Local governments' efficiency and educational results: empirical evidence from Italian primary schools

Ferraro, Simona and Agasisti, Tommaso and Porcelli, Francesco and Soncin, Mara

Tallinn University of Technology, Politecnico Milano, Centre for Competitive Advantage in the Global Economy (University of Warwick), Politecnico Milano

26 February 2020

Local governments' efficiency and educational results: empirical evidence from Italian primary schools[1]

Simona Ferraro[**]
Tallinn University of Technology, Tallinn, Estonia

Tommaso Agasisti
Politecnico di Milano School of Management, Milan, Italy

Francesco Porcelli
Centre for Competitive Advantage in the Global Economy (University of Warwick), UK and SOSE Soluzioni per il Sistema Economico S.p.a., Rome, Italy

Mara Soncin
Politecnico di Milano School of Management, Milan, Italy

Abstract: In Italy, the provision of educational ancillary services (like meals and school transportation) is in charge of the municipalities. We investigate whether municipalities differ in their efficiency when providing these services and whether such heterogeneity explains some portion of the variability observed in pupils' test scores. The paper is the first application of a nonparametric order-m model and a two-stage multilevel regression to a unique administrative dataset, made of the entire population of Italian pupils tested in reading and mathematics at grade 5 (academic years 2012/2013 and 2014/2015). Results demonstrate that local governments have different efficiency levels in providing services to schools. The test scores' variability among pupils, however, is not explained by different efficiency levels of local government in producing ancillary services.

JEL codes: I21, H52
Keywords: ancillary services, order-m, multilevel modelling, efficiency

[*] Authors would like to thank Kristof De Witte, Jill Johnes, Emmanuel Thanassoulis, Anna Mergoni for their useful advises and comments. The authors are grateful to INVALSI for having provided the original dataset, and Patrizia Falzetti for the statistical assistance in building the specific database used in this paper. Preliminary versions of this paper were presented at the 6th International Workshop on Efficiency in Education, Health and other Public Services, Hudderfield University (September 2018), at the III Seminario "I dati INVALSI: uno strumento per la ricerca", Bari (October 2018), at the Department of Economics and Finance seminar, Tallinn University of Technology, Tallinn (March 2019) and, at the Emerging Researchers' Conference, Hamburg University (September 2019). We are grateful to all participants for their comments and suggestions. All eventual errors are our solely responsibility.
[**] *Corresponding author:* Simona Ferraro, Tallinn University of Technology, Akadeemia tee 3-455, 12618 Tallinn, Estonia. Email: simona.ferraro@taltech.ee

1. Introduction

Educational institutions are responsible for providing complementary services also known as ancillary or peripheral services, beside the main core of educational services such as teaching staff, schools' books and teaching materials. The United Nations Organization for Education, Science and Culture, jointly with the Organization for Economic-Cooperation and Development (OECD) and Eurostat (UOE) so defined ancillary services: "services provided by educational institutions that are peripheral to the main educational mission, such as school meals and health services, boarding, halls of residence, and transportation to and from school" (OECD 2018). Recently, the effect of ancillary services on pupils' achievement and their role in determining the educational production function (EPF) have arisen debates given the amount of resources that many countries devote to them (Fig. A.1 Appendix A).

Developing reliable measures to investigate the effectiveness of ancillary services provided to pupils is, hence, central and critical for evaluating management practices and set up incentives, given the limited amount of resources available. Moreover, the government bodies in charge of providing these services may vary in their level of efficiency and this may in turn affect pupil's performance, to the extent to which the quality and quantity of these services are likely to have an impact of their educational experience.

In Italy, public schools at primary and lower secondary levels are in charge of delivering ancillary services as school meals and transport from and to school, receiving financial transfers from municipalities to fulfil this requirement. This has raised the need for a responsible and efficient use of resources, both by schools and municipalities. Widening the scope of school duties to include ancillary services, in addition to teaching activities, have a fundamental role in creating a more equitable school for all students, regardless their socio-economic status. In turn, this would affect students' ability to successfully pursue their studies and creating a favourable scenario for positive school attainment. If local governments differ in their efficiency for producing such ancillary services, then this might have an effect on the students' performance. The objective of this study is indeed to investigate whether the heterogeneous efficiency levels across municipalities in the provision of ancillary services have any effects on pupils' achievements.

Starting from the EPF proposed by Hanushek (1979), this research sheds a light in estimating the impact of some inputs – meals and transport to/from school - on the educational output measured by reading and mathematics pupils' scores in all the 15 Italian regions with ordinary statutes. This study employs a unique database provided by the National Institute for the Educational Evaluation of Instruction and Training (INVALSI), merged with information on expenditures for municipalities provided by SOSE (*Soluzioni per il Sistema Economico S.p.a.*). The paper applies the nonparametric technique order-m in the first stage to determine the efficiency of municipalities, considered as decision-making units (DMU). In a second stage, the efficiency scores are included as covariates in a multilevel model together with a set of environmental variables that characterize the surrounding socio-economic environment of the student,

in order to assess the relationship that these factors may have with student's achievement.

The study answers two research questions:

- *Is there variability of the efficiency level among municipalities in providing services to schools?*
- *Does the variability among municipalities' efficiency in producing ancillary services explain a portion of the variability across pupils' achievements?*

This article contributes to the literature in three innovative ways: (i) it is the first work to study the correlation between the spending on ancillary services (meals and transports jointly) on pupil's achievement; (ii) it is the first study that applies a partial frontier analysis, order-m to evaluate the efficiency of municipalities in providing ancillary services to schools and (iii) it combines for the first time, two different administrative database which, allow to have detailed information at student, school and municipality levels.

