results are set by external examiners (not by the teachers themselves) we believe this measure to be a more accurate picture on student achievement because grading by teachers might be biased due to both relative grading and grading inflation. Thus, the results on this national test which all students have to undertake at the end of lower secondary school serve as our dependent variable in the analysis. The grading scale goes from 1 to 6 where 1 is fail and 6 is top score. Table [?] give a descriptive statistics of the exam grades, by subjects. On average, the exam results in the four subjects is in the interval [3.3 to 3.6] with corresponding standard deviation approximately equal to 1. Descriptive exam results are also reported on the school level in the same table.

[5] Although all students have the right to continue at upper secondary schools and above 95 percent do continue, their choice set among different schools and different study tracks depends on their achievement in lower secondary schools.

4.2 Class size

The class size data consists of enrollment and number of classes from 1th - 9th grade from the school year 1992/1993 to the school year 2002/2003. This implies that we for each 9th grader in 2001/2002 and 2003/2003 are able to determine the average class size not only for the final grade (the 9th grade), but also for former grades. Hence for those who are in combined schools we know the average class for their whole career in the public school system. For those in pure lower secondary school we only have average class size data from 7th to 9th grade. The central assumption to be made is that the individual student has been on the same school his/her whole career. Instead of looking at class size grade by grade, we compute the average class-size the students were exposed to, both in primary school (grades 1-6) and in lower secondary school (grades 7-9). The reason why we do this is that the variation in class size from grade to grade for the students on our sample is very small. Note, that since class size data is on school level, we are not able to link the individual student to a particular class.

4.3 Family background characteristics

Student's family background is controlled for by using available data on family background characteristics from the administrative student data from Statistics Norway. These are; a dummy variable for foreign born parents (both parents are foreigners), a dummy variable for non-cohabiting parents, a dummy variable for married parents, the student's gender and age and information on both father's and mother's income and education level. We summarize father's and mother's income and take the natural logarithm to total family/ household income. The parents' education level is divided into 9 categories (total years with schooling is reported in the parenthesis) :not completed primary school (4 years), primary school (+6 years), lower secondary school (+9 years), one year at upper secondary school (+10 years), two years at upper secondary school (+11 years), three years at upper secondary school (+12 years), 3 or 4 years with higher education/ bachelor education (+15.5 years), 5 or 6 years with higher education/ master education (+17.5 years) and 3 or 4 years as a PhD student (+20years).

4.4 School/teacher characteristics

As further control variables we use employer register data on the teachers from the Ministry of labor and Government Administration. Since we are not able to link the individual teacher to the individual student/class we aggregate the teacher data up to school level and weight with the "working time per teacher". Included teacher controls are average experience (measured in year and months), the share of female teachers, the share of teachers who have a temporary contract and average teachers' education length. The last variable is computed using information on the individual teacher's position within a school. In Norway we distinguish between 5 types of teacher positions:

i) unqualified teachers (less than 4 years with higher education), ii) “adjunkt” which are teacher with four years with higher education, iii) “adjunkt with advancement” which are teacher with 5 years with higher education, iv) “lektor” which are teachers with 6 years with higher education and v) principals and other school leaders (we assume that teachers in this group have the highest education level - 6 years). We also include a dummy variable for combined / comprehensive schools.

4.5 School district variables

Finally we include the size of the school district measured in terms of inhabitants and the number of people in the school district who live in rural areas. We take the natural logarithm to both of them.

4.6 Sample selection and descriptives

We drop 10,194 observations that have missing on one or more of the variables that we use in the estimation and 15 observations on adults (born before January 1, 1980. Certain job creation programmes allow adults to take the exam).

We are therefore left with a sample consisting of 112,072 students and 2044 schools for the school years 2001/2002 and 2002/2003 (1032 schools in 2001/2002 and 1012 schools in 2002/2003).

5 Empirical approaches

Suppose achievement of student i in school s (y_{is}) is generated by the following equation:

$$y_{is} = x_{is}'\beta + w_s'\alpha + \delta \cdot csize_{is} + \eta_s + \varepsilon_{is} \quad (1)$$

with x_{is} observable attributes of the student and his parents, w_s observable characteristics of the school and its teachers, $csize_{is}$ the size of the class the student attends, η_s a school random effect and ε_{is} an idiosyncratic error term at the student level. The coefficient of interest is δ, the class size effect.

Because achievement is only measured by the end in grade 9 a value-added specification is not feasible. Achievement is grade 9 does obviously not only depend on class-size in grade 9 but will also depend on class-sizes during previous grades. As shown by Krueger and Whitmore (2001) exposure to small classes in early grades may have long-lasting effects. Because year-to-year class-sizes are too highly correlated in our data to examine their separate effects, we have chosen to measure class-size as:

- average class-size during the six years in primary school, and

- average class-size during the three years in lower secondary school.

Table 1: Sample summary statistics

	All		Disc. Samples	
	mean	s.d.	mean	s.d.
	(1)	(2)	(3)	(4)
Individual characteristics				
Girl	0.491	(0.500)	0.491	(0.500)
Age	14.523	(0.295)	14.522	(0.295)
ln(family income)	13.287	(0.557)	13.302	(0.575)
Education mother (years)	11.839	(2.693)	11.883	(2.713)
Education father (years)	11.982	(2.836)	12.051	(2.852)
Foreign born parents	0.032	(0.177)	0.035	(0.184)
Parents non-cohabiting	0.299	(0.458)	0.302	(0.459)
Parents married	0.653	(0.476)	0.650	(0.477)
ln(pop. size school district)	10.030	(1.464)	10.111	(1.428)
ln(rural pop. size school district)	7.928	(0.750)	7.920	(0.746)
School characteristics:				
Average teacher education (years)	4.611	(0.197)	4.626	(0.202)
Average teacher experience	18.838	(3.291)	18.877	(3.215)
Fraction of female teachers	0.560	(0.106)	0.557	(0.103)
Fraction of teachers with a temp. contract	0.171	(0.114)	0.170	(0.105)
Comprehensive school	0.235	(0.424)	0.208	(0.406)
Year = 2002	0.513	(0.500)	0.525	(0.499)
Average class size grades 7-10	24.263	(4.333)	24.642	(3.798)
Enrollment grade 7	84.510	(41.965)	87.938	(40.418)
Written exam score	3.445	(1.073)	3.472	(1.072)
N	112,072		34,096	
N schools	1,057		384	

Table 2: Test score summary statistics

	Individual level			
	E	H	M	S
Mean	3.551	3.619	3.306	3.325
s.d.	1.074	0.996	1.130	0.982
N	36,196	20,143	36,966	18,767
	School level			
Mean	3.479	3.565	3.241	3.334
s.d.	0.543	0.578	0.550	0.619
N	905	556	887	523

If placement of students in schools, or in classes within schools, is at least to some extent driven by unobserved school and student effects, estimation of equation#1# by ordinary least squares does not result in a coefficient that can be given the causal interpretation of the effect of changes in class-size on students' achievement.

