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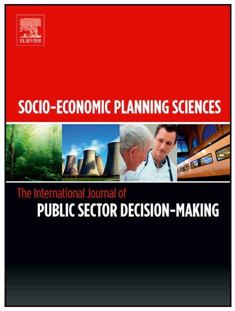

School size and students' achievement. Empirical evidences from PISA survey data

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Running head: SCHOOL SIZE AND STUDENTS' ACHIEVEMENT

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Abstract

The issue of school size has become prominent for researchers and policy makers alike. Many different arguments have been offered in order to explain how school size might affect student achievement. Overall, if smaller schools are associated with higher students' achievement in primary level, this conclusion cannot be clearly stated for the secondary schools. Empirical evidences highlight that the effect is often mixed: some studies have found higher achievement among students enrolled in smaller schools, while others have detected higher achievement in very large schools, still others have suggested a non linear relationship. In this paper, analyzing OECD-PISA 2012 data, the effect of school size is investigated considering Italian students' achievement, in order to answer the question if there is an optimal school size in Italy. For our goal, due to the hierarchical structure of data (the students are nested within school) we specify a mixed model with random intercept.

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School Size and Students' Achievement. Empirical Evidences from PISA Survey Data

Research questions

Education is pivotal for individuals' life and for the economic development of the countries. A valuable educational system is considered to be essential in achieving national economic competitiveness (OECD, 2012; Hanushek & Luque, 2003): it fosters economic growth, enhances productivity, promotes the social development and reduces social inequality. Higher levels of education are associated with markedly higher earnings, lower unemployment rate, higher labour force participation and lower criminality. Moreover, due to the technological progress, rising skills demands have made qualifications at the upper secondary level of education (either general or vocational) the minimum credential for a successful labour market entry (Rangvid, 2003). Currently, students' achievement is one of the most used measure to assess the success of school systems. In the last twenty years many studies have been addressed on the determinants of students' achievement. Researchers have found that not only the students' characteristics affect the achievement but also the features of the educational process as school size, class size and the student-teacher ratio. In particular, focusing on the influence of the size issue, while research on primary schools has generally focused on the size of the classrooms, research on secondary schools has focused on the size of the school itself. Researches have been stated that school size affect not only the achievement but influence also students' attitudes (toward school or particular disciplines), social behavior problems (vandalism, drugs/alcohol, etc.), levels of extracurricular participation, feelings of belongingness, interpersonal relations with peers and teachers, school attendance, dropout rates, self-concept (academic and general), college-related variables (acceptance, completion)

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(Cotton, 1996). In the light of this findings, many studies have been carried out specifically for Italy in the last decade. They outline a school system with many weaknesses and engaged in a long-lasting reform process (Fischer & Fischer, 2009; Benadusi & Consoli, 2004; Butera, Coppola, Fasulo, & Nunziata, 2002), where the features of school system play a key role. This is the point from which the statement problems of this paper stem: *Does the school size make a difference on the Italian students' achievement? What is the kind of relation between students' achievement and school size? Is it linear or non linear? Does the effect change considering some peculiarities of the Italian context?*. To analyse the relationship between students' achievement and school size we use the OECD-PISA 2012 data on 15-16 years old students' achievement in reading, mathematics and science taking into account for students characteristics and (some) school and context variables. The article is divided as it follows. The next Section contains a brief review on the more important and recent findings concerning the relation between school size and students' achievement. The following Section describes the multilevel random intercept model fitted to the data while in the Data section we present the data and the analysis. Final remarks are provided in a separate Section[1]

Theoretical background

As said above, education shapes capabilities, values, aspirations and inclinations of individuals; nevertheless, it enables new ways of organizing and supporting socio-economic activities that rely on numeracy and literacy. Moreover, advanced countries use educational credentials as a primary mechanism to select future generations into social and economic roles (OECD, 2012; Lewin, 2007). In that way, the key role of education in social and economic policies has called attention to control and monitor the educational processes into countries. Since the Nineties of the past century international surveys have been addressed to quantify students' performances in different disciplines and to compare

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the educational systems worldwide: the International Adult Literacy Survey (IALS) carried out in three editions (1994, 1996 and 1998) by the Organization for Economic Cooperation and Development (OECD) and Statistics Canada; the Trends in Maths and Science Study (TIMSS) (in 1995, 1999, 2003, 2007, 2008, 2011 and 2015) and the Progress in International Reading Literacy Study (PIRLS) (in 2001, 2006 and 2011), both conducted by the International Association for the Evaluation of Educational Achievement (IEA). Since the year 2000 the OECD also carries on the Program for International Student Assessment (PISA). It is administered every three years to provide comparisons of students' achievement among the participating countries; it has completed in 2015 its sixth round. Hanushek and Woessman (2010) reviewed the economic literature on international differences in educational achievement reporting the main findings of contributions that have analyzed these surveys (TIMSS and PISA, especially). A focus on the Italian school system has highlighted that the main factors affecting students' achievement are mainly related to (i) the socio-economic status of the family (the higher the status is, the better the achievement), (ii) the region of residence (students in North-Centre regions perform better than those in South), and (iii) the type of school attended (academic and technical schools perform better than vocational) (Quintano, Castellano, & Longobardi, 2012; Agasisti & Murtinu, 2012; Bratti, Checchi, & Filippin, 2007). Looking at all the three competencies, among others, Agasisti (2011a) and Perelman and Santin (2011) explore performances considering two EU countries, that is Italy and Spain, respectively. Generally, the empirical findings suggest, also, that bad achievement is affected not only by students' and family backgrounds, but also (at least, to some extent) by non-optimal organizational facets of the educational process such as the school size, the class size and the student-teacher ratio (Fonseca, Valente, & Conboy, 2011; Chiu, Chow, & McBride-Chang, 2007; Ehrenberg, Brewer, Gamoran, & Willms, 2001; Angrist & Lavy, 1999). Many different explanations have been already advanced in

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order to better understand if and why school size might affect students' achievement. See, for example, Lamdin (1995); Agasisti and Cordero-Ferrera (2013); Kuziemko (2006); Humlum and Smith (2015).

Mainly, the school size issue has been analyzed with reference to: i) the level of school attended, that is primary or secondary – while research on primary school has generally focused on the size of classrooms (Finn & Achilles, 1999), research on high school has focused on the size of the aggregate unit (Cotton, 2001) –; ii) the choice of smaller rather than larger schools – generally, it is argued that larger schools are able to offer wider curricular and extra curricular opportunities and a concomitant increase in teacher specialization (McGuire, 1989), on the opposite it is argued that smaller schools are able to offer a more personalized learning environment (Darling-Hammond, 2000) and greater interaction and participation by students and teachers (Darling-Hammond, Ancess, & Ort, 2002). For our goals we will focus only on the issues related to the secondary school level and, consequently, we report here only the main literature findings about this level of schooling. But what is the relation between school size and student achievement? There is a recent and extensive literature on school size but very few empirical studies compare students' achievement in schools with different size. Among the first contributions, Burke (1987) states that size-achievement relationship is not a clear one, though some research indicates that smaller schools facilitate higher achievement. Cotton (1996) on the review of 31 research papers which connect school size and students' performance find a positive relation between smaller school and students' achievement and a negative one for larger schools. None of the research finds large schools superior to small ones. Consequently, the student achievement in small schools is at least equal or superior to the student achievement in large schools. The following factors seems favor small schools: minorities and low-income students benefit more from small schools; small schools have less incidence of vandalism, theft or drug abuse; students' attitude toward schools

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and toward specific topics is better in small schools; small schools perform at least as well as larger schools (school grades, test scores, evaluation of higher-order thinking skills); students attendance in small schools is better than in larger schools; the dropout rates are lower. On the other side some researches have claimed that bigger schools are better in terms of economic efficiency and curricular offerings (Walberg, 1992; Fox, 1981). In addition, Smith and DeYoung (1981) show that students from larger schools may perform better due to higher turn-over of teachers; moreover, the authors consider that bigger schools with a variety of socio-cultural groups could be better for minorities, who could find their own group there. In terms of economic efficiency, big schools may be more efficient than small ones due to economies of scale. In the light of the latter findings, Leithwood and Jantzi (2009) reviewing 57 post-1990 empirical studies on school size effects in both primary and secondary levels (and on a variety of student backgrounds and organizational outcomes) find that although empirical evidence favors smaller schools, this is true mostly for students with a disadvantaged familial socio-economic background and only at primary school level. In the context on this study, as we are interested in secondary school level, Authors report that the effect of school size on students' achievement is a rather mixed one. Indeed, from the 19 studies considered (6 of which report nonlinear relationships): 5 find that as school size increases so does the achievement; 6 find an "inverse U-shaped" relationship between size and achievement, i.e. achievement rises with school size up to some optimum school size then it decreases; 8 find that as school size increases, the achievement decreases. To corroborate the idea of an optimal school size, Colegrave and Giles (2008) have reported a meta-regression analysis based on 22 estimates from 10 different studies (all of which had been published on academic journals) assessing the significant effect of the non linear term of school size. Furthermore, Newman et al. (2006) offer a systematic review of the empirical analysis that focus on the effect of secondary school size on students' achievement by synthesizing the

