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CLASS SIZE EFFECTS ON STUDENT ACHIEVEMENT: HETEROGENEITY ACROSS ABILITIES AND FIELDS

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Class Size Effects on Student Achievement: Heterogeneity across Abilities and Fields

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In this paper we analyze class size effects on college students exploiting data from a project offering special remedial courses in Mathematics and Language skills to freshmen enrolled at an Italian medium sized public University. To estimate the effects of class size we take advantage of the fact that students and teacher where virtually randomly assigned to teaching classes of different sizes. From our analysis it emerges that, controlling for a number of individual characteristics, larger classes determine a significant and sizeable negative effect on student performance in Mathematics. Importantly, this negative effect is significantly larger for low ability students and negligible for high ability students. On the other hand, class size effects do not appear to be relevant for student achievement in Language Skills.

JEL Classification: C23; I21; J24.
Keywords: Class size; student achievement; educational production function.

1. Introduction

The effects of educational inputs, such as class size, teaching quality, school resources, on student achievement have been deeply investigated in the economic literature. However, there is still an ongoing debate and no consensus has been reached about how these factors influence student performance.

One of the most cited reference on this topic is the Hanushek's (1986) review of the literature, which reaches a somewhat surprising conclusion: there is no evidence of any consistent relationship between school resources and student performance. In a more recent survey, Hanushek (2002) confirms that the majority of empirical studies do not find any significant relationship between resources devoted to education and student performance.

Card and Krueger (1992 and 1998) find, instead, a positive relationship between school resources and student achievement, showing that both low pupil-teacher ratios and high quality

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school systems lead to higher future earnings for students. A positive effect of school inputs on individual learning processes has been highlighted also by some recent works, showing for example that teaching quality improves student performance (Bettinger and Long, 2009; Rivkin et al., 2005; Rockoff, 2004; Krueger, 2003). This heterogeneity in empirical results suggests that researchers know still little about what matters for the human capital acquisition process.

Unclear results have been reached also on the effects of class size on student performance: whereas some studies conclude that small classes do not improve student achievement (Hanushek, 2003; Hoxby, 2000; Wößmann and West, 2006), other researches find evidence of a positive impact (Glass and Smith, 1979; Glass, Cahen, Smith, and Filby, 1982; Krueger 1999, Krueger and Whitmore, 2001; Angrist and Lavy, 1999).

These contrasting results may be related to serious econometric problems – such as omitted variable bias, reverse causality or measurement errors – that plagues this type of analysis and make it difficult to recover the causal effect of class size on student performance. Early studies have often relied on data in which the allocation of students to classes of different size was not the result of an exogenous assignment. For example, in some cases schools follow the policy of assigning less able students to smaller classes or that of assigning better teachers to larger classes. In other cases, the allocation of students to classes of different size is not exogenous due to parent decisions, for example parents more concerned about the education of their children may choose schools with a smaller class size. As regards measurement errors, due to the unavailability of data on students' actual class size, some past studies have used the student-teacher ratio, defined as the number of students in the school divided by the number of full time teachers. However, schools with the same student-teacher ratio may have significantly different class sizes depending, for example, on the average number of hours of teaching required (Bowles and Levin, 1968).

As a consequence of these econometric problems, estimates of class size effects may be seriously biased. With the aim to provide more reliable estimates of the influence of class size on student achievement, recent researches rely on controlled randomized experiments or natural experiments. A number of works have analyzed class size effect considering the Project STAR that randomly assigned students and teachers to classes of different size. From these empirical analyses it emerges that smaller classes increase student achievement, even after controlling for school fixed effects and teacher characteristics (Krueger, 1999; Nye, Hedges and Konstantopoulos, 1999; Krueger and Whitmore, 2001).

Although these analyses provide convincing evidence in favor of a class size effects, another stream of recent evidence based on natural experiments (e.g. Hoxby, 2000; Leuven, Oosterbeek and Ronning, 2008) find that smaller classes do not help at improving student performance.

