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On the effects of competition among junior-secondary schools a multilevel analysis of new Italian data

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Abstract

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On the effects of competition among junior-secondary schools

A multilevel analysis of new Italian data

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Keywords. Schools, competition, educational policy, multilevel models
JEL Codes. I21

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1. Introduction and objective

Since the availability of international datasets about students' achievement, many researchers tried to identify the potential role of "educational institutions" in affecting students' achievement. This literature focused, among other factors, on the possible effects of competition. The basic economic idea is that competition among schools should foster innovation and good practices, which in turns should improve students' knowledge and skills (Hoxby, 2000; Lubienski, 2003).

West & Woessman (2010) analyzed Oecd-Pisa 2003 data, and they used microdata about 220,000 students in 29 (out of 30) Oecd countries. They conclude that:

"Our estimates suggest that larger historical Catholic shares that translate into a ten percentage point larger private school sector today increase average student achievement on the PISA 2003 mathematics test by at least 9% of an international standard deviation. (…)These results reflect the consequences of private competition over the very long run and therefore may not apply directly to contemporary policies to expand school choice through voucher-like mechanisms, many of which have been enacted with provisions intended to shelter public schools from competitive pressures"

West & Woessman, 2010, p. F248.

Hanushek & Woessman (2010) conducted a meta-analysis about studies dealing with the economic and organizational determinants of students' achievement in an international perspective. Their results suggest that:

"Institutional features of school systems can account for a substantial part of the cross-country variation in student achievement. In the school system, institutions that tend to be associated with higher achievement levels include accountability measures like external exit exams, school autonomy in process and personnel decisions (…), private-school competition, and public financing. (…) While some of the evidence is descriptive, convincing causal identification has been developed that support the results on external exit exams, private-school competition, and tracking".

Hanushek & Woessman, 2010, pp. 36-37.

The evidence provided by these studies allows the researchers to conclude that, on average, competition matters in explaining variations among students' achievement in different countries.
However, an open issue is the extent to which competition matters for explaining within-countries variations among students' achievement and schools' performance. For this purpose, country-specific analysis should be realized, in order to understand the main determinants of students' achievement in a specific institutional setting. The US literature in this field is rich and well developed (e.g. Belfield & Levin, 2002 and Rouse & Barrow, 2010 report interesting summaries). Instead, the European literature is still very limited, with only studies about (i) the Swedish experience with school vouchers and (ii) the effects of quasi-markets reforms in England constitute a notable exception (Sandström & Bergström, 2005; Bradley & Taylor, 2010).

With respect to Italy, only Agasisti (forthcoming a,b,c) attempted to model the relationship between schools' competition and results. Nevertheless, given the absence of national-specific data, the studies were based on the Oecd-Pisa 2006 data, by extracting the subsample of Italian students involved in that international testing exercise.

In this paper, instead, a new wave of data released by the Italian National Evaluation Committee (Invalsi, www.invalsi.it) has been used. Since 2007/08, Invalsi administers a national assessment of students' achievement at the end of junior-secondary schooling (age 13). In these years, such exercise is going to be extended to other grades (primary and upper-secondary schooling). This evaluation procedure is very important because, although partial (it only refers to achievements) it is the first time that it is possible to analyze Italian students' performances beyond the OECD-Pisa framework. The data employed in this paper concern a sample of Italian junior-secondary schools (reference year is 2008/09), and were used to test the statistical association between (i) students' and schools' performance and (ii) competition among schools. For the purpose of measuring competition, two different variables have been employed, one as a proxy for the number of choices available for families (number of schools in a certain area) and one as a proxy for the competitive pressure put by private schools (percentage of private schooling enrollment in a certain area).

The objective of this paper is to determine if competition matters in influencing students' achievement in the Italian junior secondary schooling. Technically, the aim is to measure whether the variables that measure competition among schools in a given area are statistically associated with higher students' achievement in that area.

From a theoretical point of view, Italian schools are not forced to compete, because of the high public regulation of the sector. For instance, the allocation of public money is not based on the number of students and/or on schools' performance. Moreover, schools have not autonomy in some crucial tasks, like hiring teachers, formulating budgets, or determining teaching programs. However, some evidence suggests that actually they do compete, at least in some circumstances. For instance, schools' principals tend to report the existence of some degree of competition. The Oecd-Pisa questionnaire (edition 2006) formulated a question to understand how many schools compete for the same students in the reference area, and the possible answers were 0; 1; 2 or more. In Italy, more than 70% of schools' principals answered 2 or more.

This paper benefited from previous work about measuring competition among schools in Italy and previous analyses of new Invalsi data (Agasisti & Vittadini, 2010). Nevertheless, the paper is innovative in a number of ways:

- Previous studies analyzed the data about Italian junior secondary schools, but they did not look for statistical associations between performances and competition;
- Previous work assessed the potential role for competition, but:

    - By using Oecd-Pisa data, and not Italian-specific results like those provided by Invalsi;
    - By using multivariate linear modeling, instead of a more correct multilevel approach.
- Moreover, while the measures of competition previously developed refer to wider areas (Regions), the data here consider the Province (a narrower area) as the reference for measuring the competition faced by each school, thus increasing precision and reliability in the estimates;
- Finally, while previous analyses use a dataset in which data are aggregated at school-level, here the analysis employs individual-level data.

The methodological section will give details about the importance of such innovations. It is worth anticipating that the main results confirm the previous findings, so providing a further robustness check about the potential role of competition in affecting students and schools' performance in Italy.

