Standard costs for Italian primary public schools: a simulation through a cost function approach

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1 Motivation and objectives

Although several influential works show that improving schools' financial resources does not appear statistically associated with students' achievement (Woessmann et al., 2009), this does not mean that education systems do not cost. Schools do cost indeed, so many relevant issues arise for policymakers, like

1. how much a school should be funded
2. which are the schools that are receiving more or less than the minimum necessary for offering quality educational services
3. which are the characteristics that make the costs of a school different from another (location, composition of student body, etc.).

All these topics are relevant in a public finance perspective [this literature goes back to Chambers (1980)], as they deal with the efficiency of public sector[1]: defining adequately the 'costs' of public services and organisations will result in better public spending and efficiency (Afonso et al., 2005; Simpson, 2009).

The core of this paper deals with a method to derive information about 'standard (unit) cost' (hereafter, ST) for schools to carry out their activities and provide their educational services. ST is defined as the 'per unit' cost (i.e., cost per student) that each school should meet given its own characteristics. It is assumed that the most efficient educational system is one when all schools produce at their own best ST; in the reality, it could be the case that schools operate with a spending level that is too high or low, given their features. As a consequence, it is necessary to develop an empirical method to estimate schools' STs and compare them with observed spending levels, to inform policy making with the aim of reducing inefficiencies (i.e., differences between ST and actual expenditure). In this context, the theme of defining and calculating standard costs becomes essential, as ST can be interpreted as a 'reference amount' of money to be assigned to each school. Fundamentally, this issue reflects that of 'capitation funding' for public services, which consists in estimating the cost for providing the service to a citizen (in this case, student) with specific predetermined characteristics (Smith et al., 2001) or the 'need formulae' for funding public organisations serving different populations (King et al., 2004). Since we are interested in the process of defining ST for schools (i.e., accounting for structural differences between regions), the paper focuses on a single region, not the overall country. Eliminating between-regions variations in these confounding factors allows estimating costs much more precisely. Nevertheless, Lombardy case is of major interest altogether: it is the wealthiest region in Italy (around 25% of Italian GDP), represents around 15% of the total Italian schooling population, and turned out as the region in which achievement scores are highest according to OECD-PISA 2009 and national (INVALSI) educational tests.

This paper provides an empirical estimate of the standard costs for a sample of primary schools in Lombardy. It is worth noting that each school has a different standard cost, as ST is not an absolute, unique value, but instead a specific amount dependent upon schools' relevant specific features, such as the characteristics of the student body (percentage of foreign and disabled students, socioeconomic background, etc.), the location in the metropolitan area, and size (number of students), etc.

The research questions of this paper are:

1 How different are schools' expenditures in the comparison with their estimated standard costs?

2 How can the resources be reallocated within the Lombardy Region to align current and standard costs?

The remainder of the paper is organised as follows. In Section 2, a background about the Italian educational system is provided. Section 3 contains a literature review. Section 4 illustrates the methodology and data. Section 5 presents the results, while Section 6 discusses them and concludes.

2 Background: the Italian educational system

Although the responsibility for providing and organising several public services has been devolved to regions (the most relevant is healthcare), the Italian educational system is still highly regulated and managed by the Ministry of Education. Nevertheless, schools have some financial autonomy, related to sources others than the budget received by the central government. To better contextualise this study, it is then useful to describe the system of educational public funding. Several (public) actors are involved in the process of financing the schools, and especially both central and local governments: the Ministry of Education – which provides resources for tenured personnel (both teachers and non-teaching staff) and for schools' operations and facilities – and provinces, municipalities and regions. Schools' funding provided by the Ministry of Education along with provinces and municipalities account for more than 50 billions € (authors' elaborations on data provided by the Ministry of Education; data refer to 2012). It is worth to note, however, that just a small share of this money is assigned to schools. More than 40 billions are devoted to salaries (and the share devoted to capital expenditure is negligible): salaries are paid directly from the Ministry to any single teacher (and to non-teaching personnel as well). In other words, the amount of resources devoted to paying the personnel is not at schools' disposal. This funding system is a consequence of the current teachers' recruitment setting. Schools do not recruit teachers, neither do local agencies, but they are selected directly by the Ministry of Education, and are employed as civil servants. On a practical ground, schools which desire to recruit a new teacher, must follow an administrative register(ranking) that is built by the Ministry and articulated at province level, mainly on the basis of the age of teachers (which is supposed to be a proxy for the experience of teachers). The overall number of teachers in the country is determined by: the number of classes, the number of open positions, and the requests of teachers on the basis of the positions.

The Italian legislation also prescribes a specific share of teachers devoted only to disabled students (D.l. 16th April 1994, No. 294). Non-teaching staff follows the number of students weighted for school grade: the higher the grade, the higher the weight (D.P.R. 22nd June 2009, No. 119).

The funds provided by the Ministry of Education that go directly to schools are two:

1 a fund for 'administrative and teaching operations'

2 a fund for 'empowerment of educational supply'.

In turn, the former includes two funds: one devoted to personnel (it does not include tenured teachers' salaries, as explained above, but only resources for paying untenured teachers – those whose contract is shorter than an entire scholastic year – and supplementary services provided by tenured teachers) and one devoted to operations. Finally, the fund for the empowerment of the educational supply follows the priorities defined by the Ministry of Education year by year. Normally, they deal with teachers' training, improvement of schools' performance, sustaining disabled students, lifelong learning projects and schools' evaluation. In 2008, this fund's amount was around 180 millions €, while the fund devoted to personnel and that for operations were about 2.3 billions and 900 millions €, respectively (authors' elaborations on data provided by the Ministry of Education).