This variety of experimental and quasi-experimental empirical studies mainly used data concerning primary and secondary schools. Little is known as regards tertiary education, where class size is typically much larger than at other levels of the educational system. Some works show that college students' attitudes toward learning tend to be negatively affected by larger classes (Bolander 1973, Feldman, 1984, McConnell and Sosin, 1984). A recent study by Bandiera, Larcinese and Rasul (2008), using data from a leading UK university, show a negative and significant effect of class size for the smallest and largest ranges of class size, while the effect for intermediate class sizes (from 33 to 104 students) is not significantly different from zero. De Paola and Scoppa (2009) provide evidence of class size effects among Italian college students exploiting the exogenous variations in class size determined by a maximum class size rule introduced by the 2001 Italian university reform. From their analysis it emerges that large teaching classes produce negative effects on student performance.

In this paper we present new evidence on the effects of class size on the achievement of college students exploiting data from a project offering – with the aim to improve basic competences – special remedial courses to students enrolled in the academic year 2008/2009 at the University of Calabria, an Italian medium sized public University. The project was promoted by the Educational Department of the local Regional Government (Regione Calabria) and funded by the European Social Fund.

The remedial courses (160 hours of lectures) were carried out at the beginning of the academic year and have covered both Mathematics and Language Skills (plus other courses specific to the fields of study). Thanks to the fact that students were randomly assigned to teaching classes of different sizes, we are able to examine how class size has affected student performance.

While studies considering tertiary education typically measure student performance relying on grades obtained at a number of different exams, which may be affected by heterogeneous grading practices among professors, we measure student performance on the basis of the score they obtained at a multiple choice test performed at the end of the project (Exit test). We also have very reliable information on student predetermined abilities. In fact, in addition to data on high school grades and type of high school attended, we have information on the level of student skills in Mathematics and Language according to the score they obtained at an entry test performed at the beginning of the project, before the start of remedial courses, which aimed at investigating the general level of student knowledge.

To analyze the effect of class size on student performance we estimate a simple OLS model relating the scores obtained by students at the exit test in Mathematics and Language Skills (measured by the percentage of correct answers) on class size and controlling for the level of individual pre-determined ability, the number of lectures attended and a set of individual characteristics such as gender, province of residence etc. From our estimates it emerges that larger classes produce a negative effect on students test scores in Mathematics, whereas class size does not appear to affect scores obtained by students in the test evaluating Language Skills.

Importantly, it emerges that the positive effect of small classes is particularly relevant for low-skilled students, while it is negligible for high skilled students.

The paper is organized as follows. In Section 2 we describe the data used in our study and provide some descriptive statistics. In Section 3 we carry out the econometric analysis of the impact of class size on student test scores in Mathematics and Language Skills. Section 4 concludes.

2. Descriptive Statistics and Exogeneity Checks

Freshmen enrolled at the University of Calabria, a medium sized Public University located in the South of Italy, in the academic year 2008-2009 were involved in a project, promoted by the Educational Department of the local Regional Administration (Regione Calabria), aimed at improving student basic competences through an intensive training programme offering a number of courses in subjects such as Mathematics and Language Skills. In addition, students attended some other courses in specific subjects according to their field of study.

Students participating at the project were asked to perform an entry test, before the start of the training activities, aimed at assessing the initial levels of knowledge. Courses began in the first week of September 2008 and have lasted about 2 months, 6 hours per day for a total of 160 hours. At the end of the educational programme students were required to perform an exit test aimed at evaluating the improvement in their skills. Tests in Maths and Language Skills were the same for all students participating at the programme independently from their field of study.

In our analysis we only consider students enrolled in two fields of study: Economics and Pharmacy and Nutritional Science. These Faculties have decided to organize the teaching activity related to the remedial courses assigning students to classes of different size on the basis of their surname (in alphabetical order).[1] Our preliminary analysis shows that this is equivalent to a random assignment and that class size is not related to any student characteristic. Moreover, we show that there is no relationship between instructor's observable characteristic (gender and experience) and class size.