The remainder of the paper is organized as follows. The section 2 contains a literature review, which underlines previous findings about competition among schools in Italy. The section 3 is devoted to explain the methodology in detail, and to describe the dataset. The section 4 shows the main results of the empirical analyses. Lastly, the section 5 discusses the results and concludes with some final remarks.

2. Literature review

A comprehensive analysis of the existent literature on competition among schools and its potential effects is well beyond the scope of this paper. Thus, here is provided some information about the studies conducted in two European countries (England and Sweden) where this topic has been hotly debated, and some details about previous studies about the Italian educational setting.

Sandström & Bergström (2005) analyzed the school vouchers experience in Sweden. Specifically, they focused on the effect that competition from independent schools has on the public schools. Their data are about socio-economic status, grades and results on the national achievement tests for all students in the ninth grade in 34 Swedish municipalities for the scholastic year 1997/1998. Their conclusion is supportive of that greater competition improves the standards of public schools. The magnitude of this effect is dependent upon the econometric specification, in a range between 1% and 4% of the average schools' performance.

Bradley & Taylor (2010) studied the effects of three major policies that aimed in introducing more competition among public schools: the introduction of a quasi-market following the Education Reform Act (1988), the Specialist Schools Initiative introduced in 1994, and the Excellence in Cities program introduced in 1999. The authors use a large panel data, with information aggregated at school-level, for the period 1994-2006. Their analysis concludes:

> "We find that a one percentage point increase in the exam performance of other schools in the same district is associated with a 0.2 percentage point increase in the school's own exam performance. This suggests that competition between schools was associated with an improvement of 4 percentage points in the overall exam score during 1994–2006" (p. 16).

The authors' conclusions about positive effects of competition among schools are in line with previous research on the English situation in previous periods (Bradley & Taylor, 2002; Bradley et al., 2000; Bradley et al., 2001).

When looking at the literature about Italy, it should be noted that only recently there was a growing attention towards the determinants of students' achievement. For instance, Bratti et al. (2007) used multivariate linear regressions to analyze the Oecd-Pisa 2003 data about Italian students, while Longobardi *et al.* (2009) adopted a multilevel approach to scrutinize the Oecd-Pisa 2006 data. Both papers used individual-level data. Some common results emerged from these analyses. More specifically:

- There is a huge gap between achievement of pupils in the Northern and Southern Italy. Alone, this factor explains about 25% of the variation in students' achievement scores;
- Students in "academic" upper secondary schools (called *Licei*) outperform their counterparts in technical schools, who in turn have better scores than those in vocational schools;
- The socio-economic status (SES) of the students' families is a statistically strong predictor of the achievement score.

Nevertheless, all these contributions did not look specifically at the role exerted by competition to students' results. Two recent papers deal with this topic.

Agasisti (forthcoming a) specified an educational production function in which Math score from Oecd-Pisa 2006 data is the output. The unit of analysis was the school, that is to say all the data were organized at school level. Among the regressors (inputs), the author included three different variables measuring competition in the school's area (Region): (i) the principal's answer to the question in the Pisa questionnaire about the number of schools competing in the same area, (ii) the percentage of students enrolled in private schools in the area, and (iii) the schools' density in the area, that is the number of schools (public or private) operating in the area (standardized for 1,000 students). The analysis was conducted through a multivariate robust-clustered linear regression. Many covariates were included as control, like the percentage of girls, the percentage of foreign students, the average socio-economic status (SES) of students' families, and so on. The results show that only one of the three variables is statistically associated with schools' average achievement score, namely the schools' density.

In a subsequent paper, Agasisti (2011) analyzed the same dataset using a completely different methodological approach. More specifically, he conducted a two-step analysis. In the first, Data Envelopment Analysis has been used to derive the efficiency score for each school (inputs: students' SES, number of computers, students:teachers ratio; output: math score). In the second step, many covariates were regressed against the efficiency scores, to find statistical associations. Among the regressors, the three competition variables were included (again, alternatively). Moreover, further models explored results' changes when including all the three variables together and their interactions. The main findings are three. First, the schools' density is still the only single variable playing a role in the relationship with schools' performance. Second, when the model allows for the presence of the three variables together, also the percentage of private schools enrolment became statistically significant, albeit negatively associated with schools' performance. Previous studies showed that private schools perform worse than the public ones in Italy (e.g. Bratti et al., 2007). Lastly, the interaction term is positive and statistically related to the schools' performance, suggesting that competition induced by private schools can be positive in a area (Region), if many schools are present in that area.

Overall, in Italy there is still scant evidence about the associations between schools' results and competition among schools. Moreover, the only available results were derived through analyses of Oecd-Pisa data, which suffer two major limitations: are questionable under the profile of the ability to measure students' scholastic achievement, and refer only to upper secondary schooling level.

This paper, for the first time, focuses on a set of more reliable achievement measures (as the tests were developed coherently with the Italian-specific instructional contents). Moreover, it analyzes results at lower-secondary schooling level.

3. Methodological approach

3.1. An overview

In this paper, I adopted two different approaches to measure the potential statistical association between students' performances and competition: (i) multivariate linear regressions and (ii) multilevel models. The aim of using both methods is to compare the results as a cross-robustness-check. Moreover, as multilevel models are preferred, they are used here as a benchmark to assess previous work about Italian education that used only linear regressions to analyze the determinants of students' achievement (e.g. Bratti *et al.*, 2007; Longobardi *et al.*, 2009).