3 Previous literature

The literature about educational standard costs stems mainly from US researchers: such concentration is due to the policy relevance of the problem to allocate adequate resources across heterogeneous school districts. In the words of Baker (2006, p.171), "(…) these studies have been held up as a gold standard that should necessarily guide legislative school finance policy design". There are several methods to compute the average and adequate costs to provide educational services: average expenditures, studies of necessary resources, and statistical models of education production and cost (Taylor et al., 2005). Here, we only refer to statistical models, and especially to the estimation of cost functions, because this is the approach used in this paper.

Most of previous contributions aimed at determining the cost for providing adequate educational standards in specific US states or school districts. Duncombe and Yinger (2000, p.366) estimated a cost equation for the 709 New York state school districts, and use cost indexes reflecting "(…) how much a district must spend to achieve the same performance as a district with average cost". Reschovsky and Imazeki (2003) estimated a cost function for the primary and secondary school districts in Texas, and found that differences across districts are large; Duncombe et al. (2004) estimated the per-pupil cost of a 'sound basic education' (defined as the level to which educational activity can help students to reach a minimal performance) in New York city. Dodson and Garnett (2004) focused on Arkansas, while Imazeki (2008) worked on the costs for adequacy for school districts in California.

Costrell et al. (2008) criticised the use of the cost function approach to determine 'adequate' costs for education. The core of their concerns focuses on that experience demonstrates that is hard to find any relevant relationship between schools' expenditures and students' performances. Moreover, actual spending levels cannot be assumed to reflect actual costs, given the potential presence of inefficiency in production. Lastly, there are some econometric problems with estimations (i.e., sensitivity to selection, omitted variables bias, etc.) that make them likely to be unreliable in many cases. All the critics formulated by Costrell et al. (2008) are reasonable, and raise points of attention, many of which are discussed in this paper, in the section devoted to methodology. Therefore, the use of cost functions remains one of the key method that can be used for facing the practical problem of determining average and 'standard' costs.

Today, in Italy there is not a specific literature about the estimation of standard costs per student in primary and secondary schools. Given the highly centralised nature of the

Italian educational system (where the Ministry of Education hires a given number of teachers, and then allocate them to specific geographical and schools), the main problem addressed by researchers has been the model that the central government should use to provide a 'fair' amount of resources (teachers) to each region, based on the observable characteristics of their schools (see Fontana, 2008; Biagi and Fontana, 2008). A contribution that departs from this tradition is that of Di Giacomo et al. (2012), who estimate a direct cost function about a sample of about 1,000 Italian public primary schools; in this sense, it shares similarities with the present paper as it assumes the schools as units of analysis instead of the region, municipality or province. Their work uses expenditure per student as dependent variable, and some school-level quantitative characteristics as explanatory variables; the findings show that most schools should receive more money to deliver their services – in other words, the estimated standard cost is higher than observed expenditure levels for the most part of the schools in the sample. Despite some points in common, our study differs under many aspects. First, we focus only on one region; this way the empirical analysis can ignore many factors related to structural differences across regions, which influence costs, and so there is less risk of omitted variables. At the same time, the methodology that we propose can be extended to other regions, one by one. If the policy makers are interested to apply the method to a group of different regions simultaneously, the proposed methodology can accommodate the presence of region-specific fixed effects that can take into account structural differences across regions. Second, Di Giacomo et al. (2012) did not control for the efficiency of schools, so they indirectly assume that schools operate at their best of productivity: a strong assumption indeed, and we include a measurement of efficiency to relax it. Third, the most important difference is that the authors deliberately excluded the role of educational quality; instead, we include measures of performance, as measured by school-level scores in a standardised national test (subjects: math and reading); this way, we are able to analyse the relationship between unit costs and performance levels.

Notably, none of the other Italian papers includes measures of educational quality, and all of them consider just the relationship between costs (expenditures) and quantitative variables (like the number of students, the proportion of disabled students, etc.). Thus, our paper innovates the previous Italian literature in this field in two ways: by focusing the attention to each school's standard cost of provision, and by making explicit use of cost functions to model the schools' expenditures.

4 Methodology and data

4.1 Methodology

The first methodological challenge is to choose a functional form for the cost function to be specified. In facing this choice, we first refer to the literature, in which the proposed functions are usually log-linear (as in Imazeki, 2008) or translog (as in Gronberg et al., 2012). Then, we consider the methodological literature, which discusses the best functional forms of cost functions according to the *desiderata* for their flexibility (Johnes, 2004). At the end of this analysis, we opted for a simple log-linear specification, that is less flexible in modelling the relationships between costs and inputs/outputs, but much easier to be interpreted (as it has not the interactions and quadratic terms)[2]. Thus, in this paper, a school cost function is constructed as follows:

$$C_j = \alpha_0 + \alpha_1 Q_j + \alpha_2 I_j \left(P_j\right) + \alpha_3 Z_j + \alpha_4 S_j + \varepsilon_j \tag{1}$$

where C is the spending per pupil[3] in the school j; Q is a vector of student test scores (and it can contain also other performance measures); I is a vector of inputs (for instance, the number of teachers or of students, etc.); P is the input price (mainly staff and teachers' salaries); Z includes other control variables; S is the share of students with particular characteristics i (such as disabled, immigrants) in the school j. While (1) is a general formulation of the cost function – consistent with the existent literature in this field – we then adjusted its concrete formulation, on the basis of some assumptions and specificities described in the next paragraph, with the aim of better describing the characteristics of the Italian educational system.

The j^{th} school's spending per pupil (C_j) incorporates

1 the resources provided by the Ministry of Education

2 the autonomous expenditure(as computed through its balance sheet)[4].