Choices of parents and of schools can bias the results in either direction. If parents who have high aspirations for their offspring choose to place them in school with smaller classes, δ_{OLS} will be biased towards a larger (more negative) class size effect. If, on the other hand, schools direct their weaker performing students to small classes, δ_{OLS} will be biased towards a smaller (less negative) class size effect.

To address this endogeneity issue, we need variation in average actual class-size that is arguably not subject to the choices of parents and schools' principals or teachers. We exploit two sources of such exogenous variation. The first is a maximum class-size rule in the spirit of Maimonides' rule used by Angrist and Lavy (1999). The second exploits demographic variation at the level of districts in Norway, as in Hoxby (2000), and focuses on small schools. We discuss each in turn in the next two subsections.

5.1 Maimonides in Norway

As explained in Section **??** public schools in Norway are subject to maximum class-size rules of 28 students per class in primary education and of 30 students per class in lower secondary education. We use these maximum class-size rules as predictors for average actual class-size in primary school and lower secondary school, respectively. This generates instrumental variables similar to those used in Angrist and Lavy (1999). Predicted class size equals total enrollment in the grade level (e) divided by the predicted number of classes. The predicted number of classes equals $1+\text{int}((e-1)/csize)$, with $\text{int}(x)$ the largest integer less than or equal to x, and $csize^*$ the maximum class-size specified by the rule, being either 28 or 30. Predicted class-size *pcsize* is thus equal to:

$$pcsize = \frac{e}{1 + int\left(\frac{e-1}{csize^*}\right)}. \tag{2}$$

Thus predicted class-size is a discontinuous function of cohort enrollment with discontinuities appearing at multiples of 30 students in lower secondary school and of 28 students in primary school. That is, predicted average class size falls from 30 to $15\frac{1}{2}$ when cohort enrollment increases from 30 to 31 students in lower secondary school, and from 30 to $20\frac{1}{3}$ when cohort enrollment increases from 60 to 61 students, and so on. For primary school a very similar pattern emerges, but at slightly lower cohort enrollment levels.

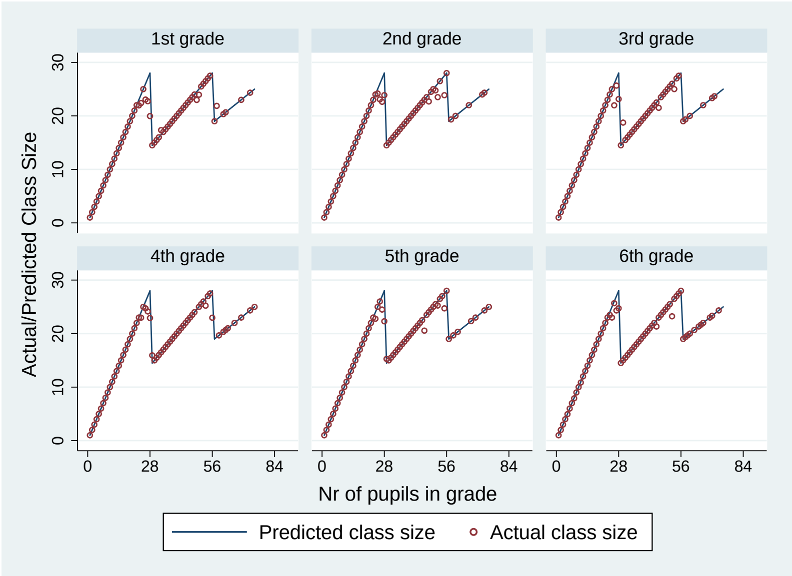
The endogenous variables in our analyses are average class-size during primary school and average class-size during lower secondary school. Average class-size during primary school is the average of the six class-sizes in grades 1-6. In principle we could use the six predicted class-sizes for grades 1-6 as instruments for the six actual class-sizes. We prefer, however, only to use predicted class-size in grade 1 to instrument average class-size during grades 1-6. The reason is that cohort enrollment in grades 2-6 and thereby predicted class-size in these grades may depend by actual class-size in grade 1. Such dependence could for instance result from parents' decisions to move from schools where they experienced large classes in first grade to schools where they observed small classes in first grade.

For similar reasons we instrument average class-size during lower secondary school (grades 7-9) by predicted class-size in grade 7, and not by predicted class-sizes in grades 8 and 9. A vast majority of students in lower secondary schools attends a separate lower secondary school (uncombined school). Grade 7 is the grade in which they enroll in these schools. Subsequent school movement may affect cohort enrollment (and thereby predicted class-sizes in grades 8 and 9). In combined schools enrollment in grade 7 may depend on actual class-size during the previous primary school period. But the fact that the maximum class-size rule changes from 28 in grade 6 to 30 in grade 7 causes that also in the combined schools students in grade 7 are confronted with a new class-size.

Figures 1 plots predicted class-size in grade 1 and average actual class-size in grades 1-6 against cohort enrollment in grade 1. Average actual class-size almost perfectly tracks predicted class-size especially around the first predicted kink. Figure 2 plots predicted class-size in grade 7 and average actual class-size in grades 7-9 against cohort enrollment in grade 7. Again the instrument and the endogenous variable follow a very similar pattern.

The identifying assumption in a regression discontinuity design is a conditional independence assumption of the error components of the outcome equation (1) with

Figure 1: Average and predicted class size, primary school



respect to the instrument given other regressors. In the current application it implies:

$$E[pcsize_{is} \cdot (\eta_s + \varepsilon_{is}) \mid x_{is}, w_s] = 0,$$

where w_s may also contain a smooth function of cohort enrollment to capture any direct effect of this variable on achievement. The identifying assumption thus essentially boils down to an exclusion restriction with respect to the discontinuities. In the subsequent analyses we will control for a quadratic function of enrollment in grade 7 (and 1).

An alternative for controlling for a smooth function of cohort enrollment is to restrict the sample to the regions around the kinks. We will present separate analyses for a sample which is restricted to schools with cohort enrollment in grade 7 (and 1) at most 5 students away from the kinks. Table 3 tests whether the groups just below and just above the kinks are different in observed characteristics.

5.2 Population variation (small schools)

A substantial number of schools in Norway have less than 15 students in their 9th grade. Some rural districts have only one school offering lower secondary education. Class-size in these schools is likely to be determined mainly by demographic variation in the district. The second approach applied in this paper uses the idiosyncratic component of districts demographic variation as an instrument for actual class-size in these small schools. This approach is akin to the use of population variation in Hoxby (2000).