The paper relies upon the analysis by Porcelli (2015) who investigates how Italian local authorities spend efficiently their resources, transferred by regions with ordinary status on social care sector. Geographical differences and the variability of pupils' test score within the country, has been already investigated by Agasisti and Cordero-Ferrera (2013), Agasisti and Vittadini (2012) and Bratti et al. (2007). These previous studies provide an excellent backdrop for analysing the magnitude and the variability in the use of resources among Italian regions, as well as the impact on the variability of pupils' outcomes across regions. In our paper, we extend these previous analyses by moving the empirical estimation at a more precise municipal level. Although our study focuses on the Italian case, the extension of the analysis proposed here is relevant for the international reader. In particular, the analysis of local governments' heterogeneity (in efficiency) is common to various countries and contexts (see the literature review in section §2.3). Moreover, it is important to understand whether the spending on ancillary services have any correlation with the academic outputs, and Italy can be seen as an example to be tested in different settings.

The remainder of the paper is organised as follows. Section §2 summarizes the literature on resources and ancillary services while Section §3 provides the background of Italian educational system. Section §4 presents the methodology, Section §5 discusses data used in the empirical study while Section §6 reports and discusses the results. Section §7 concludes.

2. Resources, ancillary services and educational results – received literature

The analysis conducted in this paper has been informed by three main streams of the academic literature. First of all, it is important to understand the importance of ancillary services in affecting educational results, within the framework of the Educational Production Function (EPF; see Hanushek 1979). Second, the discussion about how

resources can have an impact on the performance of pupils has become an important topic of investigation and rises questions on whether more resources are correlated or not with better students' performance (Hanushek 1981). Third, given the role of local governments in Italy, in providing ancillary services to students, it is crucial to investigate how efficient local governments are in the production of public services which are under their responsibility.

2.1 Ancillary services and educational results

The literature regarding the effect of ancillary services on educational attainments is scarce. Several studies have investigated, separately, the impact of transports from and to school and, the effect of school meals on educational results reflecting on how inputs influence the output in an EPF framework, traditionally discussed since the Coleman's report (Hanushek 1997; Coleman et al. 1966). Studies on the impact of the use of transport from and to school on students' results are limited, presenting basic assumptions or proposing qualitative studies. The first study that discussed the effect of transport service on pupils' outcomes is by Lu and Tweeten (1973). Based on 27 school districts within Oklahoma State and using an Ordinary Least Squared (OLS) regression, the study concludes that there is a negative correlation between time spent on the bus and test scores. The work was re-analysed by Zoloth (1976), who criticised it due to the lack of an important predictor on pupils' score: the socio-economic background. The new results show that there is a non-significant impact on pupils' score. Other qualitative studies highlight the negative impact of the time spent on the bus on test scores compared to pupils' peers who do not use the public transport (Henderson 2009; Spence 2000; Zars 1998).

Scholars have studied with more interest the impact of the school meals on pupils' outcomes through an extensive literature with studies especially from the US and the UK, but also studies from other developed and developing countries. In the US, using a sample of California public schools (Anderson et al. 2017) and school districts in Virginia (Figlio and Winicki 2005) where the nutritional content of the meals at school was increased, these studies show that there is an improvement in students' achievement. The change in the nutritional content was also experimented in Greenwich (UK) and its effect was observed and summarized in the work by Belot and James (2011) and Ensaff et al. (2013) who showed that where schools offered healthier food, students performed better. A systematic review of studies made in the UK are summarized in the work by Ells et al. (2008) and proposes a further analysis and investigation given that literature is scarce and in part, inconclusive. In Denmark, for example, Sørensen et al. (2015) presentes results from a randomized-cluster trial among Danish pupils in primary schools concluding that there is no effect of the change in the nutritional content on pupils' mathematics score. The introduction and implementation of the School Breakfast Program in US has led to new studies that show a consensus regarding the positive effect of the program on pupils' scores that led to an increase in mathematics outcomes around 8 percent of a standard deviation (Frisvold 2015; Imberman and Kugler 2014; Leos-Urbel

et al. 2013; Kleinman et al. 2002). In an experiment in Kenya, Vermeersch and Kremer (2005) investigated the effects of subsidized school meals on several outputs including educational achievement. Their findings, however, show that despite providing school meals to pupils, the test score did not improve.

It is important to clarify, here, that the contributions mentioned in this section provide a partial ground for our work. Indeed, they substantially differ from our approach, as their focus is on specific nutrition interventions and not on the resources invested for providing the service to pupils – which is instead the main objective of this paper.

The main conclusion from the effect of the use of transports from and to school and of the provision of school meals on pupil achievement is mixed and, however, no study has investigated the combined effect of these services (or of the expenditure for these services) on test scores, which it is the goal of the present work. While we do not have data about the quality of meals and of transportation services, we can provide insights about the efficiency of expenditures for these two items and study its effects on students' achievement. Seen in this perspective, the present paper is better inserted into the stream of literature which explores the effects of expenditures on educational results, which is briefly surveyed in the next section §2.2.

2.2 School resources and educational results

The relationship between school resources and students' results has been investigated since the Coleman Report (Coleman et al. 1966). Despite decades of research and the increasing necessity of ensuring an efficient and effective allocation of school resources, the topic is still controversial (Hanushek 1981, 1989 1997; Hanushek and Luque 2003, Woessmann 2003; Gundlach et al. 2001). Hanushek (1997) describes three categories of educational resources whose relationship with students' output was investigated in the literature: (i) the real resources of the classroom, especially related to teachers' quantity and quality; (ii) financial resources and (iii) other resources, like school facilities. In his review of nearly 400 studies, he highlights that there is small evidence of positive effects on student performance, thus policies increasing school resources as such would bring limited impact. On a different note, a meta-analysis on 60 studies by Greenwald et al. (1996) concludes that "broad range of resources were positively related to pupil outcomes, with effect sizes large enough to suggest that moderate increases in spending may be associated with significant increases in achievement" (p. 361). Revisiting Hanushek's studies, Card and Krueger (1996) and Fuller and Clarke (1994) point out the existence of a positive relationship between school resources and student achievement.