Thanks to this setting, in our econometric analysis we are able to avoid risks deriving from the fact that class size may be related to other possible factors affecting student performance (such as students abilities, teaching quality, family background, etc.). Therefore, the estimated class size effects rely on exogenous variations and are not affected by "selection bias".

[1] The Board of the other Faculties decided to allocate students with lower initial abilities in smaller classes.

The participation to the programme was on a voluntary basis and 1,088 students decided to attend the educational programme on a total of about 2,000 freshmen, enrolled in 2008/2009 in the Economics and Pharmacy and Nutrition Science fields.[2]

Thanks to the administrative data provided by the University of Calabria we have detailed information on these students both as regards their abilities (scores obtained at the entry and exit tests, high school grade, type of high school attended) and individual characteristics such as gender, province of residence, year of high school accomplishment.

Table 1 provides descriptive statistics for our sample students. About 64% of students are female. Students mainly come from three different types of high school: Lyceums (about 50%), Technical Schools (about 30%), whereas a percentage of 20% comes from Vocational Schools (such as Professional and Teacher-Training Schools). High School Grade ranges from 60 to 100, with a mean of 87.14. The number of freshmen enrolled in Economics (66%) is much higher than the number of freshmen enrolled in Pharmacy and Nutritional Science (34%). On the basis of the province of residence (Nuts-3 level), students mainly come from Cosenza (66.4%) that is the area in which the University of Calabria is located.

The average score attained by students at the entry test in Mathematics is 41%, while the percentage of correct answers at the entry test in Language Skills is 55%. On the other hand, the average scores obtained at the exit tests in Mathematics and in Language Skills are respectively of 37% and 69%. It is worthwhile to note that entry and exit tests are not directly comparable because their degree of difficulty is different. Nonetheless, the rate of correlation between student achievement at the entry and exit test is very high: if we regress Score Exit Test of Mathematics on the Score Entry Test of Mathematics the coefficient is 0.77 and its *t*-stat is 39. Similarly for the entry and exit test of Language Skills. In addition, scores obtained at these tests are strongly correlated with the High School Final Grade, ensuring us about the reliability of Entry and Exit Tests.

Table 1. Descriptive statistics for the sample of students.

Variables	**Obs**	**Mean**	**Std. Dev.**	**Min**	**Max**
Score Exit Test Mathematics	1088	37.129	20.259	0	100
Score Exit Test Language Skills	1088	68.958	17.605	13.333	100
Female	1088	0.642	0.480	0	1
Scientific High School (Lyceum)	1088	0.363	0.481	0	1
Humanities High School (Lyceum)	1088	0.142	0.349	0	1
Technical School	1088	0.259	0.438	0	1
Professional School	1088	0.195	0.396	0	1
Teacher-Training School	1088	0.041	0.199	0	1
High School Final Grade	1088	87.144	11.407	60	100
Year of Graduation in the High School	1088	2007.68	1.436	1987	2008
Economics Faculty	1088	0.659	0.474	0	1
Pharmacy Faculty	1088	0.341	0.474	0	1

[2] To encourage student involvement in the project, the Educational Department of Regione Calabria offered a voucher of 400 euro to students who attended at least 80% of lectures provided within the educational program.

Class Size	1088	33.933	5.998	17	46
Hours of Mathematics Lectures	1088	40.326	17.299	3	60
Hours of Language Skills Lectures	1088	20.405	5.349	0	30
Score Entry Test Mathematics	1088	41.614	17.495	0	93.33
Score Entry Test Language Skills	1088	55.027	17.046	0	100
Female Mathematics Teacher	1088	0.414	0.493	0	1
Age Mathematics Teacher	1088	45.872	12.093	29	69
Female Language Skill Teacher	1088	0.848	0.359	0	1
Age Language Skill Teacher	1088	35.402	7.864	26	57

Students have attended on average about 40 hours of lectures in Mathematics and 20 hours of lectures in Language Skills.