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Figure 2: Average and predicted class size, lower secondary school

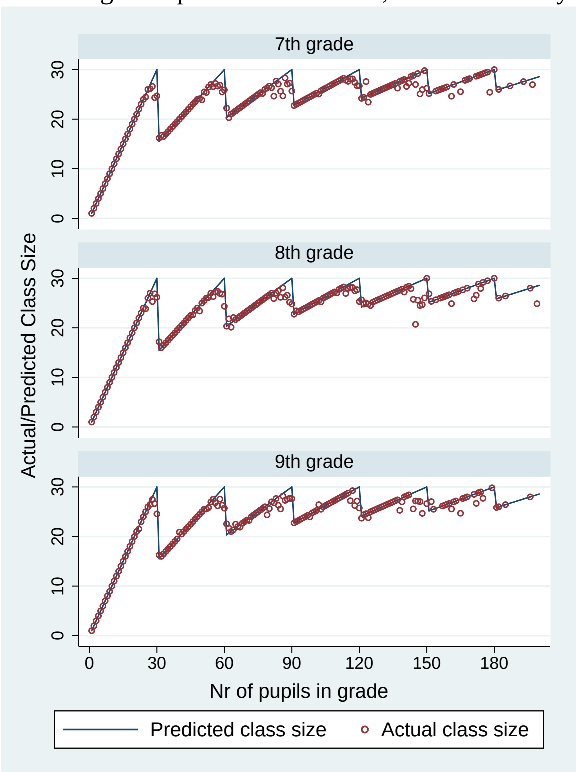


Table 3: Descriptive statistics below and above discontinuities

	mean	(above - below)	s.e.
	(1)	(2)	(3)
Girl	0.4914	0.0016	(0.0062)
Age (years)	14.5223	0.0052	(0.0117)
ln(family income)	13.3019	-0.0209	(0.0094)**
Education mother (years)	11.8828	-0.0005	(0.0019)
Education father (years)	12.0511	0.0040	(0.0019)**
Foreign born parents	0.0351	0.0288	(0.0422)
Parents do not live together	0.3018	-0.0247	(0.0164)
Parents married	0.6495	-0.0296	(0.0187)
ln(population size school district)	10.1106	-0.0531	(0.0194)***
ln(rural population size school district)	7.9197	0.0513	(0.0374)
Average teacher education	4.6260	-0.2979	(0.1477)**
Average teacher experience	18.8767	0.0009	(0.0093)
Fraction of female teachers	0.5565	0.2019	(0.3075)
Fraction of teacher with temp contract	0.1696	0.0852	(0.2958)
Comprehensive school	0.2079	-0.1278	(0.0703)*
Intercept		2.0227	(0.7902)**
Root MSE		.4849	
R-squared		0.0483	
N		34,096	

6 Results based on maximum class-size rules

To describe the relation between achievement and observables, this section starts with presenting results from naive OLS regressions on individual and school characteristics. It then proceeds with presenting the first stage results, and continues with a graphical analysis of the relations between cohort enrollment, actual class size and achievement. After that the reduced form and 2SLS results are presented and discussed. This section is restricted to effects of class-size in lower secondary school (grades 7-9). Effects of class-size in primary school is the topic of Section#8#.

6.1 Achievement equations

To describe the relations between students' achievement and their individual and school characteristics, we present results from various OLS-regressions in Table##. These results should not be given a causal interpretation. Results are presented separately for math and languages, where we have pooled English and Norwegian. Columns (1) and (3) are obtained from a specification that includes only individual characteristics as explanatory variables; while columns (2) and (4) report the results from specifications that also include school characteristics (including average class-size).

Nor surprisingly, girls perform better on languages than boys with a gender difference amounting to about 50% of a standard deviation. On the other hand there appears to be gender difference for math scores. Older students perform better than their younger classmates. Given that grade repetition is a rare event in Norway, this points to an advantage for older students within a cohort (Strøm (2004) attributes this age differential to a different school starting age).

All family background variables are significantly and strongly related with achievement, with relations being stronger for math than for languages. Family income and parents' education reveal the expected positive relations with achievement, whereas children with non-cohabiting parents and foreign-born parents perform worse.

The only school characteristics revealing a significant correlation with achievement are cohort enrollment and teacher experience. The relation between language achievement and cohort enrollment is u-shaped with a minimum around 100 students; students in schools with more of less cohort enrollment perform better. Having a more experienced teaching staff is associated with better performance in both math and languages.

Interestingly, the OLS-estimates of average class-size during grades 7-9 have the expected negative sign, but are very small and are - in spite of fairly small standard errors - not significantly different from zero. The remainder of this paper is concerned with the question whether this zero-effect survives if we apply identification methods that address the possible endogeneity bias in the class-size estimates in Table##.

Table 4: OLS. Dependent variable is exam results in 9th grade

	Math		Languages (pooled)	
	(1)	(2)	(3)	(4)
Individual characteristics				
Girl	0.0164	0.0165	0.5061	0.5060
	(0.0121)	(0.0120)	(0.0097)***	(0.0096)***
Age (years)	0.0977	0.0984	0.0561	0.0568
	(0.0186)***	(0.0185)***	(0.0137)***	(0.0136)***
ln(family income)	0.1529	0.1556	0.0867	0.0894
	(0.0129)***	(0.0130)***	(0.0090)***	(0.0091)***
Education mother (years)	0.0886	0.0884	0.0696	0.0693
	(0.0023)***	(0.0023)***	(0.0018)***	(0.0018)***
Education father (years)	0.0801	0.0802	0.0608	0.0609
	(0.0021)***	(0.0021)***	(0.0019)***	(0.0019)***
Foreign born parents	-0.1613	−0.1463	0.0203	0.0283
	(0.0359)***	(0.0349)***	(0.0265)	(0.0266)
Parents non-cohabiting	-0.1913	−0.1845	−0.0960	−0.0914
	(0.0272)***	(0.0273)***	(0.0201)***	(0.0200)***
Parents married	0.1251	0.1276	0.0682	0.0703
	(0.0266)***	(0.0266)***	(0.0196)***	(0.0194)***
ln(pop. size school district)	-0.0003	0.0189	−0.0026	0.0142
	(0.0069)	(0.0082)**	(0.0051)	(0.0072)**
ln(rural pop. size school district)	-0.0151	−0.0159	−0.0092	−0.0068
	(0.0151)	(0.0146)	(0.0101)	(0.0099)
School characteristics:				
Average class size grade 7-9		−0.0038		−0.0018
		(0.0029)		(0.0022)
Enrollment grade 7		−0.0017		−0.0034
		(0.0013)		(0.0011)***
Enrollment grade 7 squared/1000		0.0092		0.0165
		(0.0069)		(0.0053)***
Average teacher education (years)		0.0283		0.0259
		(0.0527)		(0.0438)
Average teacher experience		0.0165		0.0092
		(0.0030)***		(0.0024)***
Fract. of female teachers		−0.1267		0.0116
		(0.1073)		(0.0773)
Fract. teachers with a temp. contract		0.0596		−0.0029
		(0.0864)		(0.0655)
Comprehensive school		0.0576		−0.0021
		(0.0318)*		(0.0291)
Year=2002	-0.0416	−0.0437	−0.0059	−0.0140
	(0.0182)**	(0.0181)**	(0.0138)	(0.0138)
Intercept	-2.0372	−2.5133	−0.1703	−0.5123
	(0.3585)***	(0.4468)***	(0.2344)	(0.3174)
Root MSE	1.021	1.019	.9438	.9426
R-squared	0.1836	0.1867	0.1717	0.1739
N	36966	36966	75106	75106

Note: Standard errors are heteroscedasticity robust and corrected for school level clustering.