The school's achievement level (Q_j) is proxied by the scores from a standardised test administered by INVALSI (reading and math)[5]. We then decided to do not include input prices in the formulation of (1); as input prices are constant across the region (because teachers' salaries are regulated and paid by the Ministry of Education, and buildings and facilities provided by other public agencies) we do not consider inputs' prices differences, and P_j has been dropped from (1) – the only variation in salary is related to teachers' age, but data about these different age-specific distributions for each school are, unfortunately, not available in our dataset. As a proxy for inputs I_j, we use the number of students[6]. The vector Z_j controls for school size (both its value and square), and the location of the school in the metropolitan area of Milan. As special category students (vector C_j) we considered disabled, immigrants and rejected students (the latter are those who repeated one or more grades).

We included in the model a measure of schools' efficiency, which is important in explaining cost/expenditure differentials. Efficiency scores have been obtained through a non-parametric technique called data envelopment analysis (DEA), where students:teachers ratio and other expenditures are the two inputs, and the scores from INVALSI standardised test is the output (details in Agasisti et al., 2014).

The choice of inserting a measure of efficiency is well-supported by the literature about educational cost functions (see, for instance, Reschovsky and Imazeki, 2003; Ruggiero, 2007; Imazeki, 2008), even though not all previous studies using this approach at school level explicitly take this issue into account. Some details about the efficiency scores used here are necessary and useful. First, these scores range between 0 and 1, where 1 is the maximum level of efficiency observed in the sample. The efficiency scores are 'unadjusted', in the sense that they consider the different weights for socially disadvantaged students, but not the specific effects related to disabled or immigrants status – this is not a major problem, because these factors are independently captured in the formulation of the cost function as specified in (1).

The list of variables employed in the study, to estimate standard costs for each school, is the following:

- *Expend_perstudent* [dependent variable], that is the expenditure per student of each school. This variable is built as an estimate that we performed under some assumptions (details available from authors), as it is not a directly observable information (schools' balance sheets do not include teachers' salaries, which are paid directly by the Ministry of Education). Our variable includes teachers' salaries and other expenses such as curricular and extracurricular projects, short-term teachers' duties, etc.

- *Reading_Score* and *Math_Score*, the school-level score in standardised tests administered by INVALSI in reading and mathematics[7, 8].
- *Milan*, a dummy variable for the schools located in the metropolitan area of Milan.
- *%Rejected*, that is the proportion of students who were rejected in previous years – they must repeat the grade (the proportion of rejected students in almost zero in most schools at primary level).
- *%Disabled*, the proportion of students who have a certified disability (physical or mental).
- *%Immigrants*, students who are not Italian citizens (we did not separate between first-generation and second-generation immigrants).
- *Efficiency_Reading* and *Efficiency_Math*, which are efficiency scores for each school, derived through a non-parametric technique called Bootstrap DEA. In the models used for calculating efficiency scores, inputs are expenditures, staff and students' socioeconomic background (which is ESCS and described below), and outputs are *Reading_Score* and *Math_Score* [see Agasisti and Sibiano (2013) for details].
- *Students_perschool*: the number of students of each school; it enters the cost equation also with its square.
- *ESCS*, an indicator about the economic, social and cultural status of the students; it is built according to the OECD definition (i.e., by considering educational levels of parents, together with information about home possessions) (see Campodifiori et al., 2010). This indicator is built, by construction, to have mean = 0 and variance = 1. Therefore, this variable was not included in the empirical analysis as it is collinear with other variables (especially the average school's score in tests, and proportion of immigrant students) and did not add relevant statistical power to the cost model[9]. The reason for why this indicator does not gain statistically significance is that we included the test scores in the cost function; given the high correlation between the scores and ESCS, the effect of the latter variable is captured by the former. In this perspective, an important use of this variable, instead, was related to a robustness check. Some previous contributes suggested that analysing the relationship between costs and performances within a cost function framework can be affected by endogeneity (for instance, Dodson and Garrett, 2004), as they could be determined simultaneously, if the socioeconomic background of the school's students impact both its performances and costs. To check for this eventuality, we performed a IV approach where using ESCS as an instrument for *Reading_Score* and *Math_Score* [results available from authors and reported in Agasisti and Sibiano (2013)].
- *Teachers_perschool*: it is the number of teachers in each school. It includes both tenured teachers (who are civil servants) and untenured teachers (only long-term

ones, those with one-year contract); the latter represent around 16% of the total (this proportion is higher than the national average).

Once this regression is performed, the impact of any variable and the predicted spending per pupil of any school is obtained. Hence, the second step computes the 'standard cost' and the 'cost of adequacy'. We can obtain the standard cost, which is how much any school should spend per pupil given their characteristics and performance, by replacing the values of the variable of any school *j* in the equation with the coefficients provided by the regression (this is the predicted value of the per unit cost, $\hat{C}$). The cost of adequacy is obtained through the same method apart from the value of student's performance; in this case the value considered as the minimal ('adequate') is replaced in the equation, so that the value we obtain means how much any school should spend per pupil to make the students achieve a certain score, given the characteristics of the schools.

4.2 Data

The original datasets were provided by INVALSI, one containing student-level information and the other school-level variables (reference year: 2009/10) and refer to all primary schools in Lombardy. The two datasets were merged, and the latter was used to create the performance at school level, by computing the mean of students' achievements for any school; thus, the resulting dataset was collapsed in a school-level dataset. A procedure for cleaning the resulting dataset has been undertaken; out of the about 1,100 primary schools in Lombardy, 197 schools had missing value in almost all variables, and others have missing data on some crucial variables as well; moreover, all the about 250 private schools were dropped, since they do not report data about expenditure; finally, we detected some outliers (i.e., schools with implausible values on some variables, probably due to errors in data imputation). At the end, the sample used in this paper contains data for 587 primary schools. Pre and post-cleaning groups of schools did not show statistical differences in the distribution of observable characteristics (descriptive statistics available from authors).