In both cases, the empirical specification follows the idea of estimating an Educational Production Function (EPF) in which students' achievement is the output, and several factors are employed as inputs to "produce" the output (Hanushek, 1979; Monk, 1989; Todd & Wolpin, 2003). Mathematically, I consider the following general form:

$$Y_i = a_0 + a_1 X_{1i} + a_2 X_{2j} + e_i \qquad (1)$$

where Y_i is the achievement of the ith-student, X_{1i} is a vector of i-th student's characteristics, and X_{2j} is a vector of j-th school's characteristics, and e_i is a stochastic error that refers to the ith student.

It is worth noting here that data concerns just a single year (as available data is a cross-section for the year 2008/09). Moreover, when estimate such relationship with linear regressions, the error e_i is not decomposed into student-specific (i) and school-specific (j) errors. This is a major problem, and the use of multilevel as alternative method will provide a solution for this conundrum (§3.2.).

When looking for associations between Y_i and competition, the following formulation should be adopted:

$$Y_i = a_0 + a_1 X_{1i} + a_2 X_{2j} + a_3 Comp_j + e_i \qquad (2)$$

where $Comp_j$ is a proxy for the competition faced by the j-th school. A description of the variables used to proxy competition is given the §3.3.

3.2. Multilevel modeling

Together with estimations of the (1) and (2) with linear regressions (that was the approach adopted by Bratti *et al.* 2007), in this paper, a multilevel approach has been employed. The choice of such method is justified by the hierarchical nature of data, e.g. students nested within schools. In these cases, the multilevel modeling has many advantages with respect to the traditional linear models. Most importantly, empirical analyses suffer two main limitations when the hierarchical nature of data is not adequately considered:

- Ecological fallacy, that is interpreting at individual level some variables obtained by aggregating data at higher level;
- Atomistic fallacy, that is interpreting groups' effect by using individual-level data.

Both the problems lead to an underestimation of standard errors, which in turn confounds the statistical significance of variables at higher levels (overestimation). Such underestimation of standard errors is especially high when the correlation of individuals within groups is high. In these cases, the literature about variance and mixed-effects models suggests that hierarchical models (and particularly multilevel models) offer solutions for studying the relationships between outputs (e.g. achievement scores, in our case) and contextual and organizational variables in complex hierarchical structures (Goldstein, 1995; Hox, 1995).

In the previous literature about Italian schools, despite the many advantages of multilevel modeling, only Longobardi et al. (2009) and Agasisti & Vittadini (2010) adopted it. In this paper, a multilevel model has been used to decompose variance at different levels (individual and student levels), and the covariates (inputs) are used to explain the variance at its reference level.

Details about the estimation strategy with multilevel modeling are reported in the annex 1. However, just to provide a glance of the model, the idea is to estimate:

$$Y_{ij} = g_0 + a_1 x_{1ij} + a_2 z_{1j} + U_{oj} + e_{ij} \qquad (3)$$

where Y_{ij} is the achievement of the ith student in the jth school, g_0 is the Y mean calculated including all students, x_{1ij} is one covariate at student-level, z1j is a covariate at school-level, U_{oj} is the distance between the mean of the j_{th} school and the overall mean (second-order error), and e_{ij} is first-order error, defined as the difference between the mean of the ith student and the mean of the jth school. Obviously, the expression can be generalized to consider m student-level variabled and s school-level variables (§ annex 1). By proceeding through the (3), the different level variables (e.g. schools and students' variables) are employed to explain the variance at that level, without confounding the effects of the variables at other levels.

3.3. Data and variables[1]

Output and inputs

All the data at the individual level come from the Invalsi dataset, which refer to the final examination at the end of the lower-secondary education (reference year: 2008/09).

As output, the test score Math has been used (Math_Score). The scores have been standardized into a range [0;100], that represents the percentage of right answers to the questions of the test.

As inputs at individual level, we employed several students' characteristics: gender (dummy: Female), citizenship (a dummy – Foreign – for students who are not Italian), disabled status (dummy: Disabled). Two variables have been added to control for the age of students:

- A student who is in time for the final examination should be born in 1994; however, some students were enrolled a year before (Early), while
- some other students were not admitted to the next grade during their past academic career (Late).

Unfortunately, the dataset does not include information on the individual student's socio-economic status (SES), so it is not possible to control for this important characteristic. This point is strongly important here, and it must be borne in mind when interpreting the results –

[1] More details are in the contribution by Agasisti & Vittadini (2010), which used approximately the same dataset (but not the competition variables).

much of the variance at individual level remained unexplained because the lack of this important information.
When turning to school-level variables, the source of data is twofold. Part of the variables comes from the same Invalsi dataset (final examination of the lower secondary education, year 2008/09). Another important source was the TIMSS 2007 dataset, which refer to the year 2006/07: however, as we only matched variables recorded at school-level, it is assumed that variations in two adjacent years are very low indeed (the same approach has been used by Agasisti & Vittadini, 2010).
An indicator was originally included to define if the school is public or private (dummy: Private), but it was dropped in the results because the sample includes just 6 private schools (less than 1% of the sample) and the indicator was really collinear with other variables. Albeit the issue of private versus public schools' results is very important, the available dataset used here is not adequate for investigating this specific aspect.
The proportion of students coming from disadvantaged families has been included to control for low socio-economic conditions of the students population (disadvantaged): this variable takes value 1 if the proportion is in the range [0;10], 2 if [11;25], 3 if [26;50], and 4 if [>50]. Also, we controlled for the intensity of resource availability, by including two indicators: (i) the "shortage" of instructional materials (short_instr), and it is recorded on a four-tiers scale as follows: (1=none, 2=a little, 3=some, 4=a lot). Moreover, an indicator of the environment in which the school is located was introduced, by including an ordinal variable considering the dimension of the city/town (community): the value is 1 if citizens are [>500,000], 2 if [100,000;500,000], 3 if [50,000;100,000], 4 if [15,000;50,000], 5 if [3,000;15,000], and 6 if [<3,000].
Finally, we considered differences according to the macro-area in which the school is located. Indeed, previous literature on the achievement of Italian students demonstrated that there are relevant differences across the different areas of the country, with schools