6.2 First stage

The figures plotting cohort enrollment in grade 7 against average actual class-size during grades 7-9 and predicted class-size in grade 7 already indicate that there is a strong relation between the endogenous actual class-size variable and predicted class-size.

Table 5 tests this more formally by presenting results of first stage regressions. These first stage regressions were estimated for the full sample (thereby pooling students/schools doing exams in different subjects[6]) and for the discontinuity sample of students in schools in which cohort enrollment in grade 7 was at most 5 students away from a multiple of 30.

Columns (1) and (5) present results from regressions of average actual class size during grades 7-9 on predicted class size in grade 7 without any controls. For the full sample the predicted class size coefficient equals 0.88 and for the discontinuity sample it equals 0.57. That the estimate for the full sample exceeds that of for the discontinuity sample reflects that deviations from the allocation rule are more frequent close to the cutoffs than for other enrollment sizes. Columns (2)-(4) and (6)-(8) add controls for cohort enrollment (linear and squared) and for individuals and school characteristics. It is reassuring that the results remain very similar. Only the first-stage effect for the full sample drops by about 10% after the inclusion of the enrollment terms but remains the same thereafter. For comparison:Angrist and Lavy (1999) report first stage effects of 0.55 to 0.67 for their full sample (including controls), and of 0.35-0.50 for their discontinuity sample. Especially given that their first stage related actual and predicted class-sizes for the same grade-level whereas we relate average actual class-size for grades 7-9 and predicted class-size in grade 7, we consider the first stage results presented here to be quite strong.

6.3 Graphical analyses

To preview the relations between class-size and achievement, we plot the relations between actual class-size and enrollment and between achievement and enrollment in the same figure. Figure X does this for achievement in math and English and Figure Y for achievement in the two Norwegian languages. Test scores and class sizes are averaged over enrollment intervals of five students.

If average class-size matters for achievement we expect the enrollment-achievement relation and the enrollment-class-size relations to move in opposite directions. A sharp drop in average class-size after an enrollment multiple of 30 should then translate into a boost in achievement. This is not what we observe in Figures 3 and 4. For all four subjects the enrollment-achievement relations is very flat and shows no indication

[6]The 2SLS presented later on are based on first stage equations estimated for the sub sample of students/schools doing their exam in a specific subject. Results from these first stage equations are not reported but are very similar to the results reported here. (As they should because assignment of exam subject is random.)

Table 5: First stage - Average class size in grade 7-9

	Full sample				Discontinuity sample (+/-5)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
predicted class size	0.8360	0.7532	0.7434	0.7424	0.5749	0.5403	0.5115	0.5110
	(0.0183)***	(0.0309)***	(0.0315)***	(0.0311)***	(0.0452)***	(0.0525)***	(0.0523)***	(0.0502)***
enrollment		0.0380	0.0334	0.0344		-0.0038	-0.0212	-0.0142
		(0.0086)***	(0.0087)***	(0.0104)***		(0.0194)	(0.0184)	(0.0236)
$enrollment^2$		-0.1580	-0.1463	-0.1529		0.0673	0.0929	0.0473
		(0.0429)***	(0.0444)***	(0.0505)***		(0.1064)	(0.0963)	(0.1095)
Root MSE	1.919	1.884	1.866	1.86	2.535	2.511	2.387	2.337
R-squared	0.7875	0.7953	0.7991	0.8004	0.5328	0.5417	0.5862	0.6034
family controls	no	no	yes	yes	no	no	yes	yes
school/teacher controls	no	no	no	yes	no	no	no	yes
N Schools	780	780	780	780	195	195	195	195
N	36,966	36,966	36,966	36,966	10,712	10,712	10,712	10,712

Notes: Standard errors are heteroscedasticity robust and corrected for within school correlation. Family controls are: age, gender, education of mother (years), education of father (years), marital status parents, parents living together, foreign born parents. School/teacher controls: average teacher education (years), fraction female teachers, average teacher experience, fraction of teachers on temporary contract, and dummy for a comprehensive school (primary and lower secondary). Regressions also include a year effect.

of mirroring the enrollment-class-size function. This is a first indication of negligible class-size effects in Norway. The next subsections test this further by estimating reduced form and 2SLS equations. This should inform us about how precisely we measure the absence of any effect.

6.4 Reduced form estimates

Results from reduced form estimations of the effect of predicted class-size in grade 7 on achievement in grade 9 are reported in the top panels of Tables## to ##, separately for each of the four subjects. For each subject results are reported for both the full sample and the discontinuity sample. And for each combinations of sample and subject results are reported for four different specifications varying in the controls included. This gives a total of 32 reduced form estimates of the effect of class-size on achievement. Eight of these have the expected negative sign, the other 24 are all positive with 5 significantly different from zero.

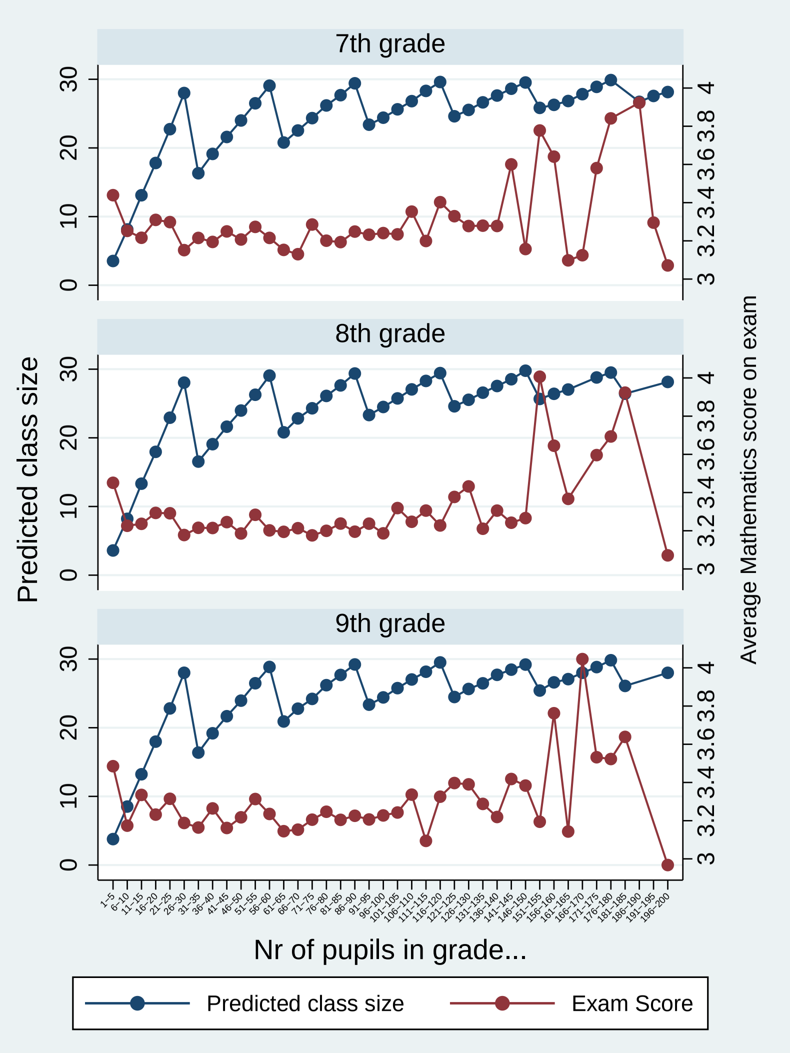
If we restrict attention to the four estimates based on the most elaborate specification and obtained from the discontinuity sample (reported in columns (8)), one has a negative sign and the other three are positive and in all cases effects are not significantly different from zero.