Before going into details about the cost function, we report two of the main sources of the cost differentials, namely the number of students per class and per teacher (the two numbers are different because more teachers are assigned to a single class). The statistics reveal that, on average, there are around 20 students per class, and ten students per teacher (in other words, there are on average two teachers assigned to each class). However, big variation does exist, as the numbers range between [9; 25] (students per class) and [6; 13] (students per teachers). Such differences can be justified on the basis of observable characteristics of the school (these are the dimensions included in the cost function), or can be due to inefficient allocation of resources, which reflects on inefficient expenditure. The empirical analysis aims at disentangling these two factors, to compute (efficient) standard costs.

Table 1 reports descriptive statistics about the variables (see previous section) for the schools in our sample. Lombardy primary schools differ both in terms of size (the number of students ranges between 90 and 1,300, with a mean of 516 and a pretty high standard deviation, about 180) and performance (achievement scores range between 31/100 and 81/100, with a mean of 62 and 68 for reading and mathematics, respectively). Expenditure per student is around 4,500€, with a standard deviation of around 680€ and a range between [2,800€; 7,100€][10].

Table 1 Lombardy primary schools: descriptive statistics (2009/10)

Variable	*Obs*	*Mean*	*Std. dev.*	*Min*	*Max*
Reading_Score[1]	587	68.66	4.69	43.51	81.01
Math_Score[1]	587	62.76	4.87	46.62	78.93
ESCS[2]	587	–0.04	0.32	–0.76	1.43
Expenditure_perstudent[3]	587	4,550.09	683.31	2,875.79	7,154.42
Teachers_Stud	587	0.11	0.01	0.07	0.16
%Immigrants	587	0.14	0.08	0.01	0.63
%Disabled	587	0.03	0.01	0.00	0.09
%Rejected[4]	587	0.00	0.00	0.00	0.03
Efficiency_Reading[5]	587	0.85	0.06	0.53	0.99
Efficiency_Math[5]	587	0.80	0.06	0.59	0.99
Teachers_perschool	587	53.77	18.69	9.00	121.00
Students_perschool	587	516.60	186.18	93.00	1,338.00
Milan[6]	587	40%			

Notes: [1]Reading and math scores are average-school test scores obtained in the 2009/10 edition of INVALSI standardised tests. The scores are net of estimated 'cheating' effects, following the procedure described in INVALSI (2009).

[2]ESCS is an indicator about the 'economic, social and cultural status' (Campodifiori et al., 2010); by construction, it has a mean = 0 and variance = 1 (computed at national level).

[3]This variable includes an estimate of the teachers' salaries plus all the other expenditures sustained by the school in the year 2009/10 (see section 'Data' for details).

[4]Proportion of students (expressed in %) who were rejected, and then repeated one or more years; the number is really low as it is very rare that a student is rejected during the primary schooling.

[5]Efficiency scores are derived through a bootstrapped version of a non-parametric technique called DEA (details in Agasisti et al., 2014). The production process is modelled by considering the expenditure and the number of teachers as inputs, and *Reading_Score* and *Math_Score* as outputs, respectively.

[6]Milan is a dummy variable equal to 1 if the school is located in the Milan metropolitan area.

5 Results

5.1 Standard costs estimates and costs for adequacy

Table 2 reports the results of the regressions, for two alternative models, in which the measures for schools' quality are *Reading_Score* and *Math_Score*, respectively. We opted for two separate models, instead of a unifying one including both *Reading_Score* and *Math_Score* to avoid problems of collinearity between them. Our post-estimation statistics illustrates how the STs defined under the two competing models are highly correlated.

Table 2 Cost function estimates: results from the log-linear regression

	Reading b/t	*Math* b/t
ln(*Students_perschool*)	–0.556*	–0.619**
	(–2.33)	(–3.14)
ln(*Students_perschool*)^2	0.033	0.040*
	(1.68)	(2.44)
Milan	0.072***	0.031***
	(7.12)	(3.62)
%Rejected	0.348	0.247
	(0.27)	(0.23)
%Disabled	3.540***	1.768***
	(7.75)	(4.51)
%Immigrants	0.143*	0.187***
	(2.21)	(3.59)
ln(*Reading_Score*)	2.681***	
	(6.2)	
Efficiency_Reading	–3.409***	
	(–6.36)	
ln(*Math_Score*)		6.329***
		(18.17)
Efficiency_Math		–7.875***
		(–18.06)
Constant	1.985	–9.257***
	(1.3)	(–7.56)
Observations	587	587
R^2	0.417	0.603
F-statistic	51.58	109.577

Notes: The dependent variables is ln(*Expend_perstudent*). t-statistic in brackets.
*10%, **5%, and ***1% statistical significance.
All the elaborations are obtained through Stata12© statistical package.

All the variables are statistically significant, with the exception of the proportion of rejected students. Economies of scale are present (as the negative coefficient for *lnStudents_perschool* shows), but are exhausted at a certain level, as the coefficient for the squared variable is positive (albeit statistically significant only in the model with *Math_score*). The proportion of disabled students and immigrants shows clear positive coefficients, confirming that educating these students is more costly (an increase of 1% of these students is associated with higher costs of around 120€ per student)[11], as previous literature already revealed. Most specifically, the positive coefficient for *%Disabled* is explainable by the necessity to employ teachers specifically devoted to these students (*insegnanti di sostegno*), while *%Immigrants* is positive possibly because schools tend to organise smaller classes when the proportion of immigrant students is high (albeit, in our dataset, the statistical correlation between the proportion of immigrant students and the teachers:students ratio – a proxy for the class size – is quite low). This is not the only explanation for the effect of *%Immigrants*, thus. Another potential source of correlation between this variable and higher costs can be the correlation with another (omitted) phenomenon, for instance students' ESCS (so, as these students are poorer, schools invest more resources to compensate lower levels of resources at home); or, it can be that higher costs are related to the necessity of realising additional activities (such as language courses, or cultural initiatives) to better integrate this students in the school climate and society. Again, more resources can be related to the fact that these students could be concentrated in areas where living costs are higher, too – and this could be reflected in schools' budgets. Unfortunately, the available data do not allow us to explore more in detail these potential mechanisms; but the results is however interesting per se, as it sheds lights on an important source of higher spending for schools, related to the proportion of immigrants that they host.