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results of 31 studies carried out on some OECD countries since 1990. The aims of these Authors are related to the results of empirical studies conducted in OECD countries that have investigated the relationship between secondary schools sizes and various outcome variables (dropout, students' achievement, etc.), in order to suggest implications for policy makers. From the studies analyzed, Authors highlight a prevailing quadratic relationship between school size and students' attainment, although the results change with reference to the different OECD countries and with the family socio-economic background of students (both at student level than at school level). Similarly, Schütz (2006) reports some results using analysis of the Trends in Mathematics and Science Studies (TIMSS 2003), focusing on the relationship between school size and achievement in maths among Grade 8 students in 51 countries. Author, controlling for some covariates (regarding school and students' characteristics), fits a linear model with quadratic term for school size. From her analysis, in those countries where the quadratic coefficient is significant, the relationship is most often an inverse U-shaped.

Method

In order to examine the association between students' achievement and school size controlling for the effect of students' and school covariates we adopt a linear regression model in a multilevel setting.

The use of a multilevel model allow to consider the hierarchical structure of the data being the students nested within schools (i.e., observations are not independent from each other). Indeed, OECD-PISA dataset consists of clustered samples which are very homogenous within themselves. Thus the use of classical regression models would produce biased standard errors estimates for the parameters of the exogenous student and school characteristics. Contextual school variables also do not vary within schools but only between schools.

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We use a multilevel random intercept model. The two-level random intercept regression model for the i-th student in the j-th school can be written as follows:

$$Y_{ij} = \gamma_0 + \Sigma_{k=i}^{m} \beta_k x_{kij} + \Sigma_{t=1}^{s} \beta_t z_{tj} + U_{0j} + \varepsilon_{ij} \tag{1}$$

Where, x_k are m variables observed at student level and z_t are the s variables considered at school level; ε_{ij} and U_{0j} denote the random error term at students and school level, respectively. These components are supposed to be normally distributed and uncorrelated:

$$\epsilon_{ij} \sim \text{IID} - N(0, \sigma^2); \qquad U_{0j} \sim \text{IID} - N(0, \tau^2); \qquad \text{cov}(U_{0j}, \epsilon_{ij}) \sim 0 \tag{2}$$

In (1) two components can be identified: (i) a *fixed* part, given by $\gamma_0 +$ $\beta_k x_{kij} +$ $\beta_t z_{tj}$, and (ii) a *random* part (the error term), that is $U_{0j}+\varepsilon_{ij}$. Thus, σ^2 represents the variance within schools, while τ^2 is the variance among schools. Consequently, it is possible to determine the intra-school correlation coefficient (ρ) by dividing the variance among schools on the total variance:

$$\rho = \frac{\tau^2}{\tau^2 + \sigma^2}. \tag{3}$$

This coefficient represents the amount of the total variance that could be imputed to the between schools variance. ρ ranges between 0 and 1: if $\rho \neq 0$, a multilevel model should be fitted to account for the hierarchical nature of the data, especially if the value is closer to 1. The assumptions about the distribution of the error terms (defined for the *empty* model) still hold, but here it is assumed that the observations within schools are correlated.

For a detailed discussion on multilevel modeling see Goldstein (2011) and Snijders and Bosker (2012). For the estimation results we use the runMLwiN routine implemented for Stata by Leckie and Charlton (2013).

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Data

PISA-OECD Surveys. PISA surveys assess not only competencies and skills, but also the students' attitudes and their learning strategies. In that way, PISA allows us to investigate upon students' achievement controlling for some relevant socio-demographic characteristics. OECD has completed in 2015 the sixth round of PISA surveys focusing on science skills. To date, PISA offers the most comprehensive and rigorous international measurement of student skills. Following the detailed assessment of each PISA's three main subjects – reading, mathematics and science – in 2000, 2003, 2006, 2009, 2012, and 2015 have been investigated. The PISA target population is that of students aged between 15.25 and 16.25 years at the time of the survey and who have completed a minimum of 6 years of formal education regardless of the type of institution where they are enrolled. The age of 15-16 marks, for many countries, the transition from a basic education to a more advanced level or professional training. Detailed information on sampling design and procedures are available in a series of thematic and technical reports at PISA-OECD website. Students participating in PISA program fill-in a very comprehensive questionnaire and information on school characteristics are also gathered. The comprehensiveness of the PISA dataset allows us in considering for the analysis a number of variables that are not usually available in most other studies. In 2012 the survey was carried out in 65 countries; for the present analysis only the records regarding Italy have been retained (the database release version is June 2014).

The total sample size for Italy is of 31,073 students clustered in 1,194 schools. It is worth noting that in order to perform regional comparisons, an oversampling scheme has been adopted for Italy. The main results of the Italian PISA 2012 survey were published in 2014. Most of the sample units (93.8%) are enrolled in a ISCED 3A/B school program; those enrolled in a ISCED 2C program (for direct access to the labor markets) account for 4.5% while only 1.6% are enrolled in a ISCED 2A program (in Italy, normally, ISCED 2A

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level is completed at age of 13 or 14). PISA measures the students' competencies not with an unique measure (a score) but it provides five Plausible Values (PV) for each of the three surveyed competencies.

The PISA literacy assessments have been designed to cover a broad range of contents across each of the topics (reading, mathematics, science). Therefore, there is a tradeoff between the amount of material to be assessed and the time constraints of administering the tests. PISA has created nine different versions (booklets) of the test, through which the test items are rotated. Because to each student is only given a fraction of the entire test, multiple imputation methodology is employed. Using Item Response Theory models (IRT), PVs are generated for each student based upon the student's responses to the test items they were given and the performance of students with similar characteristics (see the PISA technical report for more information on the scaling procedures). Due to the random component of the PV, multiple values are considered for each student. As a consequence, five PV are estimated for each student and are included in the PISA dataset. The analysis in this study takes into account all five PV for each topic and, consequently, we consider the average coefficients got using all the five PV for reading, maths and science available for each student. According to the PISA manual, "for the final estimates, it is recommended that all five plausible values be used, otherwise the standard error estimated from one plausible value will only contain the sampling variance component while it should also contain the measurement error" (OECD, 2012).

Variables Description. We consider as response variable the student's reading, science and mathematics scores (that is, for each topic five PVs) and, as covariates, following the main findings of the literature: i) students' characteristics considering also the family background (related to the economic, social and cultural status and home educational resources), ii) schools' covariates and iii) regional dummies to take into account for territorial differences (the territorial issue plays a prominent role in Italy, both

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respect to economic and social aspects, than for the educational one; see, for example, Quintano et al. (2012)).

The Italian educational literature, analyzing the determinants of students' performance, is still mainly focused on the role of family background, on the school level peer effects (Checchi, 2004), and on the causes of the existence of regional disparities in secondary students' outcomes (among others, Tramonte (2004); Bratti et al. (2007)). The community in which the school is located and the school availability to students are not yet strongly investigated in literature. The community size refer to the (likely) relationship among students' achievement and the size of the territory, while, the degree of competition is based on the number of schools available for students in a given place. The presence of more schools in a certain area should raise the performance of schools operating in that area through a 'competition effect'. In the analysis, we consider two levels of variables (to account for the hierarchical structure of data): student-level (level 1) and school-level (level 2). Table 1 reports the description of the variables considered in the model.

Regarding student's characteristics we consider the gender (`SEX`), if she/he has ever failed at ISCED 2 (`RIPISCED`), if she/he has anticipated her/his entrance to school (`ANTICIP`), the availability at home of Information and Communication Technologies (`ICTHOME`) and the school program attended (`PROGRAM`). It should be noted that in Italy the main subdivision within the upper secondary school system is: Liceo, Technical and Vocational. The Liceo refers to a class of secondary schools oriented towards the study of the classics and sciences and is aimed to train students for higher education programs (at levels ISCED 4 or 5). The Technical programs are more oriented toward practical subjects, such as business administration, computer science, chemistry, nautical disciplines, and aeronautics. The Vocational programs are even more specific, focusing on practical subjects. Family background is considered to play a prominent role in students' achievement (Agasisti & Murtinu, 2012; Bratti et al., 2007; Lauer, 2003; Hanushek &

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Luque, 2003; Korupp, Ganzeboom, & Van Der Lippe, 2002; Coleman & John Hopkins University, 1966). For our purposes it has been considered using the PISA index of economic, social and cultural status (`ESCS`) derived from the following three components: highest occupational status of parents, highest educational level of parents in years of education according to ISCED, and home possessions index. The index of home possessions comprises all the items considered on the indices related to family wealth, family cultural possessions and educational resources at home. The final values on the PISA index of economic, social and cultural status have an OECD mean of 0 and a standard deviation of 1. We also have considered the family structure (`FAMSTR`) based on students' responses regarding people living at home with them. This variable takes the following three values: (1) single-parent family, (2) two-parent family and (3) other. At school-level we consider: the mean of `ESCS` for each school (`SCHESCS`), an indicator of the wellness of the socio-economic background; an ordinal variable referred to the size of the city where the school is located (`SCHCOM`); the availability of other schools in the area (`SCHAVA`).