By taking a long-term perspective, Jackson et al. (2016) analyse the relationship between the school finance reforms in the USA and the long-term outcomes of students, like educational attainments and earnings. By using an event study and an instrumental variable approach, they find that increasing school spending per student by 10% raises the long-term outcomes of pupils especially in low-income families, given that adult poverty reduces by 3.2 percent. Lafortune et al. (2018) investigate a post-1990 school

finance reform in the USA, showing that the increase in the amount of resources provided to the school translates into an increase in educational achievement.

It is worth to notice that the bulk of literature on the topic is USA-centred, while few studies run international comparisons. Among them, Woessman (2003) analyses and 260.000 students in 39 countries, and finds that differences in student performance are to be attributed to institutional differences more consistently than to differences in the amount of resources available. In closer connection to the current study, Heinesen (2004) analyses how local public school spending in Denmark is determined by community characteristics, given that school spending represents a considerable proportion of the local authority budgets. The study finds a set of variables significantly affecting the level of expenditure, like private income and indicators of the fraction of pupils from disadvantaged backgrounds. Though, the author acknowledges the lack of data about school quality, like student test scores, that would have enabled to investigate the relationship between the expenditure of local authorities for schools and the level of school quality. This is indeed the focus of the current paper, with a specific application to the expenditure for ancillary services.

2.3 The efficiency of local governments in Italy

Some existing literature analyses the efficiency of Italian local governments. This literature aims at understanding the differences in the ability of local governments in providing the services they are responsible for in an efficient manner. Moreover, these studies sometimes describe the factors associated with this efficiency. In the context of the present study, this literature is fundamental to explore whether the efficiency of local governments can be tested as a factor associated with lower/higher academic results of the students, given that the municipalities are responsible for providing the key ancillary services of interest. Within this substantial literature, we then selected some key papers about the differential efficiency of local governments.

Boetti et al. (2012) investigated how fiscal decentralization is associated with higher levels of efficiency, by considering around 260 municipalities in the area of Turin, in a single year (2005). The authors first measure the proportion of revenues from local taxes on total current revenues. Then they correlate this indicator with efficiency in providing a set of local public services. The results suggest that fiscal autonomy is associated with lower inefficient spending. Importantly, their analysis demonstrates a high heterogeneity in the level of municipalities' (in)efficiency.

Lo Storto (2013) studies the efficiency of 103 large municipalities for a single year (2011). The indicators selected for outputs are urban infrastructure, nursery schools, area extension, and resident population. The results point to demonstrate decreasing returns to scale – a very important finding in the light of the present paper. In a related work, Lo Storto (2016) better evaluates the cost efficiency of 108 major municipalities. The most relevant finding is the presence of a trade-off between efficiency and effectiveness, the latter being measured through some indicators of service quality.

Settimi et al. (2014) analyse the efficiency of local governments in providing one major service (General Register Office) in 2009. The results suggest that efficiency gains are not associated with managing the service in aggregation between municipalities, in search of the optimal size for delivering services. Also, the efficiency estimations are robust when using alternative measures and methods – in all cases, corroborating the evidence that the distribution of efficiency scores across local governments is very heterogeneous.

Agasisti et al. (2016) derive indicators of efficiency in producing essential public services for more than 300 municipalities in the Lombardy Region, for the years 2011-13. The findings reveal how some factors are indeed associated with efficiency – for example, the financial equilibrium, the structure of population by age, scale economies, etc. The findings strongly reveal that some municipalities are substantially more efficiency than others.

D'Inverno et al. (2018) focus on the efficiency of 282 municipalities in the Tuscany region, employing a non-parametric method and using data for a single year (2011). A set of five services has been considered as output of the local governments' production (including ancillary services for education). The results suggest that changing the composition of expenditure across functions can lead to improvements in global efficiency spending. Anyway, the study confirms that municipalities in the selected Region also report very different efficiency scores.

From this brief review the literature emerges a clear lack of studies which explore specifically the link between the spending on ancillary services and academic results. Previous evidence demonstrate that local governments are quite heterogeneous in terms of efficiency, so we would like to explore if such heterogeneity has any reflex on the quality of ancillary services and, consequently, on students' academic performance. As evident from this stream of studies, local governments are likely to differ in their efficiency in a substantial way, then some of them can also be more efficient than others in providing ancillary services to schools, something that might affect the performance of students.

3. Background: notes about the Italian educational system and the role of local governments

The Italian educational system, in the period under analysis, is characterised by a strong centralization by the Ministry of Education, which is responsible for hiring teachers as well as for defining curricular programs. Despite some recent norms that aim at introducing more school autonomy (Law 107/2015), no strong reforms have been introduced over the last years with respect to the ancillary services provided by schools.

School resources are mainly provided by the Ministry of Education, Research and University (MIUR) except for limited funding by regional governments and municipalities. The central government directly provides funding for school functioning

and teachers' salaries, while regions and municipalities provide funding for services and assistance for pupils, such as school transportation, textbooks, social and health assistance, canteens, financial aid and building maintenance.