Teaching activity was organized in classes of medium size. However, for logistical reasons, given the necessity for the University to provide regular courses to sophomore students, remedial courses in "Mathematics" and "Language Skills" were taught in classes of different size, ranging from 17 to 46, with an average number of students of 33.93 and a standard deviation of 6.

Figure 1 shows the distribution of students in classes of different size. The majority of students are placed in classes of 36. Only 6% of students were assigned to classes with less than 25 students and 18% were assigned to classes larger than 40 students.

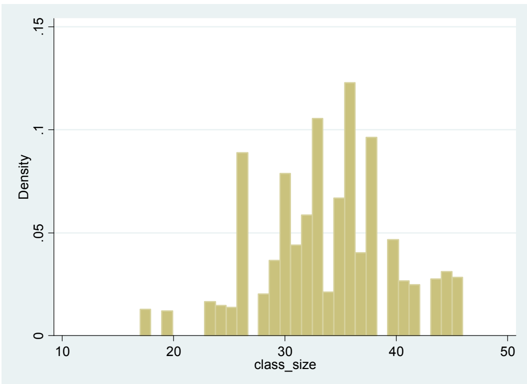

Figure 1. Distribution of students in classes of different sizes

Exogeneity Checks

Before proceeding to the econometric analysis it is necessary to verify whether the assignment of students to classes of different size, based on the alphabetic order of student surnames, has effectively produced a random assignment.

In order to analyse this aspect, in Table 2 we report the estimated coefficients from 2 OLS regressions in which the dependent variable is *Class Size* and the explanatory variables are student and teacher observable characteristics. If the assignment of students and teachers to teaching classes has been actually random, none of the coefficients should be statistically different from zero.

In column (1) estimation results show that none of the student characteristics (scores obtained by students at the entry test in Mathematics and Language Skills, gender, High School Grade, type of High School, province of residence, year of high school graduation) appears to be correlated with class size, confirming a random assignment process.

The only variable that seems relevant in defining class size is the student field of study. Students enrolled in the Economics field have attended lectures in smaller classes, on average 7 students less compared to teaching classes organized for students enrolled in the Pharmacy and Nutritional Sciences field. In analysing the effects of class size on the scores obtained by students at the exit test, we control for a field dummy variable.

We have little information on teachers who taught the remedial courses of Mathematics and Language skills: their gender and age. To analyze whether teachers with different characteristics were assigned to classes of different size, in column (2) we have included among regressors also the teachers' age and a dummy for teacher's gender (distinctly for teachers of maths and language skills). Again we do not find any statistically significant effect.

Table 2. Exogeneity Checks. Dependent Variable: Class Size

Variables	(1)	(2)
Score entry test of Mathematics	-0.00288	-0.00218
	(0.01044)	(0.00997)
Score entry test of Language Skills	0.00221	0.00397
	(0.01081)	(0.00927)
Female	0.29890	0.12827
	(0.34406)	(0.33305)
High School Final Grade	-0.01366	-0.01882
	(0.01536)	(0.01617)
Scientific High School (Lyceum)	0.29454	0.47065
	(0.44699)	(0.40812)
Humanities High School (Lyceum)	-0.57293	-0.41240
	(0.56041)	(0.45702)
Technical School	0.19253	0.20447
	(0.47615)	(0.38798)
Vocational School	-0.01044	-0.17223
	(0.98290)	(1.03208)
Cosenza	-0.22998	-0.23650
	(0.57163)	(0.53200)
Crotone	0.22861	0.14340
	(0.72759)	(0.56987)
Reggio Calabria	-0.01465	-0.16301
	(0.73434)	(0.77698)
Vibo Valentia	-0.80451	-0.78158
	(0.79123)	(0.78657)
Year of High School Graduation	-0.08577	-0.06560
	(0.08844)	(0.08738)
Economics Field	-6.91081***	-6.95320***
	(0.33736)	(1.35883)
Female Language Skill Teacher		1.83721
		(1.43457)
Female Mathematics Teacher		0.13644
		(1.60388)
Age Language Skill Teacher		-0.13934