located in the Central part of Italy performing worse than those in the North and better than those in the South (Bratti *et al.* 2007).

Measuring competition

Instead of using one single measure of competition, in this paper two different variables have been employed.

The first variable is a proxy for the number of options available for parents. Indeed, the dataset was improved by the inclusion of the number of schools operating in the Province (standardized by 1,000 students)[2]. This indicator, named Schools_Density, is a measure of the schools density in a given area (Province). There are 62 Provinces in the sample of schools used in this paper.

The second variable is a proxy for the competitive pressure put by the extent of private schooling in the reference area (Province). This indicator (%Private_enrol) is the percentage of students enrolled in private schools in the Province.

Both the indicators were calculated by using official data provided by the Italian Ministry of Education (Miur, www.miur.it), and refer to 2008/09. The inclusion of these variables has been possible because the original dataset (provided by Invalsi) disclosures the information about the schools' reference Province.

As competition is not measured at school-level, but at Province level, two methodological adjustments were necessary. First, the competition variable enters the equation (2) at Province level, so the estimation of (2) is modified as follows:

$$Y_i = a_0 + a_1 X_{1i} + a_2 X_{2j} + a_3 Comp_p + e_i \qquad (4)$$

where $Comp_p$ is the degree of competition in the pth Province.

[2] Thus, the indicator was calculated as follows: #schools/#students*1,000.

Second, when using the multilevel model, the error decomposition is threefold: at Province, school and student level. Thus, the equation 3 has been modified to consider this further decomposition:

$$Y_{ijk} = g_0 + a_1 x_{1ijk} + a_2 z_{1jk} + a_3 w_{1k} + U_{ojk} + e_{ijk} + f_k \qquad (5)$$

where k is the subscript for the kth Province, w_{1k} is a covariate at Province-level, and f_k is the Province-specific stochastic error. In the empirical analysis, the only variables included at Province level are those related to competition:

$$Y_{ijk} = g_0 + a_1 x_{1ijk} + a_2 z_{1jk} + a_3 Comp_k + U_{ojk} + e_{ijk} + f_k \qquad (6)$$

<u>Modeling the relationship between performance and competition</u>

In the paper, three different specifications of the (6) have been used:

- Model 1: The first consider $Comp_p$=Schools_Density;
- Model 2: The second consider $Comp_p$=%Private_enrol;
- Model 3: The third includes both variables as well as their interaction, because Agasisti (2011) showed how a more flexible specification can help in better understanding a more realistic role for competition.

Actually the model 1 and model 2 have been estimated both through linear regressions and multilevel models; while, for the model 3, only multilevel regressions have been used. An overview of the different models investigated in the empirical analyses is reported in the table 1.

<Table 1> around here

At the end, the sample used for the empirical analyses comprises 18,824 students, enrolled in 145 schools, sorted into 62 Provinces. Descriptive statistics are in the tables 2a and 2b.

<Tables 2a, 2b> around here

The average score for the Italian junior secondary schools is about 62/100 points, albeit great variations exist (standard deviation is approximately 22 points). The presence of such differences justifies the necessity to investigate what matters for determining students' achievement.

The foreign students account for 7% of the sample. About 9% of students repeated one or more years.

The schools located in Northern Italy are the 38% of the sample (21% in Central Italy, 41% in the South). The schools that report the highest proportion of disadvantaged families (>50%) are just the 6% of the sample, but 17% report a proportion between 26-50%. The shortage of instructional materials seems to affect only a small portion of schools (overall, 14%, just 2% declare high shortage).

When looking at the competition variables, the school's density (at Province level) is in average 4.38 (every 1,000 students), but with a wide variation (from 2.33 to 10.89). The enrolment in private schooling (again, at Province level) is about 5%, again with great variation among Provinces.

4. Results

4.1. Models 1a-1b (competition variable: schools density)

The table 3 contains the results for the EPF estimates when using a multivariate linear regression.

<Table 3> around here

Some patterns tend to emerge clearly. First, the dummy for Southern Italy comes out as statistically significant and strongly negative (-12.3 points). It confirms that schools located in Northern Italy outperform those in Southern Italy (Montanaro, 2008). Female students have slightly lower performances with respect to their male counterparts. The disabled status is associated with a greatly lower achievement score (around -12 points), as well as having repeated one or more years (-9.2 points). All the school-level variables are not statistically significant. Agasisti & Vittadini (2010) showed how these variables lose statistical power when geographical dummies are added to the model (e.g. Northern, Central and Southern Italy). The competition variable is statistically significant and positive. The coefficient is 1.66, that is to say the impact of competition accounts for around 2.6% on the achievement scores (calculated at the average performance level). Thus, the presence of more schools in one certain Province is apparently associated with a higher performance of 1.6 points for the schools in that Province.