When considering the results of educational activities, despite the centralized educational system, Italy has shown a strong geographical variation in educational achievement, as well as differences in educational resources across regions (Agasisti and Vittadini 2012). The regional inequality and persistent gap between North and South of the country has been studied using the Programme for International Student Assessment (PISA) conducted by OECD and also using INVALSI administrative data, underlining the regional gap despite no big difference in educational expenditures (Bratti et al. 2007; Checchi 2004).

In the Italian legislation, ancillary services for primary and secondary education such as school meals and transports are defined as local services on individual demand – that must be supplied by the local governments. The services are regulated within the realm of the "right to study" by the Law n. 112/1998, which specifies how financial resources for the two services are to be transferred by the municipalities to the schools that, in turn, can decide to directly provide the service or outsource it to external providers. Some reports conducted by the OECD (2015, 2016, 2017 and 2018) highlight how in Italy the level of resources devoted to the ancillary services is below the OECD average (Table 1).

Table 1. Annual expenditure per pupil for ancillary services (€/student)

	2012	2013	% change	2014	2015	% change
Italia	420	398	-5.24	407	378	-7.13
OECD average	554	522	-5.78	540	579	7.22

Source: authors' elaborations on Table 2.1 OECD Education at a Glance (2013, 2014, 2015, 2017). Values expressed in US dollars, purchasing power parity.

To fully understand the potential role of ancillary services, it is important also to note how school time is organized in Italy. According to the Law 29/2004, weekly school time at primary level may vary between 27 and 40 hours. The maximum level of weekly hours is 40 hours, also called "full-time" and it is comprehensive of the daily time spent in the school canteen, which then becomes an integral part of the services provided to the students. Families may decide to apply for the school canteen service against payment of a fee depending on their socio-economic level, as private contribution for service delivery, or to take the kids home for lunch. If the socio-economic status (SES) of the family is below a certain threshold set by the municipality, the financial contribution can be waved and is covered by general taxation (i.e. local government's expenditure). For what it concerns the school transport, the legislation provides for a free service to all the pupils whose families apply for it, giving priority to disabled and disadvantaged students. Given that ancillary services are regulated as an essential part of the educational offer, but resources for that are managed by local governments and not by schools, there is a

problem of understanding the level of efficiency and in turn effectiveness of this process, a point specifically addressed by the present study. Indeed, by exploring the (heterogenous) efficiency of local governments' expenditures for the two key services (transports and meals), we would like to understand whether such differences are then reflected on systematic variability in students' test scores.

4. Methodological approach

The methodological approach proposed in this work is developed in two steps. In a first stage, the efficiency score of municipalities in providing ancillary services to schools (meals and transports) is estimated by means of an order-m approach. In a second stage, the efficiency scores derived by the nonparametric model are tested as an explanatory factor for the variability of test scores across municipalities which is analysed with a three-level multilevel model (where the three levels are students, schools and municipalities).

4.1 The efficiency of municipalities in funding ancillary services for education

In order to determine the efficiency scores of municipalities in producing ancillary services for education, the efficient production frontier is defined in the input-output space. The frontier can be defined as the locus of the maximal attainable level of outputs for a given level of inputs (maximization of output) *or* the minimum level of inputs for a given level of output (minimization of inputs), based on the sample of decision-making units (DMUs). In this study, the order-m approach is the main empirical model adopted, by using one measure of input (expenditure) and two measures of outputs (meals and transport provided) with an input orientation (Cazals et al. 2002).

Order-m is a generalization of basic non-parametric methodologies like DEA and FDH[2] and it adds a layer of randomness to the computation of efficiency scores. The main idea is to benchmark the DMUs by the expected best performance in a sample of m peers instead of benchmarking a DMU by the best-performing peer as in DEA and FDH. Order-m performs better in mitigating the impact of (potential) outlier behaviour and allowing for uncertainty in the observed sample S (Cazals et al. 2002). Moreover, it does not consider the full set of observations to define the efficiency score, but it considers repeatedly subsamples of an integer $m \geq 1$ observations randomly drawn from the sample S. For each observation, the model is computed as the average value of the efficiency scores θ with $(\hat{\theta}_m^1, \dots, \hat{\theta}_m^D)$ defined over the D iterations. The generalized model is expressed as following:

$$\varphi_m(y) = \mathbb{E}\left[\min(X_1, \dots, X_m) \mid Y \geq y\right] = \int_0^\infty [1 - \Psi_{x|y}(x|y)]^m dx \qquad (1)$$

[2] Charnes, Cooper and Rhodes (1978); Banker, Charnes and Cooper (1984)

where the order-m estimator $\varphi_m(y)$ consists of two parts: the first equality defines the concept of the benchmark for a unit (x, y) producing a given level y of outputs in the interior of the support of Y, where m is i.i.d. random variables $(X_1, \ldots, X_m)$ generated by the conditional p-variate distribution function $\Psi_{x|y}(x|y)$. The order-m efficiency score can be viewed as the expectation of the minimal input efficiency score of the unit (x, y), when compared to m units randomly draw from the population of units producing more output than the level y (Cazals et al. 2002). For finite m, this is clearly less extreme than the full frontier and $\varphi_m(y) \to \varphi(y)$ as $m \to \infty$.