Finally, at school level, we include the variable `STRATIO`, that is the student-teacher ratio (it is the number of students who attend the school divided by the number of teachers in that school; it is used as a proxy for class size), the school size (`SCHSIZE`) and, to take into account for the (supposed) non-linear relationship, its squared term (`SCHSIZE2`)[2].

Table 1 approximately here

Moreover, to take into account for geographical differences we include a regional dummy, `REGION` (in Table 1 we report the macro area where the region is located as "N" for North, "S" for South and "C" for Center). Indeed, previous studies on the achievement of Italian students have proven that there are relevant differences across the different areas of the country, with students in the Central part of Italy performing worse than those in the North and better than those in the South (Quintano et al., 2012;

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Agasisti & Vittadini, 2012).

Application

In this Section we report the main empirical findings of the analysis, followed by a more detailed focus on the effect of school size useful to answer our research questions.

Main Results. The methodological approach is a standard multilevel model with random intercept. For our purposes we use as dependent variable the five plausible values in reading, mathematics and science and as covariates the variables described in the previous Section, centering all metric variables at their grand-mean. As previously said, according to the OECD recommendations (OECD, 2012), we use the five plausible values (for each competence) for each student. Estimation results are reported in Tables 2, 3 and 4 where the baseline levels are also specified.

Table 2 approximately here

Table 3 approximately here

Table 4 approximately here

One useful display plots the model residuals in ascending order with their 95 confidence limit (Figure 1, 2 and 3). This is also known as a *caterpillar plot*. **We have 1,029 'level 2' residuals plotted, one for each school in the data set (165 schools have been dropped due to missing data in covariates).** Looking at the confidence intervals, we can see a group of schools at each end of the plot where the confidence intervals for their residuals do not overlap zero. Remembering that these residuals represent school departures from the overall average line predicted by the fixed parameters, this means that about half of the schools differ significantly from the average at the 5% level. Overall, considering the reading achievement of their students, 270 schools are significantly less effective than average, while 504 schools are significantly more

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effective than average; for science are 278 and 483, respectively; finally for mathematics are 285 and 487. Results are very similar indeed for all three competencies.

Figure 1 approximately here

Figure 2 approximately here

Figure 3 approximately here

In Tables 2-4 we report, in the first column the coefficients estimated for the full model with student-level and school-level covariates, in the second column the corresponding standard error, in the third one the empty model coefficient estimate. We don't report the estimates obtained with the stepwise selection of the first and second level covariates, as the full model, reported in Tables 2-4, is the best in terms of Deviance and LR test. A box, on the bottom right of Tables 2-4, provides the random coefficients estimates of the model. From Tables 2-4, the random effects confirm that both between and within schools differences exist. For reading (for example) the empty model shows that the between-schools variance is 6216.21, while within-schools variance is 4232.42; thus, the latter is higher than the former, that is the most part of the variance is at school-level more than at student-level.

The columns 1 and 2 show what happens when student-level and school-level characteristics are considered. It is important to note that when student-level and school-level characteristics are controlled, between-schools variance decreases and almost all the covariates are statistically significant.

Mainly, the effect of covariates is the same for all three competencies, although some exceptions as for the gender variable. If female students perform better than males in reading ($\hat{\beta}_{\texttt{sex}} = 20.31$), in science and mathematics male students perform better than female, especially in mathematics ($\hat{\beta}_{\texttt{sex}} = -16.26$ and ($\hat{\beta}_{\texttt{sex}} = -29.36$), respectively). The age of entry to school (at 5 instead of 6 years of age – `ANTICIP`) and if the student

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has not ever failed at ISCED 2 level –RIPISCED) act positively on the achievement. The availability at home of ICT (ICTHOME) has a rather surprisingly negative effect. Note that, in PISA questionnaire, eleven items provide information for the ICTHOME index, among them those referred to the availability at home of devices like video-game consoles or smartphones and tablets; moreover, we shall consider the general high spread of ICT devices in households (according to official statistics, in Italy the share of households with at least a member in school age that have an Internet connection was 89% in 2014) (ISTAT, 2014). The type of school attended (PROGRAM) comes out to be a very important factor since students from the "Liceo" perform better than the others. The coefficients related to the family background (ESCS and FAMSTR) are significant and positive. Reading performances are better for students with higher values of the economic, social and cultural family status. The effect of the variable related to the student's family structure is slightly significant and rather unclear: controlling for the other covariates it seems that students from single-parent families perform better than those from families with both parents. The geographical variable (REGION) shows the presence of noteworthy territorial effects in reading performances. Students in Northern regions have better reading scores, indeed the average scores differ strongly among the Northern and the Southern regions and these noteworthy differences originate a wide North-South literacy-divide. Regarding the school-level covariates, ESCS school-average (SCHESCS) should be interpreted as a factor contributing to explain (i) schools' performances and (ii) between-schools variance in scores. The community size in which the school is located has a negative effect: if SCHCOM increases - ranging from village, hamlet, or rural area (fewer than 3,000 people) to a large city (with over 1,000,000 people) - the students' achievement decreases, i.e. students' performances are better if the school is located in a small context ($\hat{\beta}_{SchCom} = -4.62$ for reading and very similar values for the other competencies). In Italy students' performances are better in small context. If there are other schools in the area

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that compete to one specific school (SCHAVA), the achievement is higher ($\hat{\beta}_{SchAva_{onesch}} = 7.01$ and $\hat{\beta}_{SchAva_{twosch}} = 7.74$ for reading). These findings are in line with literature and support the view that competition has an impact on students' achievement, that is competition is a positive pressure for achievement (see, Agasisti and Murtinu (2012); Agasisti (2011b); Agasisti (2011a)). The student-teacher ratio, used as proxy of class-size, (STRATIO) impacts positively on student achievement ($\hat{\beta}_{Stratio} = 1.64$ for reading), that is higher is the number of students for teacher, higher is the achievement. Now, for our aims, we pay attention on the effect of school size on students' achievement. Reading empirical findings highlight that the effect of school size is significant and positive for the linear trait ($\hat{\beta}_{SchSize} = 0.044$), significant and negative for the quadratic term ($\hat{\beta}_{SchSize2} = -.000015$); results for science and mathematics are very close[3]. This result suggests that in Italy, for the secondary schools level, the relation is not linear: initially, students' achievement increases if the school size increases, but over a certain value of school size, students' achievement decreases (models with higher order polynomials do not provide better results). The results, obtained for the complete sample, indicates that the association between achievement and school size is described by an inverse U-shaped relationship which suggests the existence of an optimal size range. In Italy school size has an optimal size as although larger schools ensure higher students' achievement, after a certain level of school size performances decrease. Consequently, policy maker should determine the optimal level of school size in order to improve students' achievement. Different studies tend to find that school size has an inverted U-shaped relationship with achievement and conclude that the peak (typically near the middle of the school size distribution) represents the optimal-ideal school size (see, Lee and Smith (1997); Bradley and Taylor (2004); Foreman-Peck and Foreman-Peck (2006)). But, what happens if we stratify the whole sample in order to consider specific sub-samples of students? Does the school size effect change in sign and magnitude?