How robust is this finding? Even though the regression has been ran by clustering standard errors at Province level (Moulton, 1990), the use of multilevel modeling must be considered as more appropriate to investigate the relationship between performance and (province-level) competition (e.g. Primo *et al.*, 2007).

By means of comparison, the results from the multilevel model are reported in tables 4a.

<Table 4a> around here

The first column illustrates the disentanglement of the variance (and the calculation of the grand mean, represented by the intercept). The second column shows the effects of including individual-level variables; the third column adds the school-level and the competition variables.

The table 4b reports the variance's decomposition records, as well as the part of Province-level variance explained by the competition variable. This latter statistics is calculated as follows: (10.108 – 6.015)/ 10.108.

<Table 4b> around here

What emerges is that the variance is much higher at individual level (consistently with Agasisti & Vittadini, 2010), as between-provinces variance accounts for about 2% and between-schools variance for 12%. However, the different schools' density among Provinces explains about 40% of the Province-level variance – that is it contributes a lot in explaining why schools in different Provinces perform differently. The impact of competition, that remains statistically significant, is roughly 1.6% (about 1 point), lower than the impact estimated by the multivariate linear regression. It could be useful to see whether school-level variables confound (e.g. by causing overestimation) the estimated coefficient for competition. For instance, it could be that a part of Province-level variance is actually explained by school-level factors, instead of Province-level competition. To investigate if it was the case, a multilevel model has been estimated by dropping the school-level indicators. The results are shown in the table 5. The results turn out almost identical to those reported in table 4a, so confirming the statistical association between performance and schools density, as well as the high portion of Province-level variance explained by the measure of competition.

<Table 5> around here

4.2. Models 2a-b (competition variable: % Private enrolment)

In this second wave of results, the analysis considers the alternative measure of competition, which is the percentage of students enrolled in private schools (at Province level).

When approaching the analysis through a linear multivariate regression, it must be considered that the variable is potentially endogenous. Indeed, it could be the case the private schooling increases along with scarce performance of public schools. For this reason, many authors in the past adopted an Instrumented Variable approach for including private schools enrolment in the analysis (also Agasisti, forthcoming a followed this strategy). However, in this paper % Private Enrol was not instrumented, also to show how this variable can lead to biased results. The problem is instead not relevant for multilevel models, where the variable only enters the part of variance

at Province level (as seen above, it impacts only a small proportion of the variance).
The results are showed in the table 6.

<Table 6> around here

While the linear regression suggests a positive association between performance and competition (around 3.1 points, that is 4% at mean performance level), the more robust multilevel approach fails to find a significant effect of it. Thus, the results seem to confirm that (i) schools density plays a role, and (ii) % Private Enrol is not statistically related to achievement.
The comparison between linear regressions and multilevel model represents an interesting methodological point here, as it emerges how biased can be the analysis which do not account properly for the hierarchical structure of data.

4.3. Model 3 (competition variable: schools density + % Private enrol + interaction)
In this elaboration, the two indicators were included simultaneously in the analysis, as well as the interaction term (schools density * % Private enrol). The latter was considered to understand whether the two variables act together in some ways or not.
The results are illustrated in the table 7.
The choice was to limit the analysis to the multilevel approach, as the results from linear regression looks unstable for the variable % Private enroll (§ 4.2.).

<Table 7> around here

The results tend to confirm a positive role of schools density (magnitude: 1 point, about 1.5% calculated at the mean of performance). Neither % Private enrol nor the interaction term were found to be significantly related to achievement.

5. Discussion

In this paper, a new dataset available for Italian junior secondary schools has been used to detect potential relationship between measures of competition among schools and students' achievement. A sample of 18,824 students (in 145 schools, located in 62 Provinces) has been analyzed for this purpose.

Two different proxies for competition in a certain area (Province) were employed: (i) the number of schools available, standardized for every 1,000 students (Schools density) and (ii) the proportion of students enrolled in private schools (% Private enroll).

From a methodological point of view, linear multivariate regressions and multilevel models were used.

A summary of results is contained in the table 8.

<Table 8> around here

The story that emerges is that schools density is statistically associated with higher students' achievement. That is to say, if competition is playing a role in influencing students and schools' performances, the mechanism is likely to be the number of schools in the area in which each school operates.

The interpretation discussed above is coherent with that contained in Agasisti (forthcoming a,b). It is worth discussing here a comparison with those results indeed, as they were the only contributions explicitly targeted at estimating the potential effects of competition among public schools.

Some preliminary points must be considered in doing so.

First, here the analysis is conducted with a sample of junior secondary schools, while Agasisti (forthcoming a,b) realized a study on upper-secondary schools because he used the Oecd-Pisa 2006 data. Oecd-Pisa involves students who are 15 years old, and most of them are enrolled at an upper-secondary school; moreover, Agasisti excluded

from the sample those students who were still enrolled in junior secondary schools. As a consequence, some difference in the results could be due to different roles of competition in different schooling levels. Second, the competition variables used by previous studies are collected at Regional level, while those used in this paper are at Province-level. Thus, the effect described here describes what happens in a narrower area and, in general terms, the results are more credible in principle.
With all these caveats in mind, it is possible to read the table 9, where the estimated associations between competition and students' achievement are reported.