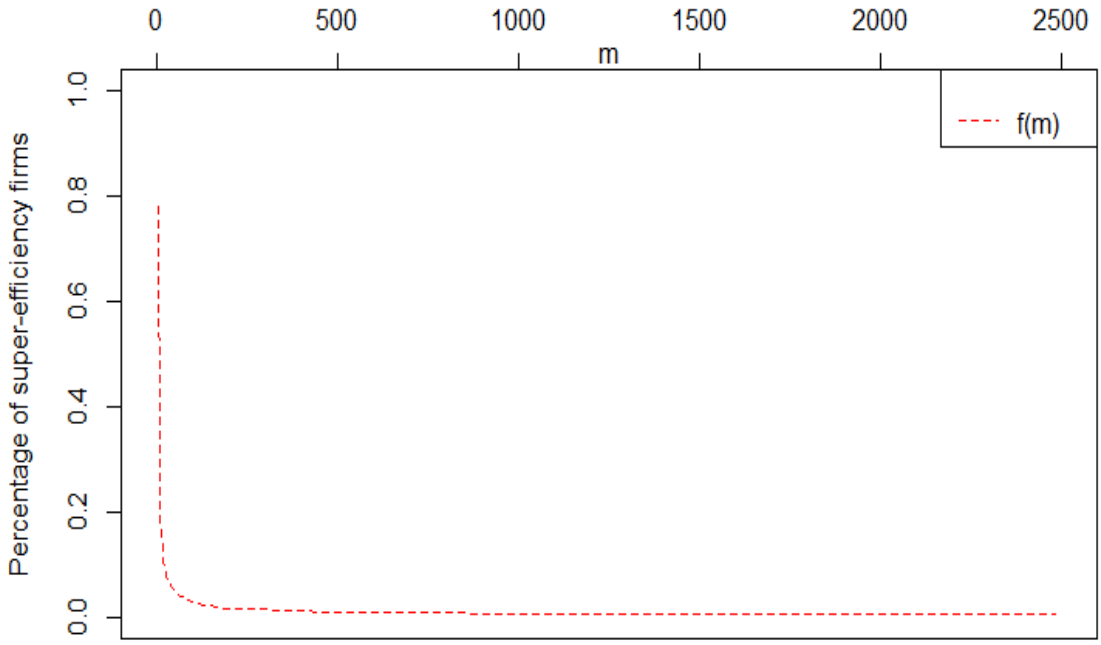
The order-m efficiency score can be, hence, defined as $\theta_m(x, y) = {\varphi_m(y)}/{x}$ and it is not limited to the value of 1: a value of $\theta_m(x, y)$ greater than 1 indicates that the DMU that is operating at the level (x, y) is more efficient than the average of m peers, randomly drawn from the population. These DMUs with efficiency scores greater than 1 are, for this reason, defined as superefficient (see Cazals et al. 2002; Tauchmann 2012 and Gnewuch and Wohlrabe 2018 for further details). The empirical approach of order-m consists of four steps: 1) from a set of peer DMUs in the sample S that satisfy the condition $Y \geq y$ denoted as B_i, a sample of m peer DMUs that is randomly drawn with replacement; 2) a pseudo-FDH efficiency score is calculated, using this artificial reference sample; 3) Steps 1 and 2 are repeated D times using the bootstrap technique; 4) order-m efficiency is calculated as the average of pseudo-FDH scores:

$$\hat{\theta}_{mi}^{OM} = \frac{1}{D} \sum_{d=1}^{D} \hat{\theta}_{mi}^{\widehat{FDH}d} \tag{2}$$

where $\hat{\theta}$ represents the efficiency score for the order-m model for the i DMU units; D represents the parameter for bootstrap. Because of random resampling, during each replication would be possible that the DMU i may or may not be a peer for other DMUs and, in the input-oriented model as in this study, the efficiency scores may be greater than 1. Order-m approach, hence, allows for super-efficient DMUs located beyond the estimated production-possibility frontier making it as the main difference with other nonparametric models. The value of m improves the accuracy and its choice is critical. For small m values, the share of super-efficient DMUs is large while, for $m \to \infty$, order-m resembles the FDH approach.

For the goal of this paper in investigating the efficiency scores at municipalities level, the baseline model uses the order-m setting $m = 100$ and bootstrap $D = 3000$. These parameters are chosen in relation to the number of super-efficient observations in the sample, by consulting the Receiver Operating Characteristic (ROC) curve illustrated in Figure 1, which is a representation of the accuracy of the choice of m detected in an elbow at about $m = 100$, which justifies the choice of the parameter.

Figure 1. Receiver operating characteristic (ROC) curve



Notes: authors' elaboration using R software. On the y axis: percentage of super-efficiency units. On the x axis: value of *m* (parameter of interest).

The values of m which correspond to the desired degree of robustness, i.e. the percentage of high performers of the population we want to exclude in our more realistic benchmarking comparison that in the sample is robust at around 2 percent. We have also investigated the model with other values for $m = 20, 50, 150$ and 200. Average efficiency values are reported in Table A.1 in Appendix A (results are not presented in the main article but are available upon request).

4.2 Exploring the determinants of the pupils' results: multilevel modelling

The difference in the variability of pupil achievement among municipalities is conducted by estimating the EPF that takes the generally acceptable form since Hanushek (1979):

$$y_{ijmt} = f(\boldsymbol{X}_{ijmt}, \boldsymbol{S}_{mt}, \boldsymbol{M}_{jt}) \quad (3)$$

where for the ith pupil, y represents the outcome of the educational process measured by the test score in reading and mathematics at school-unit j, municipality m at time t; $\boldsymbol{X}$ is a vector of pupils characteristics; $\boldsymbol{S}$ is a vector of the school-unit characteristics; $\boldsymbol{M}$ is a vector for resources transferred by municipalities to school to provide ancillary services such as school meals and transport affects pupils' achievement. We are interested in the correlation between $\boldsymbol{S}$ and pupils' outcome y where, $\boldsymbol{S}$ is included into the model by how schools use, in efficient way, those resources.