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School size effect: results by sub-groups. The results for the complete sample indicate that the relationship between school size and achievement follows an inverse U-shaped form which suggests the existence of an optimal school size. In order to better evaluate the effect of school size and its quadratic term on Italian students' achievement, we explore this relation by grouping schools by: i) the macro-area of residence of students, ii) the community size where the school is located, iii) the availability or not of other schools in the area. Tables 5 and 6 report the estimation results of the models and Figure 4 plots the predicted values of students' achievement for increasing values of school size (in Table 6 the † symbol denote missing observations due to the sampling design of PISA; in Figure 4 predicted values are obtained for each sub-sample using: the mean value for continuous variables, the baseline profile for categorical variables). From Tables 5-6 and Figure 4, in Center-Northern regions both the linear and the quadratic effect are positive and significant, suggesting that only in these regions, where the economic context is better, it is possible to set an efficient school system (in economic terms), with economy of scale (as suggested of Authors supporting better performances for large schools). On the opposite, in Southern regions, there is an optimal school size determined as a minimum number of students. Using PISA 2012 data the inverse U-shaped relationship is confirmed only for Centre-Northern regions; in South is a U-shaped form indicating that a negative relationship between achievement and school size and after a certain point of the achievement distribution the relationship became positive. So that, in Italy, the relationship is different considering the territorial area: positive (with decreasing increases) in Centre-Northern area and negative (with increasing decreases) in the Southern one. In both areas it exists an optimal school size but for Northern regions is a maximum point after which the positive effect of school size decreases, whilst for Southern regions is a minimum point after which the negative effect of school size increases.

Table 5 approximately here

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Figure 4 approximately here

Results regarding the community size where the school is located show that the dimension of the context is important in determining the optimal school size. Indeed, for very small (village) and very large (large city) contexts the relation between achievement and school size has an inverted U-shaped form, i.e. there is an optimal school size that is a maximum level of school size above which the achievement decreases. In 'towns' the relationship it is not significant. Therefore, in very small context or in very large context it is desirable to fix a maximum level of school size. Finally, for the school availability, the quadratic relationship between achievement and school size is confirmed only if there are two or more other schools in the area that compete for students; that is, if there are other schools available for students, it is desirable to fix a maximum level of school size as over this level the achievement decreases (see Figure 4).

Final remarks

This paper provides an empirical analysis about the relationship between school size and students' achievement in Italy, by using the PISA-OECD 2012 data survey. For our aims we have used a Multilevel Random Intercept model to take into account for the hierarchical structure of data (students nested into schools). We have specified a linear mixed model where the response variable is the student achievement and covariates refer principally to individual, family, school and geographical characteristics, with a quadratic term for school size. The latter has been added since there is no agreement in the literature on the functional form between school size and students' achievement. Indeed, review studies show sometimes positive and sometimes negative relationship between students' achievement and school size (for a detailed review of the literature see Cotton (2001); Andrews, Duncombe, and Yinger (2002); Luyten, Hendriks, and Scheerens (2014)). There is a striking difference between USA studies as compared to studies in other parts

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of the world, with studies from the USA indicating more often better outcomes for smaller schools. In terms of expenditure large schools are more efficient, up to a certain threshold. The evidence provided by internationally comparative datasets (especially the PISA surveys) suggests a relation between achievement and school. Moreover, for most European countries the relation appears to be positive rather than negative. This implies relatively high scores in large schools and poor results in smaller schools. In most cases, the effect of the linear term is positive and the effect of the quadratic term is negative, as for Italy, indicating that the positive effect declines as school size increases. With the aim to investigate the relationship between school size and student achievement in Italy, we have specified a non-linear effect to assess if in Italy there are empirical evidences on an optimal school size. As expected, students' and school covariates affect students' achievement, according to the main empirical findings of literature. Our attention has been addressed, especially, on the effect of school size. As suggested and discussed by literature on this topic, there are many implications (in terms of school organization, school environment, teachers' commitment, and so on) relating to different school size and students' achievement. In favor of small schools as teachers and pupils at smaller schools are more likely to have a positive perception of their school environment or, on the opposite, in favor of large schools, since the costs per pupil appear to decrease as school size increases. Our results for the complete Italian sample and for all three competencies investigated by PISA, have proved that the relationship between school size and students' achievement follows an inverse U-shaped form suggesting the existence of an optimal size range, that is, in Italy larger school size and higher achievement are positively correlated across a certain range of scores, after which increases in size are associated with decreasing students' performance. But, some peculiarities of the Italian context (related principally, but not only, to territorial aspects) have led us to hypothesize that the effect (i.e., the functional form) of school size in Italy is not the same if we split the whole sample into

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sub-samples. Consequently, we have repeated the analysis considering: i) the macro-area of residence of students, ii) the community size where the school is located, iii) the availability or not of other schools in the area. The graphical analysis displays a different functional form between school size and achievement. The issue about school size is controversial also in the Italian school system, where the whole inverse U-shaped relation hides the different school size effects in the different Italian contexts. U or inverse U-shaped curves suggest an optimal school size which varies widely considering sub-samples of data. Consequently, empirical evidences suggest that changes in schools size may change the schools achievement environment, as it is not desirable to set an optimal school size without taking into account the characteristics of the context. **In Italy, the relationship is different considering the territorial area: positive (with decreasing increases) in Centre-Northern area and negative (with increasing decreases) in the Southern one. In both areas it exists an optimal school size but for Northern regions is a maximum point after which the positive effect of school size decreases, whilst for Southern regions is a minimum point after which the negative effect of school size increases. These differences in the functional form of school size are not surprising in Italy, where strong socio-economic differences determine the well known Italian North-South divide, also for educational policies. The U-shaped form for Southern regions suggest that a minimum level of school size is required to obtain a positive relationship between school size and student achievement, that is a minimum level of school organization and technical endowment. this result is affected notably by the strong Italian territorial disparities in term (also) of educational resources. Indeed, the data from Italian Technology Observatory (MIUR, 2015), for Southern regions reveal mean values of technological educational devices lower than the national average. In Italy, the**

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Ministry of Education is responsible for the governance of the education system and sets nationwide minimum standards, to some extent it shares some of its responsibility with regions. Likely, national government should reduce the technological territorial gap providing additional educational resources to Southern regions or, in the other hand, re-allocating the available educational resources to improve the school technological endowment in the South.

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Footnotes

[1]We consider PISA 2012. Although, on time of writing, PISA 2015 data are available, this wave has no information about Italian regions here used as covariates in the multilevel models. The same happens for PISA 2006 as data are disaggregated at regional level only for 13 regions. Consequently we use the last updated wave for which regional disaggregation has been provided.

[2]In our exploratory analysis we noted that the variable about class size available in PISA 2012 school data base, namely 'CLSIZE', has been collected as a categorical one. This variable has been coded as numeric taking (for non extreme categories) the central class values and for that reason it is noteworthy discrete. Moreover it is not an observed variable, rather it is a mere evaluation demanded of the school principal. For this reason we preferred not include 'CLSIZE' in the analysis and, rather, we consider the `STRATIO` variable, built using direct information (not evaluations), that is the number of students enrolled and number of teachers in staff.

[3]The square term of `SCHSIZE` (i.e. `SCHSIZE2`) in the regression model has been tested also using the UTEST available in Stata (Lind & Mehlum, 2010) for which H_1: Inverse U shape vs H_0: Monotone or U shape. The u-test for reading supports an inverted u-shape with a lower-bound slope of 0.038 and upper-bound slope of -0.033 (p<0.01). Similar values are obtained for math and science).