<Table 9> around here

The picture that emerges is that, in all the studies, the number of schools located in a certain geographical area (Region or Province) is statistically associated with higher (average) results in that area, in terms of students' achievement. The estimated magnitude of the effects varies according to the different samples and methodologies used in the papers, but the range is between 1.5% and 3.5% - calculated at the average (math) schools' score.
On the contrary, the role of private schooling (the share of private schools' enrolment in the area) seems not to have a statistical role in influencing the schools' performance – the only exception is a study where Agasisti (forthcoming b) detects a role by using a linear regression in which both the variables (Schools_Density and %Private) are included together with the interaction terms.
Overall, the studies underline a potential role of the schools' density in an area for improving (through competition) the average schools' performance in that area. The role of private schooling in acting through competition seems, instead, less relevant.
Unfortunately, all these results must be considered as suggestive; in all the cases, only cross-sectional data are available, thus no quasi-experimental strategies could be used, nor more robust analyses

through panel data models. However, the development of annual standardized tests by Invalsi (started in 2007/08) will raise the opportunity to investigate more deeply this issue by the availability of panel data. Given the present available data, the strategy proposed in this paper overcomes some typical problems of linear regressions in analyzing cross-sectional data. Indeed, the multilevel approach adopted in the paper permits to consider properly the hierarchical nature of data (students nested into schools, clustered at Province level).

If the story about the potential role of competition is credible, it is altogether necessary to explore more in detail the mechanisms, which operates in competition. Why the schools in areas subject to higher competition do perform better? Is there a "reputation race" that modifies the motivations of teachers and students? Or do the schools' managers invest more in better teachers and facilities/structures? Or do the teachers adopt more effective teaching strategies? Or is there a mix of these and other explanations?

To correctly answer these questions, it would be important to collect more detailed (qualitative and quantitative) data about the characteristics of schools and teachers. Some literature on the schools' effectiveness (Scheerens, 2000) can provide a guideline to choose some important indicators to be collected at school level, to analyze whether schools in "high-competition" areas do differ with other schools along these dimensions.

Table 1. The empirical models: variables and estimation techniques

	Linear regression	Multilevel model
Competition variable: Schools_Density	Model 1a	Model 1b
Competition variable: %Private_enrol	Model 2a	Model 2b
Competition variable: Schools_Density + %Private_enrol + interaction	-	Model 3

Table 2a. Descriptive statistics (continuous variables)

Variable	Mean	Std. Dev.	Min	Max	Obs
Math_Score	62.22	21.92	0.00	99.99	21,336
Competition: Schools' density	4.38	1.72	2.33	10.89	20,253
Competition: %Private_enrol	0.05	0.07	0.00	0.12	20,253

Table 2b. Descriptive statistics (binary and categorical variables)

Variable	Proportion (%)	Min	Max	Obs
Female	0.49	0.00	1.00	21,336
Disabled	0.00	0.00	1.00	21,343
Foreign	0.07	0.00	1.00	21,336
Early	0.05	0.00	1.00	21,336
Late	0.09	0.00	1.00	21,336
Northern Italy	0.38	0.00	1.00	21,336
Central Italy	0.21	0.00	1.00	21,336
Southern Italy	0.41	0.00	1.00	21,336
Disadvantaged (0-10%)	0.39	0.00	1.00	19,838
Disadvantaged (11-25%)	0.38	0.00	1.00	19,838
Disadvantaged (26-50%)	0.17	0.00	1.00	19,838
Shortage of instructional material (High)	0.02	0.00	1.00	21,343
Shortage of instructional material (Some)	0.12	0.00	1.00	21,343
Community: big city	0.12	0.00	1.00	21,343
Community: city	0.31	0.00	1.00	21,343

Table 3. EPF estimations through multivariate linear regression

Competition variable: Schools' density

Math_Score	Coef.	Std. Err.	t	P>t
Central Italy	-1.516	1.267	-1.20	0.24
Southern Italy	**-12.314**	1.638	-7.52	0.00
Female	**-1.729**	0.458	-3.78	0.00
Disabled	**-12.879**	1.522	-8.46	0.00
Foreign	**-4.535**	1.198	-3.79	0.00
Early	1.192	0.789	1.51	0.14
Late	**-9.293**	0.904	-10.28	0.00
Disadvantaged (0-10%)	-2.106	5.270	-0.40	0.69
Disadvantaged (11-25%)	-3.180	5.021	-0.63	0.53
Disadvantaged (26-50%)	-4.495	5.298	-0.85	0.40
Shortage of Instructional material (High)	-3.706	6.151	-0.60	0.55
Shortage of Instructional material (Some)	-2.133	1.675	-1.27	0.21
Community: big city	2.898	2.213	1.31	0.20
Community: city	2.154	1.440	1.50	0.14
Competition: schools' density	**1.660**	0.496	3.35	0.00
Constant	**64.628**	3.959	16.32	0.00