Multilevel modelling is used for studying the factors associated with pupils' test scores, given the nested structure of the database with pupils nested within school-unit (*plesso)*[3] and school-units nested within municipalities. This paper adopts a three-level multilevel approach with random intercept taking into account pupils and schools' characteristics and the hierarchical structure of the database (Snijders and Bosker 2012; Goldstein 2011). Three-levels are indicated with pupils at Level 1, school-unit at Level 2 and municipalities at Level 3. The aim is to estimate the relationship between a response variable and a set of explanatory variables nested at different levels. Given that the within-cluster dependence violates the assumption of ordinary regression models according to which responses are conditionally independent given the covariates, the issue is overcome by using multilevel models (Bryk and Raudenbush 1992).

The econometric model is specified as follows:

$$y_{ijm} = \beta_0 + \beta_1 \boldsymbol{X}_{ijm} + \boldsymbol{\phi S}_{mt} + \gamma \boldsymbol{M}_t + v_k + u_{jk} + e_{ijk} \quad (4)$$

where y_{ijk} is the observed score for pupil ith in school-unit j and municipality m. The first part of the model $\beta_0 + \beta_1 \boldsymbol{X}_{ijm} + \boldsymbol{\phi S}_{mt} + \gamma \boldsymbol{M}_t$ represents the fixed part and it specifies the relationship between the mean of y and the explanatory variables. The random part is expressed by $v_k + u_{jk} + e_{ijk}$ while the variance components identified by σ_v^2, σ_u^2, and σ_e^2 measures how the variation is distributed between the three different levels. Municipalities' variance σ_v^2 measures the differences between municipalities, the school-unit σ_u^2 variance measures the difference in school-unit performances and pupils' variance σ_e^2 measures how variable pupils are within their school-units.

5. Data

To assess the impact of municipalities' resources for ancillary services on pupil achievement, the paper combines two sources of data in a novel way, analysing all students and all municipalities located in all the 15 Italian regions with ordinary statutes. The novel empirical application takes advantage from the use of two sources of data combined through the municipality cadastral code where the school is located, which enriches administrative data on standardised tests with information at municipality level. The first database is provided by INVALSI, which is an institutional entity under the supervision of the Italian Ministry of Education, University and Research. Yearly, it assesses skills of Italian pupils at given grades and, among its activities, investigates the causes of failure and scholastic dispersion with reference to the social context and to the types of educational offer, examines compulsory surveys for the evaluation of school value added, prepares standardised tests to assess Italian pupils' achievement. Data used in the study refers to the results in the standardised tests taken at grade 5 in reading and mathematics scores by all Italian pupils in the academic years 2012/2013 and 2014/2015.

[3] A plesso is each of the units of school buildings belonging to a comprehensive institute. Given that schools can be composed of buildings located across different municipalities, we consider the plesso-level in order to disentangle the cross-municipalities effect.

Data about achievement are enriched with detailed information about the student, the family context and a number of school characteristics, collected by questionnaires filled by students, parents, school principals and secretaries.

In addition, the database on standard and historical expenditures and on the level of services (school meals and pupils transported) for municipalities is provided by SOSE (*Soluzioni per il Sistema Economico S.p.a.*).[4] SOSE, since 2011, elaborates econometric models for the evaluation of the standard expenditure needs (SEN) of Italian local governments (see Porcelli 2015) and, since 2015, publishes online on the web portal OpenCivitas all the raw data in opendata format.[5]

The essential municipal functions for which standard expenditure needs have been evaluated include eight services (for a total expenditure equal to 34 billion): general administration services, local public transport, land management and planning, waste management, general social services, nursery services, local police, and ancillary services in education. In relation to the available information and to the nature of the analysed services, for the majority of services SEN have been computed estimating an expenditure function, while in three cases (ancillary education services, nursery services, and waste management) SEN have been computed estimating a cost function.

Ancillary education services, which are the focus of the paper, absorbs, on average, 13% of total standard expenditure needs corresponding, in terms of current expenditure, to 706.82 euros per capita. This amount, multiplied by the target resident population of over 5.7 million children between 3 and 14, generates a total current expenditure of 4039 million euros (2013 data).

Education ancillary services provided by Italian municipalities, and analysed for the evaluation of standard expenditure needs, are characterized by a multitude of activities such as: the maintenance of the school buildings, the provision of school meals, pupils' transportation, the assistance of pupils with special needs, etc. As reported in Table 2, ancillary education services can be divided into two groups: mandatory services, where the municipality has only minimal discretionarily in setting the quantity to provide, and discretionary services where, instead, the local administration can decide autonomously the level of service.

[4] SOSE S.p.A. is a company owned both by the Italian Ministry of Economy and Finance and Bank of Italy and elaborates and implements a system for the evaluation of Standard Expenditure Needs, real financial needs of a local municipality based on its territorial characteristics and the socio-demographic aspects of the resident population of Italian local governments, to guarantee that resources are distributed in an equitable and transparent way.

[5] At the end of 2013, the Italian government, with the scientific support of SOSE SpA, produced the first wave of the assessment of Standard Expenditure Needs (SEN) for all the municipalities located in normal statute regions. This marked the beginning of a radical reform of intergovernmental relations in Italy, taking the first and necessary step towards the construction of a new and more efficient mechanism for the distribution of equalization grants to finance the essential functions of municipalities. In 2016 a new wave of standard expenditure needs was released updating the methodology and reducing the final number of variables involved in the computation.