Schools located in the Milan metropolitan area face higher costs (around 130€ per student), probably owing to the higher expenditures for ancillary didactic and extracurricular activities. Technical efficiency is negatively related to costs, suggesting that better management helps in reducing per-student costs. The coefficients attached to students' achievement (*Reading_Score* and *Math_Score*) are high and statistical significant, suggesting that higher levels of spending are associated with better academic results. On the basis of the coefficients of the cost equations, raising the average score of a school of one point costs approximately 189€ or 495€ per student, Reading and Math respectively; the larger costs associated with the latter are due to the lower average achievement in this subject. In other terms, the marginal costs associated to an increase of one point in educational standards range between 4% and 10% of the average standard cost per student. The estimated coefficients are similar for the efficiency scores; they can be interpreted as raising the efficiency score of 0.05 (in a scale [0; 1]) implies savings which are equal to increase the test score of one point.

In Table 3, we report synthetic statistics about the average 'standard cost' computed for Lombardy schools (panel A), and the same statistics for 'cost of adequacy' (panel B) when achievement level is set at 81 and 70 for *Reading_Score* and *Math_Score*, respectively. These values were chosen because they represent the highest observed level of performance (at school level) in our sample (more precisely, at 99th percentile), so they can be interpreted as upper-bound estimations of costs for adequacy[12].

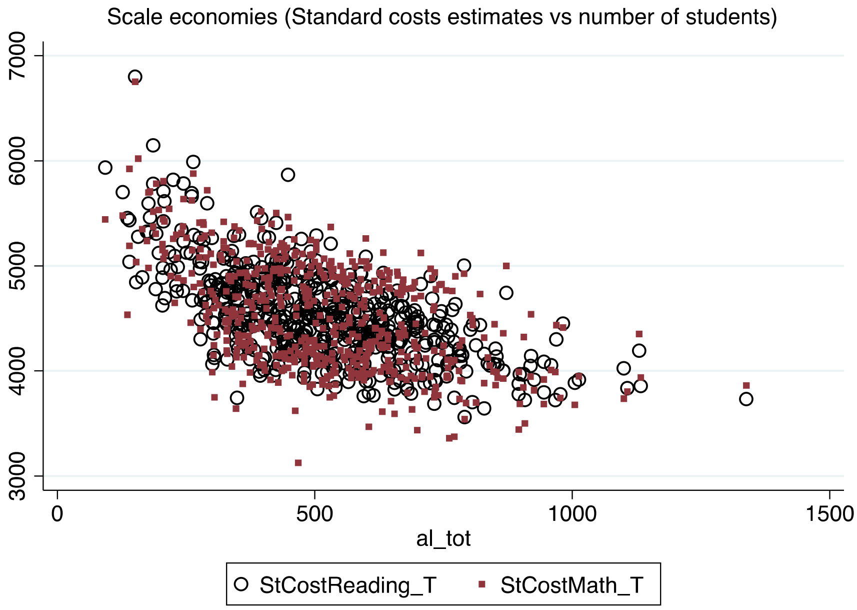
Table 3 Standard and adequacy costs' estimates, descriptive statistics

	Mean	*Std. dev.*	*Min*	*Max*
Expenditure per student	4,550	683	2,876	7,154
Panel A				
Standard_Cost_Reading[1]	4,522	435	3,561	6,799
Standard_Cost_Math[1]	4,530	513	3,125	6,751
Panel B				
Adequacy_Cost_Reading[2]	6,996	1,764	4,036	18,601
Adequacy_Cost_Math[2]	10,533	6,089	2,058	58,070

Notes: [1]*Standard_Cost_Reading* and *Standard_Cost_Math* are calculated by substituting estimated coefficients from the cost function (see Table 2).
[2]*Adequacy_Cost_Reading* is calculated by imposing *Reading_Score* = 81; *Adequacy_Cost_Math* is calculated by imposing *Math_Score* = 70.

The results suggest that standard costs estimates are similar when considering *Reading_Score* or *Math_Score* as educational output, and are about 4,500 € per student. Such estimates are quite close to the present expenditure level: this is not surprisingly, as estimating standard costs does not necessarily imply to reduce the overall spending, but to redistribute the spending across schools in a more efficient (that is, cost-minimising) way. Standard deviation of estimates standard costs is quite low (around 500€), and lower than observed standard deviation of expenditures per student (which is around 680€), suggesting that present costs' differences between schools should be slightly reduced to improve spending efficiency. The estimates of standard costs maintain the property of scale effects, as they are negatively related to the schools' size (Figure 1). The distribution of standard cost estimates is different if considering Reading or Math as educational output; while the latter follows a normal distribution, the former presents two peaks above and below the mean (around 4,000 and 5,000 € per student).The distribution is virtually censored at 6,000€ per student, with only few schools with an estimated standard cost over this value. The standard cost estimates are quite similar when considering *Reading_Score* or *Math_Score* as educational output, so cross-checking the robustness of the results – no matter which variable is chosen as a proxy for the educational results.