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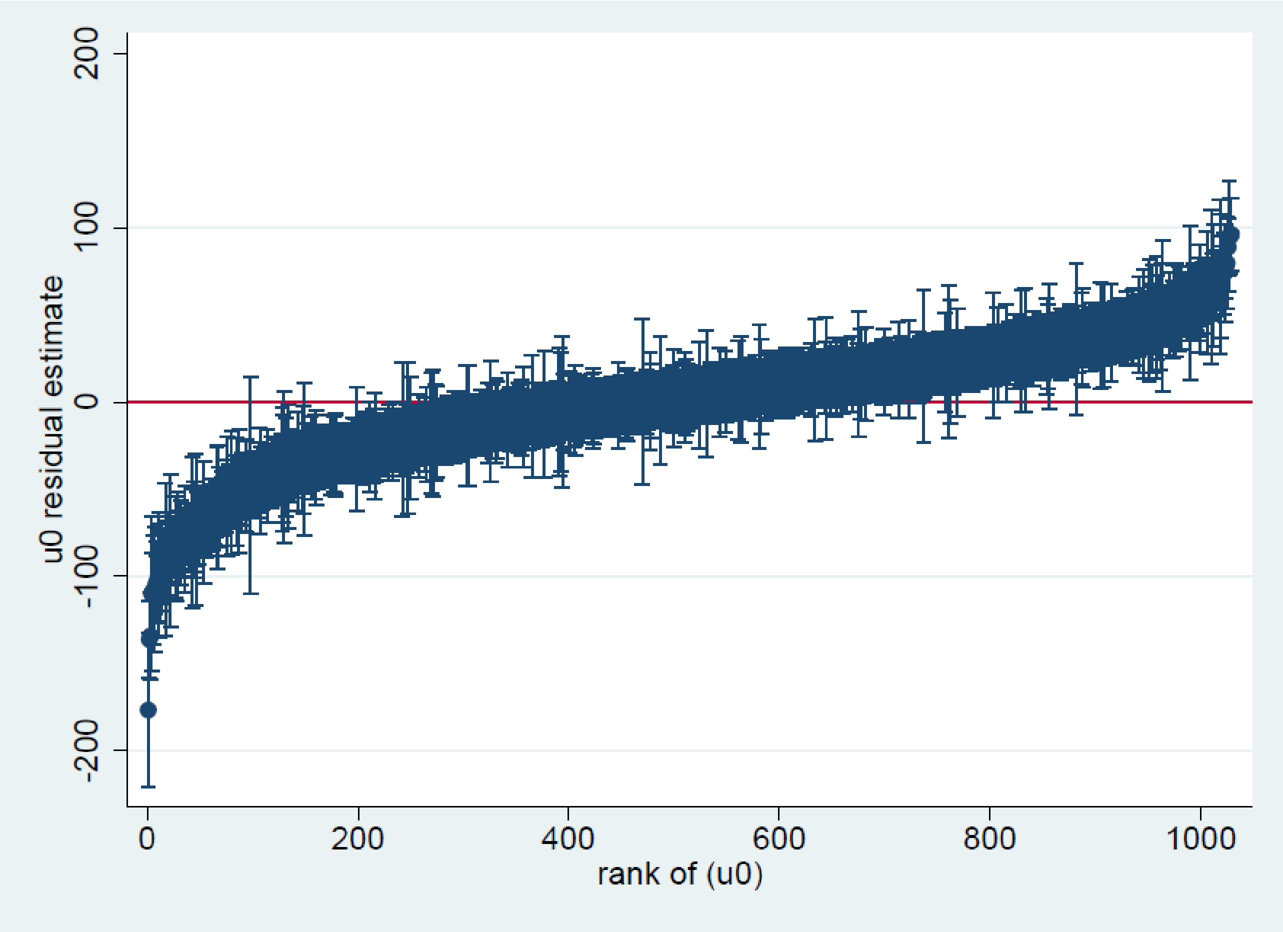

Figure 1: caterpillar plot - reading

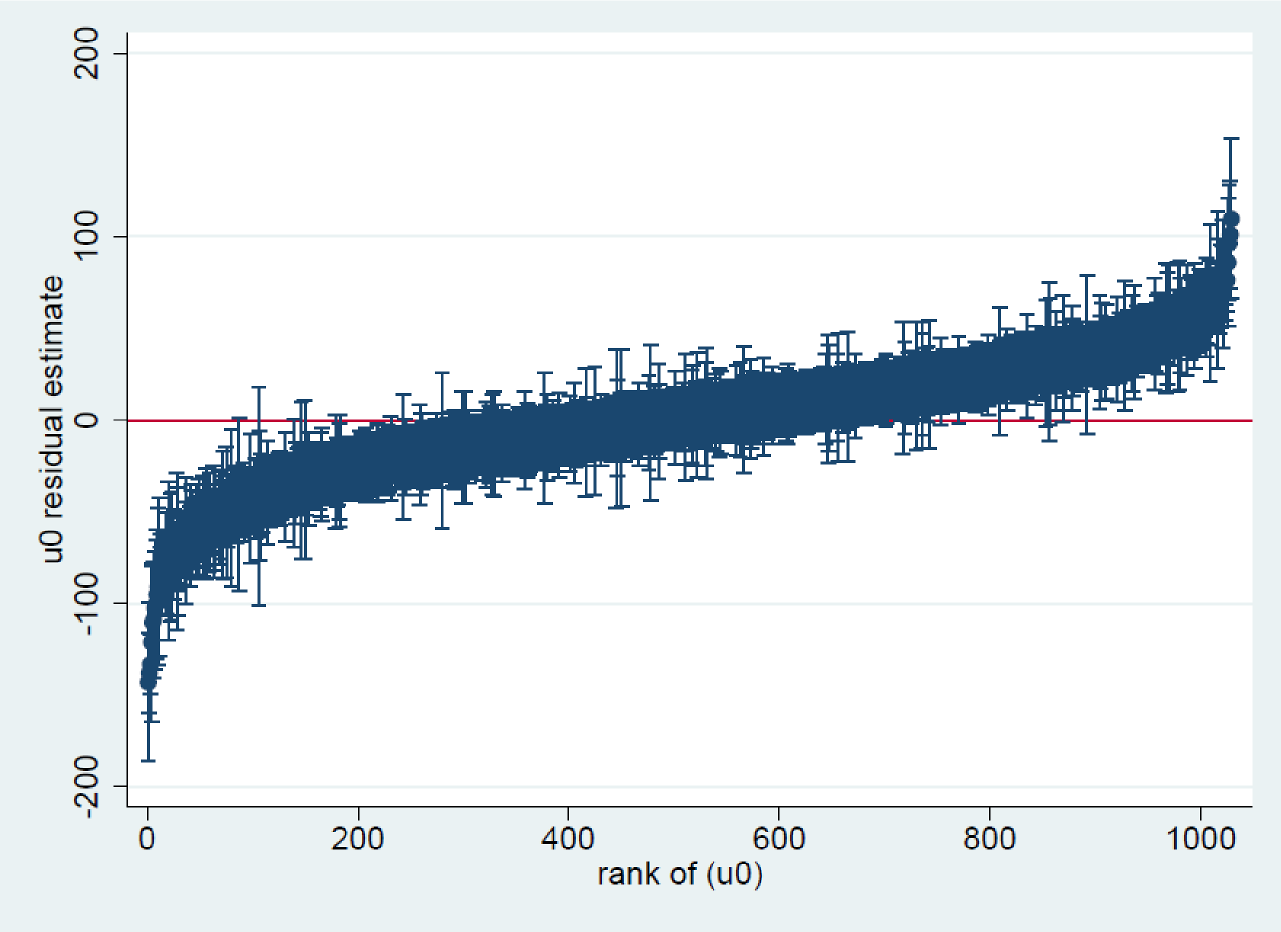

Figure 2: caterpillar plot - mathematics

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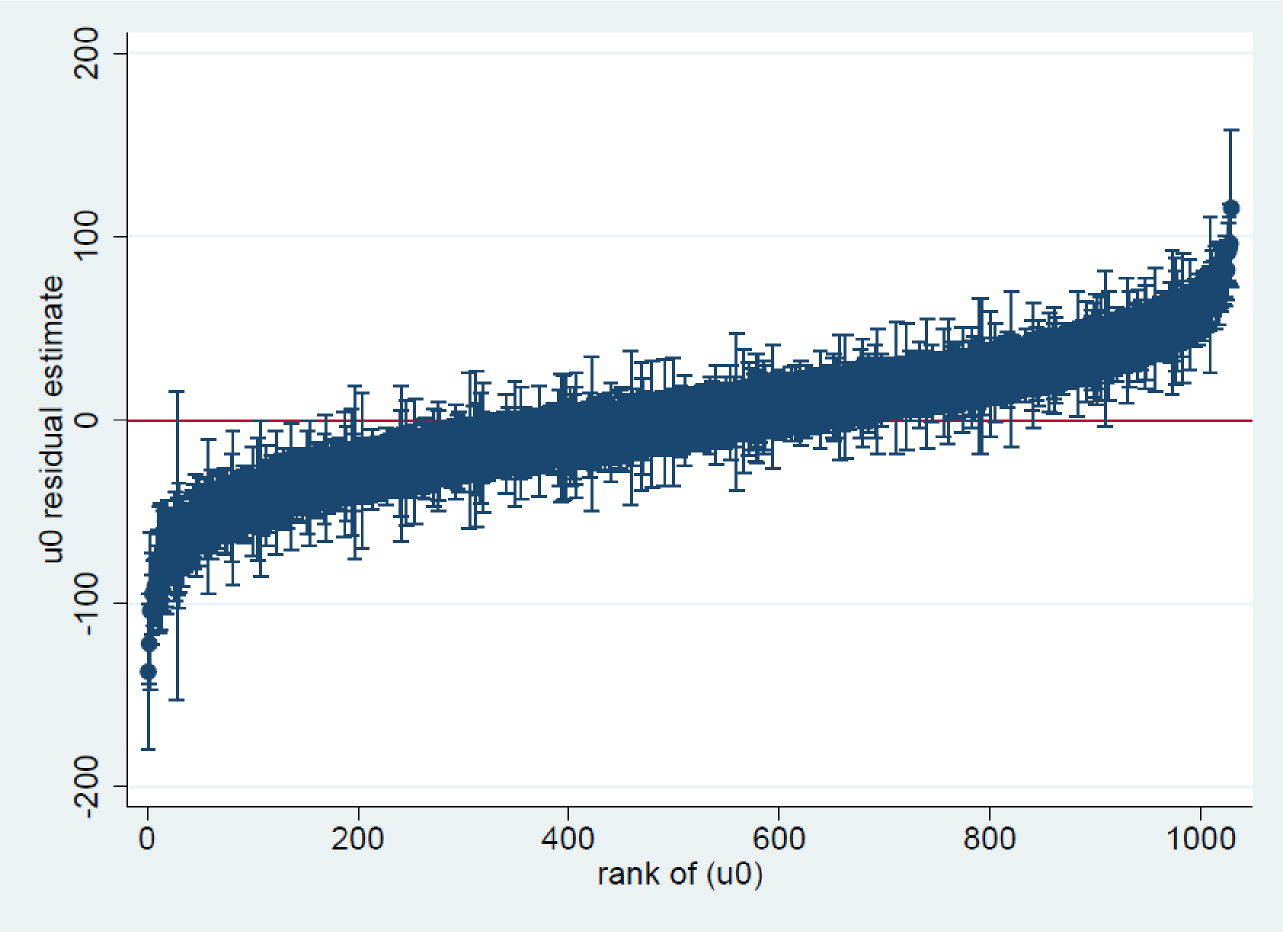