Standard errors are clustered at Province level

Table 4a. EPF estimations through multilevel model

Competition variable: Schools' density

Math_Score	Empty	Individual variables	Individual and school level variables
Central Italy	-2.422	-2.776	-2.150
	0.269	*0.200*	*0.331*
Southern Italy	**-9.679**	**-10.619**	**-10.609**
	0.000	*0.000*	*0.000*
Female		**-1.859**	**-1.822**
		0.000	*0.000*
Disabled		**-12.003**	**-12.002**
		0.000	*0.000*
Foreign		**-4.380**	**-4.558**
		0.000	*0.000*
Early		1.089	**1.253**
		0.116	*0.088*
Late		**-8.235**	**-8.266**
		0.000	*0.000*
Disadvantaged (0-10%)			1.097
			0.683
Disadvantaged (11-25%)			0.926
			0.732
Disadvantaged (26-50%)			-0.931
			0.741
Shortage of instructional material (High)			-3.066
			0.467
Shortage of instructional material (Some)			-2.306
			0.242
Community: big city			1.134
			0.664
Community: city			1.578
			0.343
Competition: Schools' density			**1.050**
			0.014
Constant	**67.353**	**69.800**	**63.757**
	0.000	*0.000*	*0.000*

Notes: Statistical significance in bold; p-values in italics

Table 4b. Multilevel ancillary results

Competition variable: Schools’ density

Math_Score	Empty	Individual variables	Individual and school level variables
Variance: between Provinces	10.359	10.108	6.015
Variance: between schools	55.888	54.563	57.054
Variance: between individuals	390.326	380.954	377.562
Total variance	456.573	445.625	440.631
%Provinces	2.27%	2.27%	1.37%
%schools	12.24%	12.24%	12.95%
Explained by competition	40.49%	*at province level*	

Table 5. EPF estimations through multilevel models without school-level control variables

Competition variable: Schools’ density

Math_Score	Coefficient	Std. Err.	Z-value
Female	**-1.856**	0.277	0.000
Disabled	**-12.020**	2.226	0.000
Foreign	**-4.380**	0.637	0.000
Early	1.098	0.693	0.113
Late	**-8.240**	0.546	0.000
Central Italy	-2.674	2.038	0.190
Southern Italy	**-11.413**	1.645	0.000
Competition: schools' density	**1.039**	0.403	0.010
Constant	**64.997**	2.189	0.000
Variance: between Provinces	6.135		
Variance: between schools	55.003		
Variance: between individuals	380.961		
Total variance	442.099		
%Provinces	1.39%		
%schools	12.44%		

Table 6. EPF estimations through linear multivariate regression and multilevel model

Competition variable: % Private Enrol

Math-Score	Linear regression EPF		Multilevel model	
	Coeff.	p-Value	Coeff.	p-Value
Central Italy	**-1.894**	0.058	-2.322	0.328
Southern Italy	**-12.228**	0.000	**-11.281**	0.000
Female	**-1.802**	0.000	**-1.825**	0.000
Disabled	**-12.761**	0.000	**-11.994**	0.000
Foreign	**-4.359**	0.001	**-4.553**	0.000
Early	0.942	0.403	1.263	0.085
Late	**-9.090**	0.000	**-8.265**	0.000
Disadvantaged (0-10%)	-0.935	0.851	0.094	0.973
Disadvantaged (11-25%)	-3.134	0.532	-0.317	0.908
Disadvantaged (26-50%)	-3.136	0.573	-2.109	0.463
Shortage of Instructional material (High)	-4.707	0.498	-3.159	0.446
Shortage of Instructional material (Some)	-2.161	0.226	-2.152	0.271
Community: big city	0.615	0.747	0.591	0.821
Community: city	1.378	0.304	1.338	0.419
Competition: % Private enrollment	**3.167**	0.027	3.497	0.559
Constant	**71.490**	0.000	**69.335**	0.000
Between-Provinces variance				10.425
Between-schools variance				55.466
Individual level variance				377.555
Between-Provinces variance (%)				2.35%
Between-schools variance				12.51%

Table 7. EPF estimations through multilevel model

Competition variable: Schools density + % Private Enrol + interaction term

Math_Score	Coefficient	Std. Err.	z	P>z
Central Italy	-1.944	2.300	-0.850	0.398
Southern Italy	**-10.201**	1.957	-5.210	0.000
Female	**-1.822**	0.286	-6.370	0.000
Disabled	**-11.996**	2.453	-4.890	0.000
Foreign	**-4.557**	0.652	-6.990	0.000
Early	**1.253**	0.734	1.710	0.088
Late	**-8.265**	0.561	-14.730	0.000
Disadvantaged (0-10%)	0.971	2.704	0.360	0.720
Disadvantaged (11-25%)	0.853	2.713	0.310	0.753
Disadvantaged (26-50%)	-1.035	2.838	-0.360	0.715
Shortage of Instructional material (High)	-3.070	4.229	-0.730	0.468
Shortage of Instructional material (Some)	-2.271	1.979	-1.150	0.251
Community: big city	1.110	2.715	0.410	0.683
Community: city	1.629	1.677	0.970	0.331
Competition: % Private enrollment	6.540	85.468	0.080	0.939
Competition: Schools' density	**1.055**	0.514	2.050	0.040
Competition: interaction	-0.662	16.439	-0.040	0.968
Constant	**63.416**	4.036	15.710	0.000

Between-Provinces variance	7.113
Between-schools variance	57.128
Individual level variance	377.561
Between-Provinces variance (%)	1.61%
Between-schools variance	12.93%

Table 8. EPF estimations through linear multivariate regressions and multilevel models