Figure 1 Scale economies: the relationship between standard cost estimates and school size (number of students)



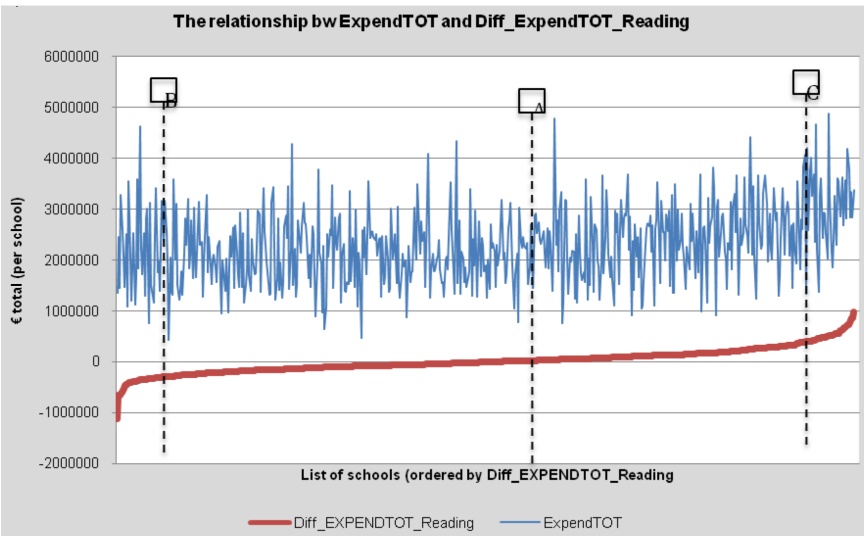
On the other side, adequacy costs estimates are higher (panel B), from around 7,000€ to over 10,000€ per student when considering *Reading_Score* and *Math_Score* as educational output, respectively. Standard deviation is big, suggesting that differences between schools in terms of costs should be quite high, particularly because of the present performance levels (with low-performing schools – well below the 'adequate' level of performance set for the simulations), which requires much higher costs to reach adequacy. Such estimates are likely to provide only theoretical ideas about the required cost levels, as the real ability of such schools to reach high performance levels is questionable – at least in the short run. In this perspective, Costrell et al. (2008) provided critics about the ability of cost function approaches in providing reliable information about the desirable and necessary amount of money to be spent by each school.

5.2 Potential consequences for reallocating expenditures across schools

In this section, we illustrate the potential effects of applying a funding method that is based on schools' standard costs (second research question); in other words, we are assuming that each school should receive a lump-sum budget based on the estimated standard cost.

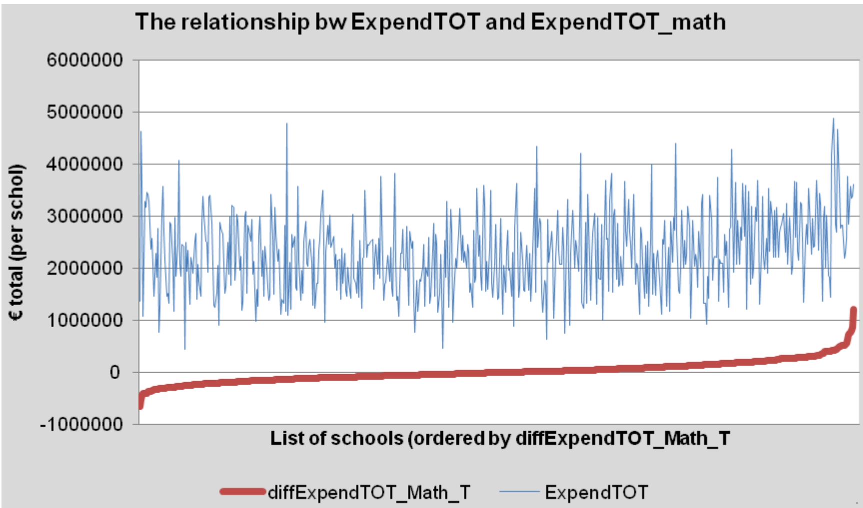
For sake of clarity, we computed the difference between expenditure per student and standard cost estimates. Such calculation has been based on the total costs (not 'per student' basis), and we named the resulting variable *Diff_expend_TOT*. Figure 2 plots the value of the variable for each school: the red line is *Diff_Expend_TOT*, while the blue line is the observed (total) expenditure. By selecting a single school, the graph provides evidence about the impact of the potential reallocation of resources. For instance, let is consider the school A in the panel A; for this school, the standard cost estimate is practically equal to its observed expenditure, so that it should receive an amount of money equal to the current spending level. Instead, the school B spends less than its standard cost potential, so it should receive around 200,000€ (that can be added to the current spending level, around 200,000€). The contrary holds for the school C, which should reduce its expenditure (as the difference between actual and standard expenditure is positive).

Figure 2 The difference between expenditure per student and standard cost estimates, total cost (unit cost * number of students), (a) panel A: reading (b) panel B: math



(a)

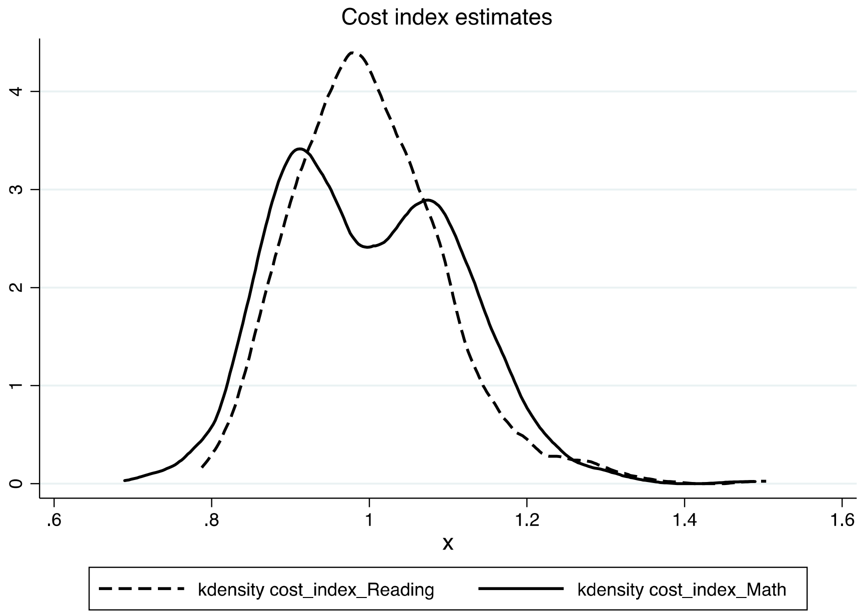
Figure 2 The difference between expenditure per student and standard cost estimates, total cost (unit cost * number of students), (a) panel A: reading (b) panel B: math (continued)