6.5 2SLS results

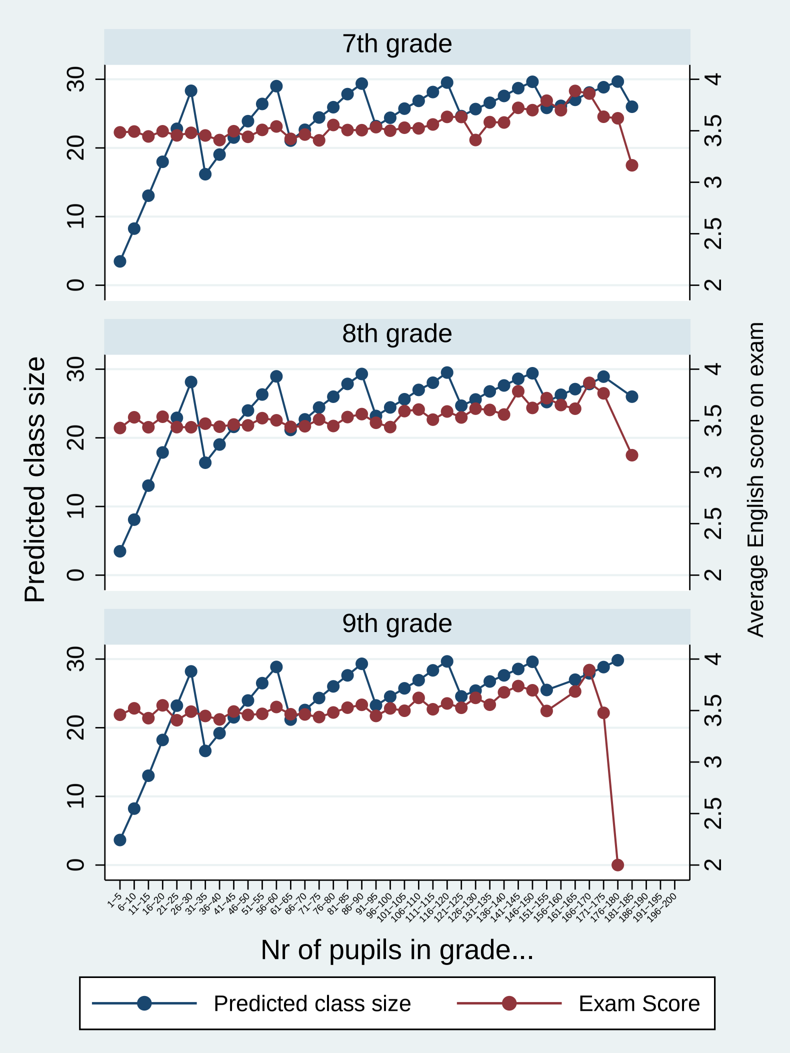
The bottom panels of Tables 6 to 9 present the 2SLS results which rescale the reduced form results by the first stage effect. These results are suitable for comparison with results from other studies. For class-size reductions to be cost-effective the effect of a one student reduction needs to be in the vicinity of 3 percent of a standard deviation (cf. Krueger (1999); Woessmann and West (2005)). We tested formally whether the 2SLS exclude effects of this magnitude and conclude that they do. All 32 2SLS estimates are larger (less negative) than -0.03. If we restrict our inferences again to the four estimates from the most elaborate specification using the discontinuity sample, we can even exclude effects as small as 1 percent of a standard deviation for math and the Norwegian languages and of 1.5 percent of a standard deviation for English at the 5%-confidence level.

7 Short and long term impacts

The previous section investigated how average class size in lower secondary education affects performance on exit tests when students are aged 15/16. Although we did not detect a significant impact of average class size on student performance by the end of lower secondary education, but since our point estimates are rather precise we can rule out relatively small effects. Even though class size in lower secondary education does