		(0.15968)
Age Mathematics Teacher		-0.00907
		(0.06265)
Constant	211.79723	175.43624
	(177.40109)	(175.49204)
Observations	1088	1088
R-squared	0.30760	0.35807

Note: OLS estimates. Dependent variable: Class Size. Robust standard errors are reported in parentheses. The symbol *** indicate that coefficients are statistically significant at the 1 percent level.

3. The Econometric Analysis of Class Size Effects

In this section we estimate class size effects by using an OLS model based on the following equation:

$$Y_i = \beta_0 + \beta_1 Class\_Size_i + \beta_2 X_i + \varepsilon_i$$

where Y_i is the score obtained by student i at the exit test (respectively in Mathematics and in Language Skills), $Class\_Size_i$ refers to the number of students who have attended remedial courses together with student i. X_i is a vector of i individual characteristics (gender, type of High School attended, High School Grade, province of residence, hours of training activities attended, scores at the entry test), ε_i is the error component. We correct the potential residuals' heteroskedasticity with the White-Huber procedure. Moreover, standard errors are clustered at the class level in order to avoid problems arising from shocks that may be common to students who have attended lectures in the same class (Moulton, 1986).

We aim to analyze the effects of class size on the performance of students, measured with the score at the exit test in Mathematics or in Language Skills, according to the specification, that is to find out the sign and the magnitude of the coefficient β_1.

Table 3 shows the estimated coefficients from a number of OLS regressions based on equation (1). The dependent variable is the student's exit test score in Mathematics. In column (1) we first estimate an equation with no individual controls, in which student performance is regressed only on class size and on a dummy variable for the field of study. Having attended courses in a larger class is associated with significantly lower test scores in Mathematics (the effect is statistically significant at 10 per cent level). The dummy for the field of study is negative but not statistically significant.

In column (2) we add a number of additional individual controls: lectures attended, levels of predetermined abilities, gender, type of high school, etc. The effect of class size remains substantially unchanged in magnitude (from –0.283 to –0.307), but it gains in terms of statistical significance. From this estimate it emerges that an increase in class size of 10 students leads to a reduction in test scores obtained at the mathematics exit test of 3.07 percentage point.

As far as student characteristics are concerned, our results are consistent with those emerging from previous literature on student academic performance. Students with higher predetermined abilities, measured both considering the score obtained at the entry test in Mathematics and the High School grade, achieve better results at the exit test in Mathematics. Other things being equal, students who have attended a Scientific Lyceum perform much better than students who come from Vocational Schools (reference category), whereas students who have attended a Classical Lyceum or a Technical School are not statistically different from those in the reference category. In addition, students who have attended a higher number of remedial lectures in Mathematics get a higher score at the exit test. Students enrolled in Economics perform worse that students enrolled in Pharmacy and Nutritional Science, statistically significant at 10 percent level. Finally, student's gender, age and province of residence do not seem to produce any statistically significant effect on student performance in Mathematics.

Table 3. OLS estimates of the class size effect on students test scores. Dependent variable: Score Exit Test Mathematics