(b)

A way to represent the results in a simple manner, that can be clear to policy-makers, is to derive cost indexes. We used the definition suggested by Reschovsky and Imazeki (2003, p.276): "(…) how much [a school] must spend, *relative to the [school] with average costs*, for its students to meet the state's performance standards". To follow this definition, we used our estimated schools' standard costs, and divided them by the average standard cost observed in the sample (4,521€ and 4,532€ for models with *Reading_Score* and *Math_Score*, respectively). The resulting cost indexes range around a mean = 1, and can be interpreted as the amount of resources that each school should spend more/less. For instance, if a school has a cost index = 1.21, it should spend 1.21 times with respect to the current spending; if it is 0.78, it should reduce the spending and reach a point equal to 0.78 of the current level. The distribution of cost indexes is reported in Figure 3; the numbers below the figure show the proportion of schools that are in the percentiles of the cost index's distribution. Overall, the results illustrate that, in the most part of distribution (between 25th and 75th percentiles), the cost indexes range between [0.93; 1.06] and [0.91; 1.08] – standard costs for reading and math, respectively. As expected, the distributions of cost indexes mirror those of standard costs.

Figure 3 Cost indexes' distributions



Notes: Cost index is defined as "how much [a school] must spend, relative to the [school] with average costs, for its students to meet the state's performance standards". We used standard costs for computations, and the averages used are those reported in the table 3 (€ 4,521 and € 4,532 for models with *Reading_Score* and *Math_Score*, respectively).

Percentiles	*Models w/ Reading_Score*	*Models w/ Math_Score*
1%	0.82	0.77
5%	0.86	0.84
10%	0.88	0.87
25%	0.93	0.91
50%	0.99	0.99
75%	1.06	1.09
90%	1.12	1.15
95%	1.17	1.19
99%	1.29	1.28
Mean	1.00	1.00

6 Discussion and concluding remarks

This paper contributes to the institutional debate in Italy about the definition of standard costs for public organisations, with the aim of raising efficiency of public provision in the context of the ongoing decentralisation: such issue is of strategic relevance given the evidence about large differences in terms of efficiency, productivity and performances of public organisations in the different Italian regions. In this perspective, the case of educational public spending is of primary importance, as it absorbs about 4.5% of the GDP every year.

In this paper, we focus on a model to calculate standard costs (ST) for a sample of 587 public primary schools in an Italian region; our approach relies on the statistical estimation of cost functions. The ability of determining ST can be essential in a policy perspective as they can be used as a benchmark to assess misallocation of resources and as guideline to improve performance and productivity. Our paper is one of the first empirical contributions that proposes a practical method to estimate the unit standard costs of providing primary education; and this is the first that explicitly takes quality of educational results into account.

The results show that controlling for current performance levels, schools spend more to educate disabled and immigrant students. This finding has a lot of potential consequences especially in a managerial and policy making perspective. Looking at managerial aspects, school principals and governing bodies must be aware of the effects of having immigrant or disabled students in school's classes; in addition to providing them specific educational attentions, they also require additional investments for keeping at the pace of other students. The equality of educational opportunities, in this sense, also passes through practical choices such as how many resources investing for these students, for which activities, how to build classes, etc. Turning to the policy implications, it is evident that a fair system for allocating public resources across schools must consider also the composition of schools' population of students, and not only how numerous they are; the Italian educational system is still far from this way of regulating public funding to schools.

Also, the estimates suggest that substantial scale economies exist and explain part of expenditure differentials. This finding could support recent legislative initiatives which aim is to reduce the (high) number of schools and consolidate them into larger institutions. Our study did not target specifically the question about the optimal size of schools. This topic is very interesting under a research profile, and future research is needed in this area; it must be acknowledged, however, that the size of schools could be also affected by reasons others than economic optimality (for instance, dislocation in rural areas). Such considerations are likely to be stronger in the case of primary education; thus, the empirical research about optimal size should also adequately consider these additional determinants of schools' dimensions.

Higher levels of performance are associated with higher costs, while efficiency (defined in a technical sense, i.e., the ratio of input transformation into outputs) helps in reducing per unit costs. This result, albeit quite intuitive, raises a further point about the importance of improving students' performances. Raising the quality of students' educational skills and competences is not only useful for making them better citizens in the new knowledge societies; this is also the way through which our educational system can be more sustainable in the next decades. If efficiency in educational provision is not reached (i.e., more money must be spent for maintaining the same level of educational achievement), then the unit costs are condemned to increase as well – and, giving that primary education is funded though public money, and public budgets are tightening over time, this means that our educational system will become financially unsustainable.

One of the main interesting points is that, despite an average high level of efficiency, many schools operate at a cost that is different from their (theoretical) standard. A possible way of making the regional educational more efficient and equal is to redistribute resources (human and financial) across schools; the paper illustrates potential ways to do that, and calculates cost indexes that show how resources themselves should be reallocated. Overall, the reallocations seem not require dramatic changes, but just optimisation at the margin. Such operation assumes that other variables are unchanged (for instance, the educational quality of each school); however, this can be another aspect of interest – deriving results assuming the ability to improve performance through different cost levels. Thus, on the basis of estimated coefficients of the cost function, we simulated the costs necessary for improving performance at the highest (observed) level, and they come out as very (maybe implausibly) high; however, increasing efficiency through more effective educational practices can act in containing per unit costs (see the discussion above about improving schools' efficiency).