Figure 3: caterpillar plot - science

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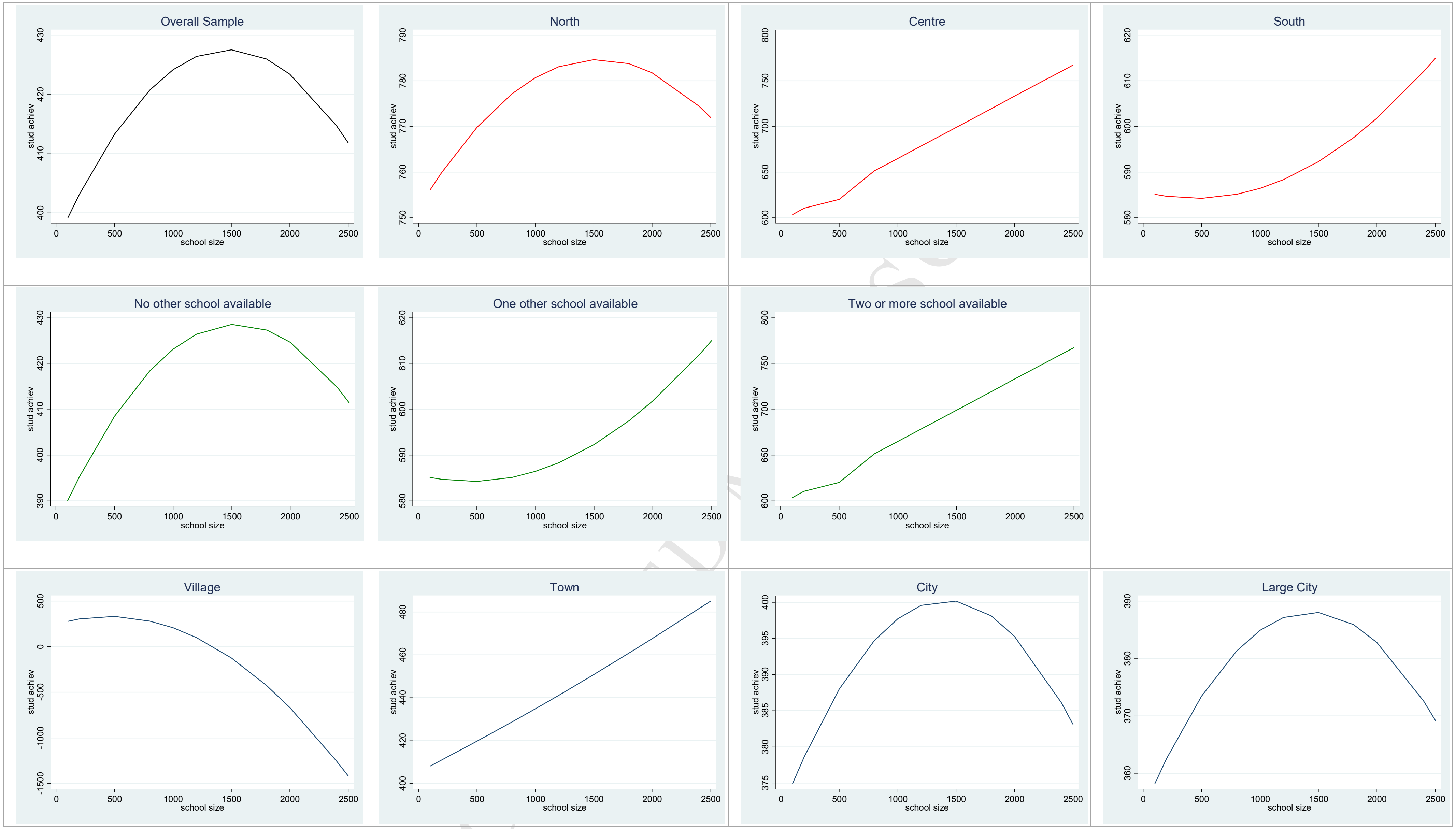

Figure 4: predicted values for reading achievement by school size

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Abstract

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Table 1:: Variables details and descriptive statistics

Continuous Variables					
Label	Description	mean	st dev	min	max
PVREAD	*(Plausible values in reading)*	495.264	91.307	27.537	791.931
PVMATH	*(Plausible values in maths)*	492.058	87.943	121.989	790.941
PVSCIE	*(Plausible values in science)*	500.157	87.297	114.920	770.552
ICTHOME	*(ICT availability at home)*	0.394	0.969	- 4.018	2.783
ESCS	*(Index of economic, social and cultural status)*	-0.028	0.951	- 4.700	2.700
SCHESCS	*(Average ESCS for each school)*	-0.029	0.482	- 2.580	1.578
SCHSIZE	*(School size)*	676.748	401.882	16	2974
STRATIO	*(Students-teacher ratio)*	9.901	3.696	0.632	72.537

Categorical Variables					
Label	Description	Obs.	cum.	%	cum. %
SEX	*(Student's gender)*				
	1 = Male	15,830	15,830	50.94	50.94
	2 = Female	15,243	31,073	49.06	100.00
FAMSTR	*(Family structure)*				
	1 = Single Parent	2,803	2,803	9.43	9.43
	2 = Two Parents	26,755	29,558	90.03	99.46
	3 = Other	161	29,719	0.54	100.00
PROGRAM	*(School program)*				
	1 = Liceo	15,701	15,701	50.53	50.53
	2 = Technical	9,452	25,153	30.42	80.95
	3 = Vocational	4,000	29,153	12.87	93.82
	4 = other	1,920	31,073	6.18	100.00
SCHAVA	*(Other Schools available to students)*				
	1 = No one	13,216	13,216	45.80	45.80
	2 = One other	6,475	19,691	22.44	68.24
	3 = Two or more other	9,166	28,857	31.76	100.00
SCHCOM	*(Community size in which the school is located)*				
	1 = Village, hamlet, or rural area (<3,000 people)	897	897	3.09	3.09
	2 = Small town or town (3,000 to about 15,000 people)	5,810	6,707	20.02	23.11
	3 = City (15,000 to about 100,000 people)	14,946	21,653	51.51	74.62
	4 = Large city (over 100,000 people)	7,365	20,018	25.38	100.00
ANTICIP	*(If the student has anticipated the entrance to school)*				
	1 = Yes	3,717	3,717	12.30	12.30
	2 = No	26,497	30,214	87.70	100.00
RIPISCED	*(If the student has ever flunked)*				
	1 = Yes	1,189	1,189	4.20	4.20
	2 = No	27,145	28,334	95.80	100.00
REGION	*(Student's region)*				
	Abruzzo C	1,499		4.82	
	Basilicata S	1,539		4.95	
	Bolzano N	2,139		6.88	
	Calabria S	1,521		4.89	
	Campania S	1,497		4.82	
	Emilia-Romagna N	1,494		4.81	

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Friuli N	1,463	4.71
Lazio C	1,486	4.78
Liguria N	1,427	4.58
Lombardy N	1,523	4.90
Marche C	1,476	4.75
Molise C	1,151	3.70
Piedmont N	1,472	4.74
Apulia S	1,581	5.09
Sardinia S	1,369	4.41
Sicily S	1,464	4.71
Tuscany C	1,411	4.54
Trento N	1,358	4.37
Umbria C	1,399	4.50
Aosta Valley N	806	2.59
Veneto N	2,002	6.44

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Table 2: Estimated coefficients for the null and the full models. Reading