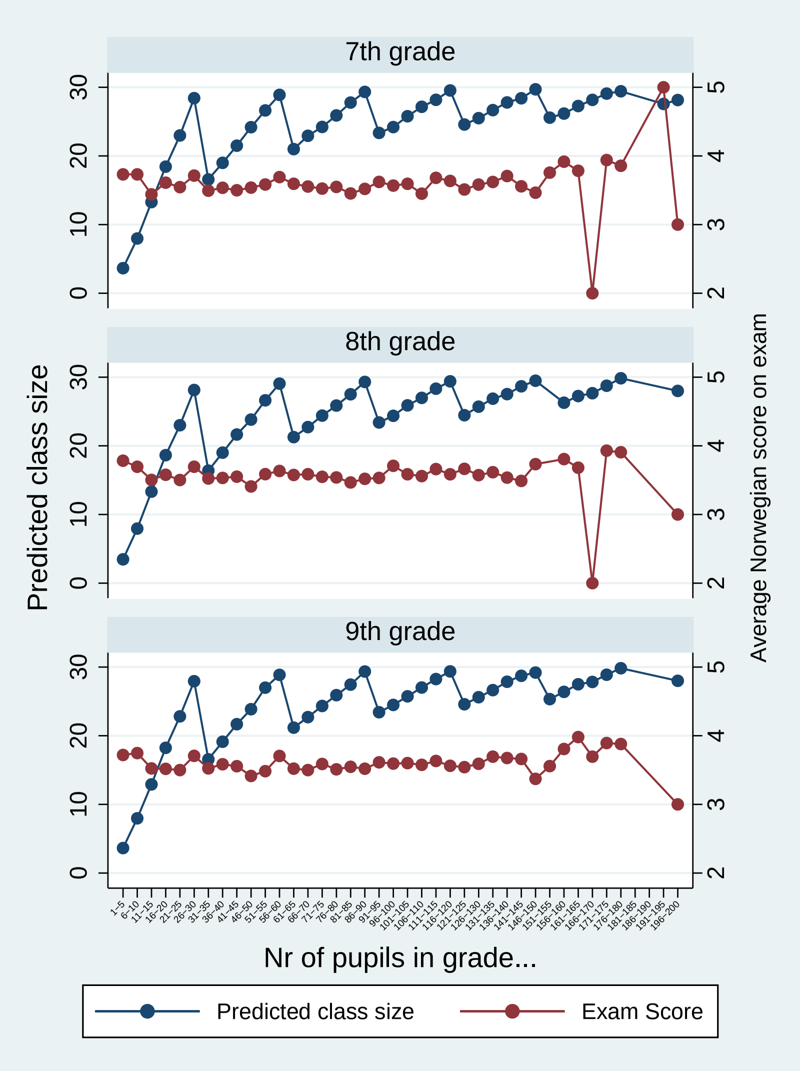


(a) Mathematics

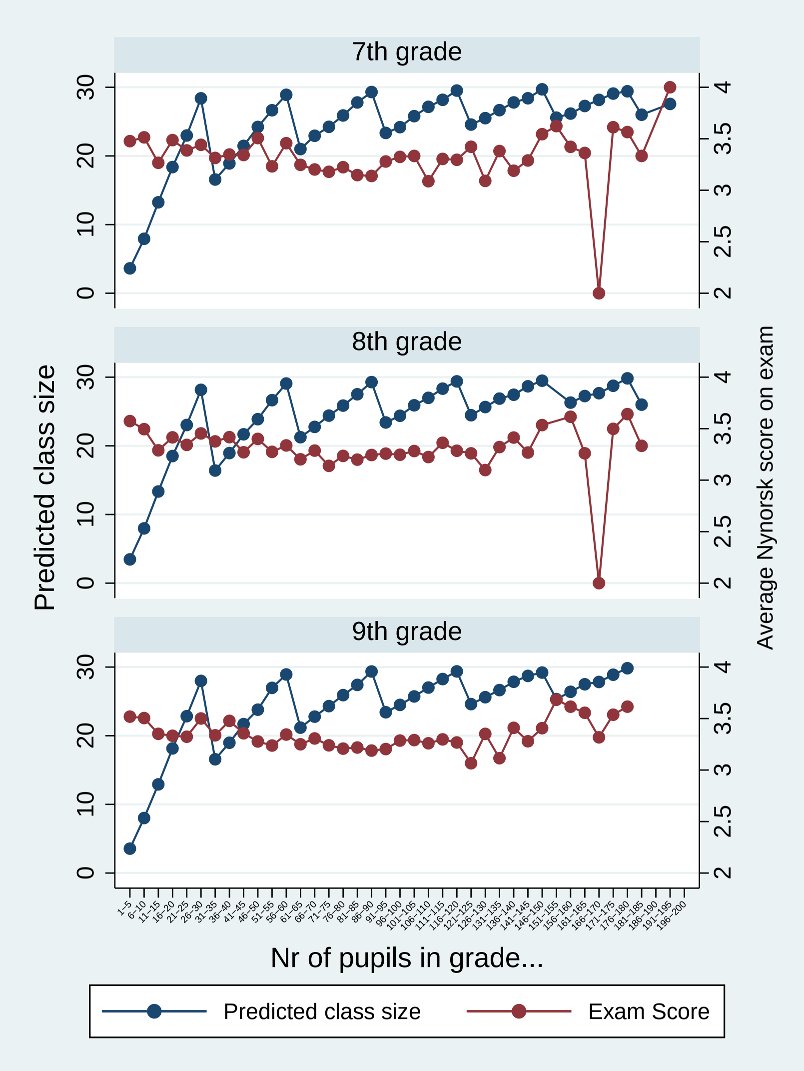


(b) English

Figure 3: The relationship between class size and test scores: Mathematics and English



(a) Norwegian



(b) Nynorsk

Figure 4: The relationship between class size and test scores: Norwegian and Nynorsk

Table 6: Reduced form and 2SLS estimates for mathematics

	Full sample				Disc sample (+/-5)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Reduced form							
predicted class size	0.0066	0.0020	-0.0016	-0.0021	0.0125	0.0014	0.0023	0.0036
	(0.0026)**	(0.0036)	(0.0028)	(0.0027)	(0.0055)**	(0.0050)	(0.0040)	(0.0042)
enrollment		-0.0024	-0.0026	-0.0019		-0.0032	-0.0010	0.0008
		(0.0018)	(0.0012)**	(0.0013)		(0.0023)	(0.0014)	(0.0018)
enrollment^2		0.0208	0.0128	0.0102		0.0321	0.0093	0.0025
		(0.0099)**	(0.0065)**	(0.0068)		(0.0123)***	(0.0072)	(0.0080)
Root MSE	1.129	1.127	1.02	1.019	1.132	1.126	1.024	1.023
R-squared	0.0008	0.0048	0.1844	0.1866	0.0021	0.0138	0.1842	0.1860
	2SLS							
average class size	0.0079	0.0026	-0.0022	-0.0028	0.0217	0.0025	0.0044	0.0070
	(0.0031)**	(0.0048)	(0.0037)	(0.0036)	(0.0096)**	(0.0093)	(0.0078)	(0.0081)
enrollment		-0.0025	-0.0026	-0.0018		-0.0032	-0.0009	0.0009
		(0.0019)	(0.0013)**	(0.0014)		(0.0023)	(0.0014)	(0.0018)
enrollment^2		0.0212	0.0125	0.0098		0.0319	0.0089	0.0022
		(0.0103)**	(0.0068)*	(0.0070)		(0.0123)**	(0.0072)	(0.0083)
Root MSE	1.129	1.127	1.02	1.019	1.133	1.126	1.025	1.024
R-squared	0.0006	0.0047	0.1844	0.1867	0.0003	0.0136	0.1840	0.1857
family controls	no	no	yes	yes	no	no	yes	yes
school controls	no	no	no	yes	no	no	no	yes
N Schools	780	780	780	780	195	195	195	195
N	36,966	36,966	36,966	36,966	10,712	10,712	10,712	10,712

Notes: see table 5.

Table 7: Reduced form and 2SLS estimates for English

	Full sample				Disc sample (+/-5)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Reduced form							
predicted class size	0.0094	0.0047	-0.0004	-0.0008	0.0096	0.0054	0.0012	-0.0000
	(0.0022)***	(0.0032)	(0.0026)	(0.0025)	(0.0044)**	(0.0049)	(0.0039)	(0.0037)
enrollment		-0.0013	-0.0025	-0.0020		0.0028	-0.0004	0.0001
		(0.0015)	(0.0010)**	(0.0012)		(0.0026)	(0.0019)	(0.0023)
enrollment^2		0.0146	0.0123	0.0094		-0.0086	-0.0003	-0.0034
		(0.0088)*	(0.0058)**	(0.0062)		(0.0157)	(0.0113)	(0.0116)
Root MSE	1.073	1.071	.9816	.981	1.073	1.072	.9814	.9792
R-squared	0.0016	0.0041	0.1644	0.1655	0.0014	0.0031	0.1655	0.1696
	2SLS							
average class size	0.0113	0.0064	-0.0005	-0.0011	0.0156	0.0093	0.0020	-0.0000
	(0.0026)***	(0.0043)	(0.0035)	(0.0035)	(0.0072)**	(0.0084)	(0.0067)	(0.0066)
enrollment		-0.0016	-0.0025	-0.0019		0.0025	-0.0004	0.0001
		(0.0016)	(0.0011)**	(0.0014)		(0.0026)	(0.0019)	(0.0023)
enrollment^2		0.0159	0.0122	0.0091		-0.0073	-0.0001	-0.0034
		(0.0092)*	(0.0061)**	(0.0066)		(0.0157)	(0.0113)	(0.0115)
Root MSE	1.073	1.072	.9816	.981	1.073	1.072	.9814	.9792
R-squared	0.0014	0.0040	0.1644	0.1655	0.0008	0.0029	0.1654	0.1696
family controls	no	no	yes	yes	no	no	yes	yes
school controls	no	no	no	yes	no	no	no	yes
N schools	794	794	794	794	205	205	205	205
N	36196	36196	36196	36196	11448	11448	11448	11448

Notes: see table 5.