Table 2 – Ancillary education services

	National average (2013)
Mandatory services	
School surface sq. meter per resident age 3-14	12.71
Private school pupils per 100 residents age 3-14	10.12
Municipal school pupils per 100 residents age 3-14	2.20
Municipal school pupils with special needs per 100 municipal school pupils	2.58
Transported pupils with special needs per 100 residents age 3-14	0.23
Discretionary services	
Transported pupils per 100 residents age 3-14	10.54
Pupils with school meal service per 100 residents age 3-14	24.07

Source: Authors' elaborations on OPENCIVITAS data.

Considering the structure of municipal ancillary education services, from the OpenCivitas database we decided to extract information regarding the local governments' expenditure and the level of services related to the two discretionary services: school meals and school transport.

Information on the level of services and the amount of current expenditure have been collected for 2010 and 2013 in order to coordinate them with students' test scores data that, at the beginning of the research activity, where available up to 2014/2015 academic year. In particular, given that it may take time for the investments in ancillary services to provide evidence on student achievement, we consider (at least) a 2-years lag for data about municipality expenditures.

Given that the relationship between the resources and the amount of ancillary services provided by the local government may be influenced by the average level of a wealth across municipalities, we also merged existing information with the average income level per municipality, as provided by Sole 24Ore[6] independent website for all Italian municipalities.

It is important to highlight that the dataset constructed for the empirical analysis combines INVALSI information on pupils' test score with SOSE information on the level of expenditure and output for ancillary education services thereby allowing to perform a multidimensional analysis on inputs, outputs (combined together using efficiency analysis) and outcomes.

The indicator of the efficiency level is derived using the efficiency score estimated by a bootstrap order-m approach, obtained estimating the model by the package *frontiles* in R (http://www.r-project.org). The model is run at municipality-level, with efficiency scores varying between 0 and 1. The closer to 1 is the efficiency score, the more efficient is the DMU and if the DMU presents values greater than 1, the DMU is defined as superefficient. As an input, we consider the yearly expenditure for ancillary services, while outputs are the number of served students by the school canteen and transportation

[6] http://www.infodata.ilsole24ore.com

services. The number of students served by school canteen is computed as an equivalent number of students based on the provision of school meals, in particular the total number of meals served each year is divided by 200 (the maximum number of meals that can be consumed in one academic year). Instead, the number of students served by the transportation service is measured independently from the kilometres. A limitation in the database with respect to the inputs, is the lack of a quality indicator which might be included in the estimation, and that can partially explain the differences in efficiency levels (if the production of different quality requires higher costs which are not captured by quantities).

The initial database consisted approximately of 400,000 observations nested into 5,500 municipalities in which is located at least one school-unit, for both of academic years 2012/2013 and 2014/2015. The dataset has been cleaned for missing values and the final dataset contains 320,000 observations within approximately 4,500 municipalities, for 2012/2013 and 2014/2015.

Our reference grade is grade 5, the last year of primary school in Italy and the covariates are student's and family characteristics such as gender, whether the student is early-enrolled (i.e., enrolled for the first time when 5-year-old, the norm being to start the school when 6-year-old), or if the student is late-enrolled, the immigrant background, educational level of parents, the index of Economic, Social and Cultural Status (named ESCS, as a proxy of family SES). At school-unit level, we introduced variables related to the average gender composition, percentage of immigrants of first and second generations, percentage of early and late enrolled, percentage of parents with highest level of education (i.e. who gained a tertiary education diploma), ESCS index at school-unit level. Finally, the weekly school time is accounted for, with "full time" indicating the maximum number of hours, i.e. 40 school hours per week. At the municipality level, the variable related to the school meals and transports from and to school are included.

The outputs used for the empirical analyses are reading and mathematics scores administered by INVALSI and expressed as net scores and scores are standardized with mean equals to 200 and standard deviation of 100. The test score in reading and mathematics vary from one academic year to another and between subjects, with a mean of 207 to 211. List of the variables are presented in Table 3 while some descriptive statistics are presented in Table 4a and 4b.

Table 3. Variables and definitions

	Variables	Definition
Student level	Test score_r	Reading test score
	Test score_m	Mathematics test score
	Gender	Student's gender: Girl (dummy)
	Early enrolment student	Student's enrolment status: early (dummy)
	Late enrolment student	Student's enrolment status: late (dummy)
	Immigrant first gener.	Student's immigrant status: 1st generation (dummy)
	Immigrant second gener.	Student's immigration status: 2st generation (dummy)
	Highest education father	Educational level father (dummy)
	Highest education mother	Educational level mother (dummy)
	ESCS	Economic, social and cultural status (index)
	Centre	Geographical macro-area: centre (dummy)
	South	Geographical macro-area: south (dummy)
School-unit level	Percentage student girl	Girls at school-unit (%)
	Percentage immigrant first	Student's immigrant status: 1st generation (%)
	Percentage immigrant second	Student's immigrant status: 2st generation (%)
	Percentage 27 hours	Hours spent at school (%)
	Percentage 28_30 hours	Hours spent at school (%)
	Percentage 31_39 hours	Hours spent at school (%)
	Percentage 40 hours	Hours spent at school – full time (%)
	Percentage early enrolment	Student's enrolment status: early (%)
	Percentage late enrolment	Student's enrolment status: late (%)
	Percentage highest education father	Highest educational level father (%)
	Percentage highest education mother	Student's enrolment status: late (%)
	ESCS school-unit	Economic, social and cultural status (index)
Municipality level	Efficiency	Efficiency scores from order-m
	Meals	School meals
	Transport	Transport from/to school
Controls	GDP_municipality	Average GDP for municipality

Source: Authors' elaborations on INVALSI-SOSE data.