	Full Model		Null Model	
Label	$\hat{\beta}$	Std. Err.	$\hat{\beta}$	Std. Err.
`cons`	375.247***	10.368	476.655***	2.292
`SEX` (basel.=M)	20.309***	0.888		
`ANTICIP` (basel.=Yes)	−8.294***	1.204		
`RIPISCED` (basel.=Yes)	45.448***	2.295		
`ICTHOME`	−5.528***	0.453		
`ESCS`	5.308***	0.497		
`FAMSTR` (basel.=Single Parent)				
—Two Parents	−5.448***	1.394		
—Other	−23.273***	6.987		
`REGION` (basel.=Abruzzo C)				
—Basilicata S	11.617	6.977		
—Bolzano N	38.842***	7.932		
—Calabria S	−25.214***	7.409		
—Campania S	−7.915	6.728		
—Emilia-Romagna N	22.987**	7.482		
—Friuli N	43.815**	6.220		
—Lazio C	3.526	7.168		
—Liguria N	17.328*	7.469		
—Lombardy N	34.666***	7.159		
—Marche C	35.326***	6.235		
—Molise C	4.838	7.850		
—Piedmont N	31.875***	6.821		
—Apulia S	23.778***	6.985		
—Sardinia S	7.928	6.430		
—Sicily S	−7.222	6.807		
—Tuscany C	27.043***	7.393		
—Trento N	56.095***	8.162		
—Umbria C	17.014*	7.361		
—Aosta Valley N	61.939***	10.176		
—Veneto N	46.897***	6.365		
`PROGRAM` (basel.=Liceo)				
—Technical	−20.489***	3.776		
—Vocational	−55.507***	6.504		
—Other	−72.038***	6.883		
`SCHAVA` (basel.= no other)				
—One other available	7.018*	3.104		
—Two or more available	7.742**	2.914		
`SCHESCS`	40.555***	4.419		
`STRATIO`	1.642***	0.381		
`SCHCOM` (as num.: 1,2,3,4)	−4.620*	1.941		
`SCHSIZE`	0.044***	0.009		
`SCHSIZE2`	−0.000015**	< 0.000		

Random effects:	
Full Model	Empty Model
Between schools var.:	
1334.37	6216.21
Within schools var.:	
3666.63	4232.42
$\hat{\rho}$:	
0.27	0.59

$*** : p \leq 0.001$; $** : p \leq 0.01$; $* : p \leq 0.05$

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Table 3: Estimated coefficients for the null and the full models. Maths

	Full Model		Null Model	
Label	$\hat{\beta}$	Std. Err.	$\hat{\beta}$	Std. Err.
cons	456.577***	9.870	476.205***	2.072
SEX (basel.=M)	−29.358***	0.944		
ANTICIP (basel.=Yes)	−11.419***	1.207		
RIPISCED (basel.=Yes)	42.930***	2.083		
ICTHOME	−4.971***	0.454		
ESCS	5.438***	0.519		
FAMSTR (basel.=Single Parent)				
—Two Parents	−1.740	1.385		
—Other	−25.255***	7.117		
REGION (basel.=Abruzzo C)				
—Basilicata S	3.790	7.160		
—Bolzano N	51.175***	7.536		
—Calabria S	−28.935***	7.405		
—Campania S	−14.908*	6.752		
—Emilia-Romagna N	31.447***	7.240		
—Friuli N	48.132***	6.960		
—Lazio C	−0.843	7.472		
—Liguria N	19.584**	6.793		
—Lombardy N	37.372***	7.570		
—Marche C	39.041***	6.427		
—Molise C	1.979	7.502		
—Piedmont N	33.318***	6.910		
—Apulia S	16.292*	6.747		
—Sardinia S	5.804	6.426		
—Sicily S	−16.352*	6.899		
—Tuscany C	34.550***	7.564		
—Trento N	58.259***	7.546		
—Umbria C	19.612**	7.505		
—Aosta Valley N	53.517***	9.616		
—Veneto N	53.593***	6.409		
PROGRAM (basel.=Liceo)				
—Technical	−17.308***	5.359		
—Vocational	−52.775***	7.858		
—Other	−65.631***	7.396		
SCHAVA (basel.= no other)				
—One other available	3.807	2.871		
—Two or more available	4.801	2.783		
SCHESCS	36.039***	4.953		
STRATIO	1.790***	0.450		
SCHCOM (as num.: 1,2,3,4)	−6.422***	1.774		
SCHSIZE	0.045***	0.011		
SCHSIZE2	−0.000016**	< 0.000		

Random effects:	
Full Model	Empty Model
Between schools var.:	
1197.47	5071.65
Within schools var.:	
3559.86	4019.19
$\hat{\rho}$:	
0.25	0.56

$*** : p \leq 0.001$; $** : p \leq 0.01$; $* : p \leq 0.05$

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Table 4: Estimated coefficients for the null and the full models. Science

Label	Full Model $\hat{\beta}$	Full Model Std. Err.	Null Model $\hat{\beta}$	Null Model Std. Err.
`cons`	442.502***	9.684	484.112***	2.078
`SEX` (basel.=M)	−16.267***	0.920		
`ANTICIP` (basel.=Yes)	−7.122***	1.217		
`RIPISCED` (basel.=Yes)	42.139***	2.220		
`ICTHOME`	−6.097***	0.470		
`ESCS`	5.674***	0.524		
`FAMSTR` (basel.=Single Parent)				
—Two Parents	−1.745	1.402		
—Other	−33.380***	8.289		
`REGION` (basel.=Abruzzo C)				
—Basilicata S	−4.806	6.942		
—Bolzano N	56.627***	7.764		
—Calabria S	−35.827***	6.739		
—Campania S	−17.904**	6.320		
—Emilia-Romagna N	35.317***	6.926		
—Friuli N	52.430**	5.988		
—Lazio C	3.022	7.415		
—Liguria N	27.944***	6.867		
—Lombardy N	39.877***	7.066		
—Marche C	43.574***	5.830		
—Molise C	−4.105	7.265		
—Piedmont N	34.393***	6.674		
—Apulia S	13.886*	6.369		
—Sardinia S	14.580*	5.944		
—Sicily S	−15.677*	7.443		
—Tuscany C	33.402***	7.227		
—Trento N	66.104***	7.395		
—Umbria C	21.130**	7.234		
—Aosta Valley N	51.147***	9.379		
—Veneto N	57.885***	5.820		
`PROGRAM` (basel.=Liceo)				
—Technical	−17.334***	4.231		
—Vocational	−52.065***	6.234		
—Other	−67.271***	7.062		
`SCHAVA` (basel.= no other)				
—One other available	3.070	2.904		
—Two or more available	5.293	2.780		
`SCHESCS`	35.686***	4.312		
`STRATIO`	1.354***	0.401		
`SCHCOM` (as num.: 1,2,3,4)	−6.522***	1.835		
`SCHSIZE`	0.040***	0.009		
`SCHSIZE2`	−0.000013**	< 0.000		

$***: p \leq 0.001$; $**: p \leq 0.01$; $*: p \leq 0.05$

Random effects:	Full Model	Empty Model
Between schools var.:	1179.68	5098.83
Within schools var.:	3768.76	4154.17
$\hat{\rho}$:	0.24	0.55

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Table 5: Estimated coefficients. Full models by sub-samples (Std. Err.s in brackets). Reading