Table 8: Reduced form and 2SLS estimates for Norwegian

	Full sample				Disc sample (+/-5)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Reduced form							
predicted class size	0.0041	0.0037	-0.0002	-0.0000	0.0099	0.0093	0.0073	0.0084
	(0.0025)	(0.0037)	(0.0034)	(0.0035)	(0.0052)*	(0.0057)	(0.0052)	(0.0058)
enrollment		-0.0036	-0.0032	-0.0042		-0.0042	-0.0024	-0.0029
		(0.0013)***	(0.0013)**	(0.0016)***		(0.0020)**	(0.0020)	(0.0025)
enrollment^2		0.0250	0.0151	0.0191		0.0232	0.0071	0.0093
		(0.0063)***	(0.0061)**	(0.0069)***		(0.0095)**	(0.0096)	(0.0109)
Root MSE	.9961	.9942	.8864	.8861	.9831	.9822	.8794	.8794
R-squared	0.0004	0.0042	0.2089	0.2096	0.0018	0.0039	0.2029	0.2034
	2SLS							
average class size	0.0048	0.0051	-0.0003	-0.0000	0.0167	0.0184	0.0144	0.0156
	(0.0030)	(0.0052)	(0.0048)	(0.0048)	(0.0087)*	(0.0117)	(0.0104)	(0.0112)
enrollment		-0.0039	-0.0032	-0.0042		-0.0049	-0.0026	-0.0028
		(0.0015)***	(0.0015)**	(0.0018)**		(0.0022)**	(0.0021)	(0.0024)
enrollment^2		0.0262	0.0151	0.0191		0.0246	0.0079	0.0085
		(0.0071)***	(0.0068)**	(0.0076)**		(0.0096)**	(0.0097)	(0.0107)
Root MSE	.9962	.9943	.8864	.8861	.984	.9833	.88	.8803
R-squared	0.0001	0.0040	0.2089	0.2096	.	0.0017	0.2017	0.2018
family controls	no	no	yes	yes	no	no	yes	yes
school controls	no	no	no	yes	no	no	no	yes
N schools	527	527	527	527	120	120	120	120
N	20143	20143	20143	20143	6176	6176	6176	6176

Notes: see table 5.

Table 9: Reduced form and 2SLS estimates for Nynorsk

	Full sample				Disc sample (+/-5)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Reduced form							
predicted class size	-0.0035	0.0047	0.0017	0.0029	0.0087	0.0066	0.0044	0.0076
	(0.0028)	(0.0043)	(0.0040)	(0.0040)	(0.0063)	(0.0066)	(0.0060)	(0.0061)
enrollment		-0.0079	-0.0065	-0.0081		-0.0088	-0.0059	-0.0052
		(0.0015)***	(0.0015)***	(0.0019)***		(0.0025)***	(0.0024)**	(0.0035)
enrollment^2		0.0437	0.0343	0.0410		0.0502	0.0346	0.0326
		(0.0075)***	(0.0069)***	(0.0082)***		(0.0128)***	(0.0122)***	(0.0162)**
Root MSE	.9821	.9786	.882	.8809	.985	.9801	.8845	.8838
R-squared	0.0004	0.0076	0.1942	0.1964	0.0023	0.0127	0.1972	0.1993
	2SLS							
average class size	-0.0041	0.0065	0.0024	0.0040	0.0148	0.0130	0.0088	0.0142
	(0.0033)	(0.0060)	(0.0055)	(0.0055)	(0.0110)	(0.0133)	(0.0119)	(0.0118)
enrollment		-0.0083	-0.0066	-0.0083		-0.0093	-0.0060	-0.0051
		(0.0018)***	(0.0017)***	(0.0021)***		(0.0027)***	(0.0024)**	(0.0034)
enrollment^2		0.0453	0.0348	0.0420		0.0512	0.0350	0.0319
		(0.0084)***	(0.0076)***	(0.0089)***		(0.0134)***	(0.0123)***	(0.0158)**
Root MSE	.9819	.9788	.8821	.8811	.9859	.9809	.8844	.8843
R-squared	0.0007	0.0071	0.1941	0.1962	0.0006	0.0111	0.1974	0.1984
family controls	no	no	yes	yes	no	no	yes	yes
school controls	no	no	no	yes	no	no	no	yes
N schools	501	501	501	501	115	115	115	115
N	18767	18767	18767	18767	5760	5760	5760	5760

Notes: see table 5.

Table 10: The effect of class size in primary and lower secondary education on achievement

	Average class size in:	
	Primary (1)	Lower Sec. (2)
Mathematics (N=7,720)	0.0093	-0.0024
	(0.0094)	(0.0060)
English (N=8,229)	-0.0037	0.0042
	(0.0073)	(0.0051)
Norwegian (N=4,073)	0.0033	0.0030
	(0.0081)	(0.0072)
Nynorsk (N=3,799)	-0.0100	0.0036
	(0.0099)	(0.0076)

not appear to have an important impact on student performance, we cannot exclude that class size in primary education is effective in raising performance.

To investigate the impact of class size in primary education on lower secondary education achievement we consider the sample of comprehensive schools. Fifty-four percent of the schools in Norway is comprehensive and provides education at both the primary and lower secondary level. These schools are typically located in more remote areas and are relatively small. To illustrate the latter: more than half of the lower secondary schools are comprehensive but they account for only 24 percent of the student population. The reason for focusing on these schools is that we have information on the class size and enrollment not only at the lower secondary level but also at the primary level. For our cohorts of lower secondary students we can calculate average class size for the years they spend in primary education. We will need to assume however that lower secondary pupils in comprehensive schools also spend their primary education years there.

We estimate jointly the impact of average class size in primary education and lower secondary class size on achievement. We proceed in the same way as lined out in section 5; average class size in primary education is instrumented with predicted class size in the first grade of primary education, and average class size in lower secondary education is instrumented with predicted class size in the first grade of lower secondary education. The instruments are highly significant in the first stages and both the Anderson canonical correlations likelihood-ratio test statistic and the Cragg-Donald chi-squared test statistic show that our system is identified. Table 10 reports the results of the second stage.

The second column shows the results for average class size in lower secondary education. The estimates on the various outcomes closely resemble the results found above for the sample of all schools. None of the estimated effects are significant and only one of the effects (for mathematics) has the expected sign. As above we can rule out (negative) effects larger than 1.5 percent of a standard deviation. Turning to the results for class size in primary education we see that none of the effects are significant. We now find negative points estimates for two other outcomes: English and Nynorsk. The precision for the class size in primary education is somewhat lower and we cannot rule out effects in the order of 3 percent of a standard deviation.