Variables	(1)	(2)	(3)	(4)	(5)
Class Size	-0.283*	-0.307**	-0.297**	-0.294**	-0.302**
	(0.152)	(0.146)	(0.140)	(0.143)	(0.138)
Class Size(Scores Entry Test Mathematics) (demeaned)*				0.009*	
				(0.005)	
Class Size(High School Grade) (demeaned)*					0.017*
					(0.010)
Economics Field	-1.871	-11.142*	-11.878*	-12.077*	-12.098*
	(3.516)	(5.931)	(6.077)	(6.079)	(6.059)
Hours of Mathematics Lectures		0.206**	0.210**	0.213**	0.214**
		(0.098)	(0.103)	(0.102)	(0.101)
Scores Entry Test Mathematics		0.518***	0.517***	0.224	0.516***
		(0.036)	(0.037)	(0.190)	(0.037)
Female		0.187	0.041	0.015	0.178
		(1.468)	(1.500)	(1.498)	(1.462)
High School Final Grade		0.189***	0.189***	0.188***	-0.395
		(0.057)	(0.056)	(0.056)	(0.349)
Scientific Lyceum		9.040***	9.058***	8.978***	8.878***
		(1.266)	(1.268)	(1.243)	(1.250)
Classical Lyceum		2.815	2.843	2.659	2.627
		(1.872)	(1.880)	(1.867)	(1.880)
Technical School		1.608	1.614	1.623	1.385
		(1.407)	(1.417)	(1.404)	(1.383)
Teaching-Training School		-0.745	-0.881	-1.042	-0.953
		(2.094)	(2.087)	(2.097)	(2.087)
Year of High School accomplishment		-0.451	-0.481*	-0.465*	-0.584
		(0.275)	(0.272)	(0.269)	(0.612)
Female teacher			1.305	1.287	1.382
			(1.567)	(1.577)	(1.561)
Teacher age			-0.070	-0.066	-0.072
			(0.098)	(0.098)	(0.099)
Constant	47.771***	910.989	973.413*	954.219*	1,233.777
	(7.440)	(551.948)	(549.244)	(540.693)	(1,235.4)
Observations	1129	1088	1088	1088	1088
R-squared	0.005	0.339	0.341	0.343	0.344

Note: OLS estimates. Dependent variable: Test score at the Exit test in Mathematics. In all specifications we control for province of residence dummies. Robust standard errors – clustered at class level - are reported in parentheses. The symbols ***, **, * indicate that coefficients are statistically significant, respectively, at the 1, 5, and 10 percent level.

As it possible to see in column (3) the estimated effect of class size remains substantially unchanged when we add among our controls the age of mathematics' teachers, which should represent a proxy of teaching experience and a dummy for female teachers. Incidentally, these two variables have no statistically significant effect on student performance.

In column (4) and (5) we investigate whether the effect of our variable of interest is heterogeneous across students with different predetermined ability. At this aim in column (4) we replicate specification (3) and we include among explanatory variables an interaction term between *Class Size* and the score obtained by the student at the entry test in Mathematics (the latter variable is de-meaned). The coefficient on *Class Size* in this specification represents the effect of class size on students characterized by an ability in Mathematics equal to the average level. For this kind of students, an increase of 10 students in class size produces a negative effect of 2.9 points in test score.

The interaction coefficient turns out to be positive and statistically significant at the 10 percent level, implying that a large class size lowers student performance significantly less for high skilled students, that is, higher ability students able students suffer a smaller negative effect on attending courses in larger classes. In order to better evaluate this aspect, in Table 4 (using the coefficients of Table 3, column 4) we show class size effects in relation to the initial abilities in Mathematic for five categories of students.

Table 4. Class size effects according to students abilities evaluated at the initial test in Mathematics

Student's abilities	Class Size Effect
Low skilled students 10%	-0.479
Low skilled students 25%	-0.394
Median ability of students	-0.294
Higher skilled students "top 75%"	-0.195
Higher skilled students "top 90%"	-0.109

From our estimates it emerges that 10 more students in a class lead to a reduction in test scores of 2.94 percentage points for the median ability student. This negative effect is stronger for low skilled students who are placed at the 10 percentile: the reduction of test scores when class size increases is equal to 4.79 percentage points. On the other hand, the estimated effect of class size is equal to 1.09 percentage points for high skilled students placed at the 90 percentile.

This can be seen in Figure 2 where the estimated student performance in Mathematics is graphed against Class Size, respectively, for students placed at the top of the predetermined math skills distribution (90th percentile), at the median level and at the bottom (10th percentile).