All these results are stable after several robustness checks that we performed with different hypotheses, models and assumptions. Nevertheless, we are aware of some drawbacks. We have data about just a cross-section of one year (2009/10), and this implies potential measurement errors. The use of standard cost functions – which include a random noise component – reduces the impact of such eventuality, but cannot solve the problem completely. Also, the measure of educational 'quality' is based on the scores in a standardised academic test in a single year, thus is subject to year-by-year fluctuations. In the next future, longer datasets can led to panel-data estimates and make the analyses more robust.

This paper has a number of policy implications. First, it provides evidence of the positive correlation between performance (as measured through the INVALSI standardised tests) and costs, at school level. An extensive literature pointed at demonstrating a lack of positive effects of resources on achievement results (Hanushek, 1989); however, the (also wide) literature about cost functions suggests quite the contrary (Duncombe and Yinger, 2011). This study did not address this issue directly, as the research question is not testing whether schools that spend more also obtain higher performance; therefore, the empirical analysis shows that, conditioning on other schools' characteristics, higher levels of performance are associated with higher unit costs. This result contrasts one finding of Di Giacomo et al. (2012): the authors, by means of a factor analysis, found that average school performance is not correlated with per unit expenditures. However, they did not include performances directly in the cost equation (that is instead our approach), so methodological differences are so profound that they prevent a straightforward comparison of these results.

Second, the results also suggest that many schools operate at a cost that is not equal to the 'standard' one, given their characteristics. An interesting question should be to understand which factors are behind this misalignment. A potential explanation is that the bureaucratic and centralised process to determine the number of teachers per school led to an inefficient allocation of them across schools. If it is the case, a potential solution is giving the schools more power to decide their size and the number of necessary teachers; through such autonomy, they can choose the best combination of input factors to educate their student population to reach the highest possible performance. In this scenario, schools should receive a lump-sum budget and be free to hire their teachers, contracting their number and (at least in part) their salaries. An alternative story is that are there other factors explaining cost differentials, which are not captured adequately by the cost function model used in this study (for instance: the geographical conformation of the territory in which the schools operate, structural differences between schools in the teachers' average age – that can influence overall salaries –, etc.). In this case, the model should be corrected according to these factors. The available data does not allow investigating these topics more, and this limitation requires developing better and more complete datasets for future research.

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Notes

1 The literature about the evaluation of performance and efficiency in the specific case of education is ancient as well, see for example, Färe et al. (1989).

2 As we explain later, we also used a translog specification as a robustness check (and also a translog with the scores in reading and mathematics simultaneously): the results are almost identical. The interested reader can refer to Agasisti and Sibiano (2013), the working paper version of the paper available in SSRN.

3 As spending can incorporate inefficiency, it cannot be considered a proper 'cost' as defined in the standard microeconomic context (cost-minimisation behaviour); nevertheless, we control for inefficiency to reduce the bias as much as possible.

4 In Italy, there are not reliable data about the expenditure at school-level. The main reason for this lack of information is that the salaries of teachers, which absorb around 90% of overall educational expenditure, are not paid by the single schools but by the Ministry of Treasury directly. As a consequence, the balance sheets of the schools report only other expenses, and more specifically those for projects and for short-term untenured teachers (the salaries on long-term untenured teachers [one-year contracts] are again paid by the Ministry of Treasury). For deriving an indicator about the expenditure per student for each school in our sample, we then made some assumptions, described in the Annex of Agasisti and Sibiano (2013).

5 With the aim of checking the potential endogeneity of this variable, we performed a robustness test conducted through an instrumental variables (IV) approach, and we show that the results are unchanged (available from authors).

6 However, as a robustness check we also estimated an alternative cost function by using the number of teachers, and the results are virtually unchanged [see the Annex in Agasisti and Sibiano (2013)]. The main idea is that using the number of students or teachers is almost the same – the two variables are highly correlated – and indeed this is the case. The number of students is here preferred as the number of teachers is sometimes affected by classification problems (for instance how counting part-time or supporting teachers).

7 Raw test scores are quite unreliable as they were affected by a massive cheating phenomenon, because the test is administered without external examiners and schools tend to adopt opportunistic behaviours (for instance, teachers suggest the right answers to the students. As a consequence, the resulting scores were not reliable). This problem has been almost completely solved by INVALSI, which developed a statistical-based method to correct the 'raw' scores, using information about average scores obtained in school-administered exams and data about the variance within and across classes to obtain 'cheating-corrected' test scores (INVALSI, 2009). In this paper we used these more reliable 'corrected' scores.

8 While a measure that combines reading and math scores together would be preferable in theory, it is difficult on a practical ground to define it. INVALSI does not realise any synthesis of the two scores, so we prefer to maintain the distinction between them. In a robustness check, we include both in the same cost function, and the results are virtually identical.

9 Indeed, the pairwise correlation of ESCS with both the test scores is >0.35 and statistically significant at the conventional 1% level.

10 These figures are slightly higher than those exposed by Di Giacomo et al. (2012) for the Lombardy schools (that came out as around 4,000€). However, the authors themselves admit that their measure can be underestimated, as it did not include expenditures related to specific revenues obtained by local authorities; as our variable is built through schools' balance sheets, the latter are included and the average expenditure is higher accordingly.

11 This estimate is completely coherent with that provided by Di Giacomo et al. (2012), who reported an average incremental cost of 121€ per student when increasing the proportion of disabled students of 1%. Other direct comparisons of coefficients are prevented, as the variables included in the cost equations are different.

12 In the Annex in Agasisti and Sibiano (2013), we report some simulations of adequacy costs based on different levels of *Reading_Score* and *Math_Score*.