Summary of the results

	Competition: Schools Density		Competition: %Private Enrol		Together
	Linear Regression	Multilevel	Linear Regression	Multilevel	Multilevel
Central Italy	-1.516	-2.150	**-1.894**	-2.322	-1.944
Southern Italy	**-12.314**	**-10.609**	**-12.228**	**-11.281**	**-10.201**
Female	**-1.729**	**-1.822**	**-1.802**	**-1.825**	**-1.822**
Disabled	**-12.879**	**-12.002**	**-12.761**	**-11.994**	**-11.996**
Foreign	**-4.535**	**-4.558**	**-4.359**	**-4.553**	**-4.557**
Early	1.192	**1.253**	0.942	1.263	**1.253**
Late	**-9.293**	**-8.266**	**-9.090**	**-8.265**	**-8.265**
Disadvantaged (0-10%)	-2.106	1.097	-0.935	0.094	0.971
Disadvantaged (11-25%)	-3.180	0.926	-3.134	-0.317	0.853
Disadvantaged (26-50%)	-4.495	-0.931	-3.136	-2.109	-1.035
Shortage of Instructional material (High)	-3.706	-3.066	-4.707	-3.159	-3.070
Shortage of Instructional material (Some)	-2.133	-2.306	-2.161	-2.152	-2.271
Community: big city	2.898	1.134	0.615	0.591	1.110
Community: city	2.154	1.578	1.378	1.338	1.629
Competition: % Private enrollment			**3.167**	3.497	6.540
Competition: Schools' density	**1.660**	**1.050**			**1.055**
Competition: interaction					-0.662
Constant	**64.628**	**63.757**	**71.490**	**69.335**	**63.416**

Table 9. The statistical association between competition and students' achievement: a comparison with previous studies

Estimated effects of competition on Math achievement scores	Agasisti (forhcoming a)	Agasisti (forthcoming b)	This paper
Schools density	2.7%	3.5%	1.50%
% Private Enrol	n.s.	-5%	n.s.
Interaction	-	1%	n.s.

Notes. n.s. stands for "not statistically associated"

Agasisti (forthcoming a) performs a linear multivariate regression

Agasisti (forthcoming b) performs a Tobit regression on DEA scores

The results of this paper are those obtained with multilevel model (tables 4a and 6)

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Annex 1.
A description of the multilevel strategy adopted in the paper

In this paper, the strategy is based upon a two-stage approach: in the first, we estimated an "empty" model, to decompose the variance between student-level and school-level, while in the second we added explanatory variables both at student and school levels. A brief description of this methodology is reported in this annex[3].

<u>The "empty" model</u>
We applied an empty model to our dataset, of the following form:

$$Y_{ij} = \gamma_0 + U_{oj} + \varepsilon_{ij} \qquad (a_1)$$

where Y_{ij} is the dependent variable (test score) for the ith student in the jth school. γ_0 is the Y mean calculated including all students, and U_{oj} is the distance between the mean of the jth school and the overall mean (second-order error). Finally, ε_{ij} is first-order error, defined as the difference between the mean of the ith student and the mean of the jth school.
The assumption is that both the errors have a normal distribution with mean equal to 0 and a constant variance:

$$\begin{aligned} &\varepsilon_{ij} \approx IID - N(0,\sigma^2), U_{oj} \approx IID - N(0,\tau^2) \\ &Cov(U_{oj}, \varepsilon_{ij}) = 0 \end{aligned} \qquad (a_2)$$

Thus, σ^2 represents the variance within schools, while τ^2 is the variance among schools. As a consequence, we can calculate the "intra-school" coefficient of correlation, by dividing the variance among schools and the total variance:

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[3] Notation used here is partially different from that in the §3.2.

$$\rho = \frac{\tau^2}{\tau^2 + \sigma^2} \qquad (a_3)$$

The coefficient represents the part of the total variance that could be imputed to the "among schools" variance. If $\rho \neq 0$ (that is to say, part of the variance is explained at group-level instead that at individual level), a multilevel model will be adopted to account for the hierarchical nature of the data.

The multilevel model with random intercept

In this second step, we added to the empty model some independent variables, which aim is to explain the within-school and among-schools variance.

By means of formal simplicity we assume a two-levels structure of the data, and the availability of one covariate at student-level (x_{1ij}) and one at school-level (z_{1j}), then the equation of the multilevel model with random intercept is:

$$\begin{aligned} Y_{ij} &= \alpha_{0j} + \alpha_1 x_{1ij} + \varepsilon_{ij} \\ \alpha_{0j} &= \gamma_0 + \alpha_2 z_{ij} + U_{oj} \end{aligned} \qquad (a_4)$$

It is important to point out that the random intercept α_{oj} is explained also by considering the effect of z_{ij}. When merging the two equations illustrated in (4), then a single equation can be formulated:

$$Y_{ij} = \gamma_0 + \alpha_1 x_{1ij} + \alpha_2 z_{1j} + U_{oj} + \varepsilon_{ij} \qquad (a_5)$$

In the (5), two components can be identified: (i) a "fixed" part, represented by $\gamma_0+\alpha_1 x_{1ij}+\alpha_2 z_{1j}$, and (ii) a "random" part (the error terms) $U_{oj}+\varepsilon_{ij}$.

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 indeed:

$$Cov(y_{ij}, y_{i'j'}) = \begin{cases} 0 & \forall i \neq i', \forall j \neq j' \\ \tau^2 & \forall i \neq i', \forall j = j' \end{cases} \quad (a_6)$$

Lastly, a generalization of the (a_5) can be presented assuming m student-level variables and s school-level variables:

$$Y_{ij} = \gamma_0 + \sum_{k=1}^{m} \alpha_k x_{kij} + \sum_{t=1}^{s} \alpha_t z_{tj} + U_{oj} + \varepsilon_{ij} \quad (a_7)$$