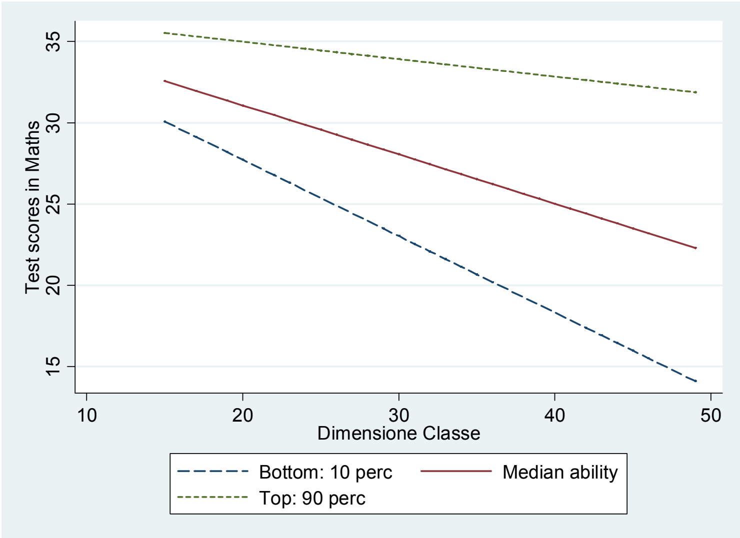

Figure 2. Students performance in Mathematics in relation to their abilities and Class size

Figure 2 shows that students characterized by a high level of initial competences in mathematics obtain better results in the exit test in Mathematics, both in the smallest and in the largest range of class size. The benefit of reducing class size (say from 40 to 20) is quite small for high ability students, whereas it is very relevant for low skilled students.

Very similar results emerge when we measure student initial ability considering the High School Grade (de-meaned) and interact it with Class Size. As it possible to see from column (5) of Table 3 students who have obtained a High School Grade higher than the average are less negatively affected by larger teaching classes. The interaction term is positive (0.017) and statistically significant at 10 per cent level.

We turn now our attention to class size effects on student achievement in language skills. Table 5 reports OLS estimates using the same specifications as in Table 3, but instead of considering as dependent variable the score obtained at the exit test in Mathematics, we analyze the effects of class size on students achievement in Language Skills (measured as the percentage of correct answers at the exit test in this subject).

Contrary to the pattern of the class size coefficients showed in Table 3, in Table 5 the effect of class size on students performance in Language Skills is not significantly different from zero. The coefficient is negative but not statistically significant at any conventional level.

Therefore, it seems that small class size does not appear to be particularly relevant for student achievement in language skills. In column (4) we have included an interaction term between Class Size and the score obtained by the student at the entry test in Language skills (the latter variable is de-meaned). Again we find that the negative effect of larger teaching classes is less relevant for high ability students. However, also when focusing on low ability students, the class size effect is not statistically significant.

As regards control variables, the type of school attended comes out to be a very important factor in explaining students performance at the exit test in Language Skills (all coefficients are significant at the 1 percent level). As expected, students who have attended a Classical Lyceum perform much better (9.9 points) than those in the reference group (Other Vocational Schools). Students characterized by a higher level of ability perform better: both the coefficients on the High School Grade and on the score at the entry test in language skills are positive and statistically significant at the 1 per cent level. In addition, students with higher attendance at lectures (Hours of Language Skills Lectures), obtain better scores. Female students show a better performance in Language skills (statistically significant at the 5 percent level). Finally, there is any statistically relevant differences in the performance of students enrolled in the Economics and Pharmacy and Nutritional Sciences. The experience of teachers seem to have a positive effect on student performance.