8 Results for small schools using population variation

[in progress]

9 Heterogeneous outcomes

As can be seen in table 4, which presented the OLS results, there are a strong positive correlations between parental education and income and student outcomes. In this section we investigate whether the effect of class size on student outcomes might differ between various groups of students. [mention references that look at disadvantage students]. For the moment we focus on two groups of students; i) those with a lower educated mother (10 or less years of schooling, lower third of the distribution) and, ii) those students from families whose family income is below the median.

We test whether changes in class size matter for these subgroups of students differentially we include an interaction effect between class size and an indicator variable that equals one for more disadvantaged group. Table 11 presents 2SLS results on the four outcome measures for both the full sample and the discontinuity sample. Columns (1) and (4) present the coefficient on average class size in lower secondary school and columns (2) and (5) the coefficients on the interaction of class size and the relevant indicator variable. Finally columns (3) and (5) show the p-values of the t-test on the interaction effect.

None of the interaction effects with maternal education is statistically significant. Moreover, one would perhaps expect that students with lower educated parents benefit more from smaller classes. If this would have been the case then the sign of the interactions should be negative, which is the opposite of what is observed.

With respect to family income a similar pattern emerges, but where no significant effects were found we now see that for both Norwegian and Nynorsk students from poorer families benefit from larger classes. A finding which deserves further explanation and exploration.

[add s.e. to table]

Table 11: Heterogeneous class size effects

	Full sample			Disc sample		
	class size	interaction	p-val	class size	interaction	p-val
	(1)	(2)	(3)	(4)	(5)	(6)
I. Lower educated mother						
- Mathematics	-0.0048	0.0044	*0.138*	0.0015	0.0050	*0.498*
- English	0.0010	-0.0032	*0.292*	-0.0024	0.0074	*0.371*
- Norwegian	-0.0012	0.0009	*0.803*	0.0096	0.0086	*0.393*
- Nynorsk	-0.0006	0.0048	*0.158*	0.0054	0.0061	*0.493*
II. Below median family income						
- Mathematics	-0.0024	0.0005	*0.891*	0.0040	0.0015	*0.875*
- English	0.0004	-0.0017	*0.568*	-0.0001	0.0032	*0.711*
- Norwegian	-0.0039	0.0058	*0.093*	0.0007	0.0253	*0.012*
- Nynorsk	-0.0025	0.0081	*0.018*	-0.0042	0.0248	*0.015*

10 Interactions with teacher characteristics

In their analysis of class-size effects in 11 different countries, Woessmann and West (2005) find sizable and significant negative class-size effects in only two countries - Greece and Iceland - whereas they can rule out such effects for the other countries. In an attempt to explain why Greece and Iceland and no other countries exhibit substantial class-size effects they advance the idea that class-size reduction is only beneficial if the teaching staff is of low quality. This hypothesis is based on indication that in both countries teachers are disproportionally recruited from the lower tail of the ability distribution. To test their hypothesis by presenting results from regressions that include interaction terms between class-size and teacher education, and find some support for their idea.

Building on this idea, we report in table 12 results from regressions that include interactions between teachers' length of education and class-size from regressions that include interactions between teachers' experience and class-size. The regressions also include main effects of the interacted variables. Results are reported separately for different subjects as outcome variables and for both the full sample and the discontinuity sample.

Supportive for Woessmann and West's hypothesis would be positive coefficients for the interaction terms (students of lower educated or less experienced teachers do better in smaller classes). In contrast to this, only 4 out of the 16 reported interaction effects in table 12 have this sign, with one of these significantly different from zero.

11 Summary and discussion

Based on estimation results that exploit arguably exogenous variation in class-size, we find no significant effect of class-size during lower secondary school and primary school on achievement in grade 9 in Norway. For class-size in lower secondary school we can even exclude effects as small as 1.5 percent of a standard deviation for a one student reduction in average class-size during three years.

Effects are similar for different social backgrounds groups and are also invariant for differences in teacher characteristics. These latter results lend no support for the idea that reduced class-size is especially beneficial for disadvantaged students or in situations with ill-prepared teachers.

Our findings contrast sharply with most of the recent studies that apply experimental and quasi-experimental methods to estimate the class-size effect. Interestingly, while we applied the same identification strategy as Angrist and Lavy did in their study for Israel the findings are very different. We interpret this as evidence that there is no such thing as a universal class-size effect.

[in progress]

Table 12: Class size interactions with teacher characteristics

	Full sample			Disc sample		
	class size (1)	interaction (2)	p-val (3)	class size (4)	interaction (5)	p-val (6)
Teachers' length of education						
- Mathematics	0.0666	-0.0152	*0.174*	0.1265	-0.0267	*0.472*
- English	0.0062	-0.0015	*0.894*	0.0192	-0.0037	*0.915*
- Norwegian	-0.0495	0.0108	*0.306*	0.1238	-0.0242	*0.687*
- Nynorsk	-0.0389	0.0092	*0.450*	0.2322	-0.0485	*0.463*
Teachers' experience						
- Mathematics	0.0151	-0.0010	*0.054*	0.0233	-0.0009	*0.627*
- English	0.0081	-0.0005	*0.288*	0.0060	-0.0003	*0.859*
- Norwegian	-0.0262	0.0014	*0.020*	-0.0326	0.0024	*0.153*
- Nynorsk	0.0111	-0.0004	*0.497*	0.0398	-0.0016	*0.520*

References

Angrist, J. D. and Lavy, V. (1999). Using Maimonides' rule to estimate the effect of class size on scholastic achievement. *Quarterly Journal of Economics*, 114(2):533–575.

Bingley, P., Jensen, V. M., and Walker, I. (2004). The effects of school resources on participation in post-compulsory education: Danish quasi-experimental evidence, and evidence that controls for family, school and neighbourhood effects. Working paper.

Boozer, M. and Rouse, C. (2001). Intraschool variation in class size: Patterns and implications. *Journal of Urban Economics*, 50:163–189.

Browning, M. and Heinesen, E. (2003). Class size, teacher hours and educational attainment. Workin Paper 2003-15, Centre for Applied Microeconometrics.

Hoxby, C. M. (2000). The effects of class size on student achievement: New evidence from population variation. *Quarterly Journal of Economics*, 115(4).

Krueger, A. B. (1999). Experimental estimates of education production functions. *Quarterly Journal of Economics*, 114(2):497–532.

Krueger, A. B. and Whitmore, D. M. (2001). The effect of attending a small class in the early grades on college-test taking and middle school test results: Evidence from project star. *Economic Journal*, 111:1–28.

Strøm, B. (2004). Student achievement and birthday effects. Mimeo, Norwegian University of Science and Technology.

Urquiola, M. (2000). Identifying class size effects in developing countries: Evidence from rural schools in Bolivia. Policy Research Working Paper 2711, World Bank.

Woessmann, L. and West, M. (2005). Class-size effects in school systems around the world: Evidence from between-grade variation in TIMMS. *European Economic Review*, forthcoming.