Label	Area			School Community Size				School Availability		
	North	Center	South	Village	Town	City	Large City	No other	One other	Two or more
cons	430.153***	372.080***	366.294***	225.834***	395.173***	360.278***	335.014***	373.416***	375.041***	380.125***
	(13.479)	(17.892)	(16.597)	(33.987)	(22.310)	(13.206)	(17.921)	(16.416)	(19.106)	(16.975)
SEX (basel.=M)	23.828***	16.867***	18.330***	25.166***	19.229***	19.788***	21.925***	21.022***	20.598***	19.113***
	(1.334)	(1.631)	(1.666)	(5.831)	(2.058)	(1.201)	(1.772)	(1.330)	(1.685)	(1.654)
ANTICIP (basel.=No)	−5.849***	−5.192*	−14.344***	−1.318	−10.898***	−7.980***	−7.699***	−8.584***	−8.270**	−7.805***
	(1.525)	(2.409)	(2.572)	(9.236)	(3.108)	(1.689)	(2.079)	(1.901)	(2.510)	(1.972)
RIPISCED (basel.=Yes)	41.345***	45.922***	55.048***	44.223***	41.426***	48.925***	41.641***	43.775***	46.669***	48.200***
	(3.267)	(4.183)	(4.645)	(7.905)	(5.416)	(3.068)	(5.152)	(3.135)	(5.031)	(4.531)
ICTHOME	−7.049***	−5.432***	−3.659***	−10.858***	−4.909***	−5.495***	−5.635***	−3.888***	−8.629***	−5.821***
	(0.721)	(0.804)	(0.826)	(3.096)	(1.073)	(0.593)	(0.922)	(0.668)	(0.899)	(0.805)
ESCS	6.134***	3.896***	5.279***	1.431	6.348***	5.208***	5.070***	4.806***	5.461***	6.001***
	(0.800)	(0.983)	(0.820)	(3.736)	(1.103)	(0.671)	(1.011)	(0.731)	(1.060)	(0.875)
STRATIO	1.215*	2.267*	4.103***	2.181	1.327	1.426***	2.235*	1.672**	2.972***	1.399**
	(0.500)	(0.981)	(0.852)	(1.641)	(0.927)	(0.429)	(1.093)	(0.598)	(0.965)	(0.532)
SCHESCS	51.448***	32.116***	27.071***	−39.581	31.985***	41.723***	45.179***	44.411***	31.198**	40.080***
	(8.554)	(6.396)	(5.686)	(25.921)	(8.250)	(6.340)	(8.791)	(7.039)	(9.214)	(8.280)
FAMSTR (basel.=Single Parent)										
—Two Parents	−4.115*	−2.218	−12.701***	−11.409	−10.955***	−2.489	−6.469*	−6.115**	−5.131*	−4.652
	(1.889)	(2.760)	(3.007)	(7.563)	(3.030)	(1.930)	(2.772)	(2.123)	(2.593)	(2.602)
—Other	−19.612	−24.640*	−28.697*	−45.782	−18.931	−26.978***	−6.557	−27.448**	−13.289	−21.524
	(12.055)	(10.730)	(11.407)	(31.273)	(17.552)	(8.391)	(13.246)	(9.107)	(21.027)	(11.994)
PROGRAM (basel.=Liceo)										
—Technical	−9.784	−30.558***	−23.440***	−8.837	−29.353***	−22.882***	−3.264	−18.264***	−23.456***	−19.000*
	(7.621)	(3.539)	(5.322)	(13.300)	(7.471)	(4.204)	(9.460)	(5.171)	(5.742)	(8.955)
—Vocational	−34.761**	−80.675***	−59.892***	−104.821***	−70.357***	−51.708***	−52.427***	−48.941***	−67.901***	−56.620***
	(11.183)	(8.904)	(7.740)	(20.588)	(9.430)	(8.224)	(12.373)	(9.247)	(11.089)	(12.248)
—Other	−69.116***	−63.751***	−68.486***	−102.642***	−87.347***	−80.714***	−57.772***	−67.949***	−101.903***	−60.895***
	(11.757)	(12.598)	(11.928)	(21.222)	(11.681)	(10.424)	(14.751)	(9.441)	(13.956)	(14.003)
SCHCOM (as num.: 1,2,3,4)	−11.698***	−3.103	−2.502					−6.052*	3.433	−5.970
	(2.854)	(3.675)	(3.230)					(3.084)	(3.780)	(3.299)
SCHAVA (basel.= No other)										
—One other available	5.154	8.635	5.838	−17.584	−4.378	7.555	17.208*			
	(5.393)	(5.793)	(5.533)	(20.296)	(7.106)	(4.053)	(6.834)			
—Two or more avail.	4.465	8.374	6.849	−16.771	7.528	5.818	18.099**			
	(5.106)	(5.427)	(5.041)	(14.019)	(6.820)	(3.826)	(6.716)			
SCHSIZE	0.042**	0.068**	−0.007	0.383**	0.028	0.414***	0.048*	0.033*	0.026	0.057***
	(0.013)	(0.023)	(0.022)	(0.126)	(0.031)	(0.130)	(0.021)	(0.015)	(0.027)	(0.015)
SCHSIZE2	−0.000014*	−0.000030*	0.0000007	−0.000420**	0.000002	−0.000015**	−0.000017	−0.000007	−0.000014	−0.000019*
	(< 0.000)	(< 0.000)	(< 0.000)	(< 0.000)	(< 0.000)	(< 0.000)	(< 0.000)	(< 0.000)	(< 0.000)	(< 0.000)

$***: p \leq 0.001$; $**: p \leq 0.01$; $*: p \leq 0.05$

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Table 6: Estimated coefficients for the regions. Full models by sub-samples (Std. Err.s in brackets). Reading

Region	School Community Size				School Availability		
(*bas.*=Abruzzo C)	Village	Town	City	Large City	No other	One other	Two or more
—Basilicata S	117.732***	8.953	10.457	†	25.444*	−17.040	11.340
	(14.878)	(16.573)	(10.880)	(–)	(10.976)	(13.845)	(10.280)
—Bolzano N	134.237***	57.893***	37.245***	17.203	39.306**	36.069**	35.795**
	(24.527)	(18.028)	(10.096)	(19.636)	(14.007)	(12.531)	(13.933)
—Calabria S	66.319***	−32.234	−29.061*	−5.671	−9.494	−50.715***	−34.994**
	(13.274)	(17.807)	(12.238)	(11.173)	(11.374)	(13.693)	(13.388)
—Campania S	34.931	−9.800	−6.365	−9.595	2.434	−26.206*	−12.080
	(20.863)	(26.715)	(9.392)	(10.403)	(10.405)	(11.344)	(10.828)
—Emilia-Rom. N	†	−4.325	30.412**	29.319**	31.730**	3.331	17.733
	(–)	(24.702)	(10.714)	(9.493)	(11.801)	(14.450)	(12.032)
—Friuli N	4.282	48.238**	36.856***	53.600***	42.315***	44.424**	39.124***
	(47.029)	(16.508)	(9.073)	(9.019)	(9.963)	(13.343)	(8.774)
—Lazio C	†	−4.234	−8.190	15.649	0.905	−13.615	14.839
	(–)	(29.354)	(9.172)	(9.208)	(10.809)	(15.630)	(8.982)
—Liguria N	†	−36.087	14.088	30.659**	20.235	−19.134	29.596**
	(–)	(30.697)	(9.386)	(10.387)	(12.620)	(13.286)	(10.555)
—Lombardy N	248.812***	33.013	34.388***	38.577**	59.842***	19.387	26.738**
	(46.788)	(19.091)	(9.775)	(13.166)	(11.876)	(14.931)	(9.431)
—Marche C	120.731***	20.488	35.519***	42.272**	46.880***	29.409*	20.500*
	(14.643)	(17.331)	(7.958)	(14.318)	(9.643)	(13.659)	(9.013)
—Molise C	50.423***	1.266	1.978	†	22.485*	−29.058	−10.614
	(14.615)	(18.631)	(9.863)	(–)	(9.899)	(18.697)	(21.215)
—Piedmont N	169.091***	33.285	34.884***	19.879	41.533***	10.623	33.929***
	(21.085)	(20.342)	(8.887)	(11.066)	(10.618)	(14.971)	(9.297)
—Apulia S	†	19.666	23.495**	23.329	42.101***	0.984	10.373
	(–)	(20.842)	(9.068)	(12.828)	(10.566)	(13.525)	(10.766)
—Sardinia S	−38.906**	13.536	9.416	10.532	14.840	−3.117	5.230
	(15.157)	(17.570)	(8.994)	(7.712)	(10.448)	(10.882)	(9.538)
—Sicily S	†	6.115	−21.657*	8.549	−8.917	−11.427	4.026
	(–)	(19.847)	(9.448)	(6.667)	(9.697)	(14.250)	(11.432)
—Tuscany C	†	46.615*	15.551	35.944***	35.389**	4.877	28.271**
	(–)	(18.251)	(11.172)	(9.255)	(12.875)	(11.125)	(10.203)
—Trento N	139.945***	64.680***	65.840***	31.550*	81.913***	60.751***	26.698*
	(14.353)	(17.599)	(14.063)	(14.932)	(10.945)	(16.456)	(12.294)
—Umbria C	†	30.625	14.639	18.760	29.177**	−5.701	6.869
	(–)	(24.645)	(9.310)	(11.509)	(10.261)	(12.849)	(16.124)
—Aosta Valley N	94.545***	65.519***	70.458***	†	75.496***	29.947	61.142***
	(20.063)	(20.215)	(16.044)	(–)	(14.869)	(16.970)	(12.260)
—Veneto N	104.221***	55.157**	56.985***	36.814***	59.236***	29.614*	42.020***
	(18.543)	(18.330)	(8.263)	(9.994)	(9.931)	(12.018)	(9.447)

$***: p \leq 0.001$; $**: p \leq 0.01$; $*: p \leq 0.05$

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- Using PISA data we study factors affecting Italian students' achievement paying attention on school size
- Data have been analyzed using a Multilevel model
- School size affects students' achievement in Italy, but the functional form is not linear
- The optimal school size hypothesis has been investigated
- Some policy implications have been introduced to highlight the usefulness of the empirical analysis

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