Table 5. OLS estimates of the class size effect on students test scores. Dependent variable: Score Exit Test in Language Skills

Variables	(1)	(2)	(3)	(4)	(5)
Class Size	-0.159	-0.087	-0.066	-0.042	-0.067
	(0.142)	(0.134)	(0.132)	(0.129)	(0.132)
Class Size(Scores Entry Test in Language Skill) (demeaned)*				0.010*	
				(0.005)	
Class Size(High School Grade) (demeaned)*					0.003
					(0.006)
Economics Field	-1.910	-2.063	-1.767	-1.653	-1.768
	(1.744)	(1.750)	(1.835)	(1.860)	(1.837)
Hours of Language Skill Lectures		0.126	0.138*	0.142*	0.137*
		(0.085)	(0.079)	(0.078)	(0.078)
Scores Entry Test Language Skills		0.383***	0.383***	0.053	0.383***
		(0.041)	(0.042)	(0.175)	(0.042)
Female		2.799**	2.867***	2.918***	2.893***
		(1.097)	(1.042)	(1.035)	(1.044)
High School Final Grade		0.229***	0.229***	0.223***	0.115
		(0.046)	(0.046)	(0.045)	(0.216)
Scientific Lyceum		5.174***	5.116***	4.939***	5.089***
		(1.495)	(1.458)	(1.385)	(1.441)
Classical Lyceum		9.811***	9.980***	9.871***	9.952***
		(1.354)	(1.385)	(1.345)	(1.381)
Technical School		4.094**	4.050**	3.859**	4.009**
		(1.521)	(1.506)	(1.457)	(1.491)
Teaching-Training School		5.631**	5.748**	5.783**	5.746**
		(2.321)	(2.298)	(2.309)	(2.301)
Year of High School graduation		0.007	-0.024	-0.014	-0.021
		(0.272)	(0.265)	(0.263)	(0.265)
Female teacher			2.816	2.736	2.823
			(3.427)	(3.425)	(3.430)
Teacher age			0.145*	0.148*	0.145*
			(0.083)	(0.084)	(0.084)
Constant	75.742***	10.537	63.860	61.513	68.176
	(5.340)	(548.071)	(532.467)	(529.616)	(531.705)
Observations	1129	1088	1088	1088	1088
R-squared	0.003	0.289	0.295	0.298	0.295

Note: OLS estimates. Dependent variable: Test score at the exit test in Language Skills. In all specifications we control for province of residence dummies. Robust standard errors – clustered at class level – are reported in parentheses. The symbols ***, **, * indicate that coefficients are statistically significant, respectively, at the 1, 5, and 10 percent level.

4. Concluding Remarks

Studies analyzing the effect of class size on student performance generally focus on primary and secondary education, while little work has been done to consider postsecondary education, partly because of the lack of suitable datasets.

However, skills acquired by undergraduate students, during their academic experience, are crucial for their success in the labor market and many countries are moving towards systems that establish a link between teaching effectiveness and university funding. Understanding which factors are more likely to affect student performance is crucial for policies aimed at increasing teaching quality in universities and colleges.

This paper has tried to contribute at reaching this objective by providing evidence on the effects of class size on a sample of Italian college students. In order to study class size effects, we have exploited data from a project offering special remedial courses to freshmen enrolled at an Italian medium sized public University in the academic year 2008-09, with the aim to improve their basic competences in mathematics and language skills.

We exploit exogenous variations in class size deriving from the random assignment of students and teachers to teaching classes of different sizes, which allows us – differently from many other empirical studies – to avoid risks deriving from the fact that class size may be related to other possible factors affecting student performance (such as students abilities, teaching quality, family background, etc.)

From our analysis it emerges that, once we control for a number of individual characteristics, larger classes determine a significant and sizeable negative effect on student performance in Mathematics. Importantly, we find that the negative effect of class size is significantly larger for low skilled students. On the other hand, class size effects do not appear to be relevant for student achievement in Language Skills.

From a policy point of view, these results suggest that is relevant to arrange Mathematics lectures in classes of small size, since a reduction in class size appear to be mostly effective for student performance in this type of subject. In addition, the organization of teaching classes should take into account student abilities: the benefits of smaller classes is much more relevant for low ability students.

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