Table 4a. Descriptive Statistics academic year 2012/2013

	Reading				Mathematics			
Variables	Obs	Mean	Min	Max	Obs	Mean	Min	Max
Test score	309,576	207.23	1.11	351.22	311,376	210.42	-5.56	388.49
Girl	309,576	0.50	0	1	311,376	0.50	0	1
Early enrolment	309,576	0.01	0	1	311,376	0.01	0	1
Late enrolment	309,576	0.03	0	1	311,376	0.03	0	1
First immigration status	309,576	0.04	0	1	311,376	0.04	0	1
Second immigration status	309,576	0.06	0	1	311,376	0.06	0	1
Highest education father	309,576	0.10	0	1	311,376	0.10	0	1
Highest education mother	309,576	0.11	0	1	311,376	0.11	0	1
ESCS	309,576	0.02	-3.11	2.60	311,376	0.04	-3.10	2.60
% girls	309,576	49.61	0	93.75	311,376	49.49	0	94.12
% first immig. status	309,576	4.16	0	100	311,376	4.23	0	100
% second immig. status	309,576	6.19	0	100	311,376	6.26	0	100
% 27 hours	309,576	14.21	0	100	311,376	14.24	0	100
% 28_30 hours	309,576	51.13	0	100	311,376	50.92	0	100
% 31_39 hours	309,576	3.29	0	100	311,376	3.28	0	100
% 40 hours	309,576	22.11	0	100	311,376	22.20	0	100
% early enrolment	309,576	1.11	0	81.25	311,376	1.12	0	75
% late enrolment	309,576	2.91	0	61.11	311,376	2.96	0	61.11
% highest educ. father	309,576	9.56	0	81.82	311,376	9.54	0	81.82
% highest educ. mother	309,576	11.45	0	86.67	311,376	11.42	0	89.29
ESCS school-unit	309,576	0.02	-1.94	1.97	311,376	0.04	-2.24	1.99
Meals	309,576	0.23	0.01	0.63	311,376	0.23	0.01	0.63
Transports	309,576	0.14	0.01	0.88	311,376	0.14	0.01	0.86
Efficiency scores	309,576	0.45	0.13	1.57	311,376	0.45	0.13	1.58
GDP_municipality	309,576	20.19	11.91	74.74	311,376	20.01	11.91	42.12
North	309,576	0.48	0	1	311,376	0.48	0	1
Centre	309,576	0.20	0	1	311,376	0.20	0	1
South	309,576	0.32	0	1	311,376	0.32	0	1

Source: Authors' elaborations on INVALSI-SOSE data.

Table 4.b Descriptive Statistics academic year 2014/2015

	Reading				Mathematics			
Variables	Obs	Mean	Min	Max	Obs	Mean	Min	Max
Test score	303,511	209.65	-23.41	392.90	318,502	209.81	14.58	364.75
Girl	303,511	0.49	0	1	318,502	0.49	0	1
Early enrolment	303,511	0.01	0	1	318,502	0.01	0	1
Late enrolment	303,511	0.02	0	1	318,502	0.02	0	1
First immigration status	303,511	0.03	0	1	318,502	0.03	0	1
Second immigration status	303,511	0.07	0	1	318,502	0.08	0	1
Highest education father	303,511	0.12	0	1	318,502	0.12	0	1
Highest education mother	303,511	0.15	0	1	318,502	0.15	0	1
ESCS	303,511	0.02	-2.84	2.27	318,502	0.03	-2.84	2.27
% girls	303,511	49.12	0	100	318,502	48.93	0	100
% first immig. status	303,511	3.34	0	100	318,502	3.48	0	100
% second immig. status	303,511	7.40	0	100	318,502	7.56	0	100
% 27 hours	303,511	1.45	0	100	318,502	1.40	0	100
% 28_30 hours	303,511	29.56	0	100	318,502	29.34	0	100
% 31_39 hours	303,511	28.67	0	100	318,502	28.19	0	100
% 40 hours	303,511	0.47	0	100	318,502	0.45	0	100
% early enrolment	303,511	1.02	0	100	318,502	1.00	0	100
% late enrolment	303,511	2.40	0	100	318,502	2.49	0	100
% highest educ. father	303,511	11.95	0	100	318,502	11.82	0	100
% highest educ. mother	303,511	15.08	0	100	318,502	14.95	0	100
ESCS school-unit	303,511	0.02	-2.48	1.86	318,502	0.03	-2.48	2.18
Meals	303,511	0.25	0.01	0.70	318,502	0.25	0.01	1.73
Transports	303,511	0.12	0.01	0.92	318,502	0.12	0.01	0.94
Efficiency scores	303,511	0.28	0.05	1.60	318,502	0.28	0.05	1.57
GDP_municipality	303,511	16.70	7.09	51.40	318,502	16.98	6.35	51.40
North	303,511	0.51	0	1	318,502	0.51	0	1
Centre	303,511	0.24	0	1	318,502	0.25	0	1
South	303,511	0.25	0	1	318,502	0.24	0	1

Source: Authors' elaborations on INVALSI-SOSE data.

6. Results from the empirical analysis

6.1 Analysis of the efficiency of municipalities in providing ancillary services to school

The estimated values of local governments' efficiency scores, which are derived before merging the dataset with student level information, highly depend on the choice of m that defines the position of the frontier relative to the data. For the aim of our study and for the reasons discussed in the previous section, we choose $m = 100$ and $3{,}000$ bootstraps.

The scenario shows two different paths: the average efficiency scores decrease between the two academic years (2012/13 and 2014/2015) meaning that, on average, more municipalities have moved away from the production-possibility frontier becoming less efficient. Moreover, it might be useful to see in Table 5 that the share of efficient DMUs,

i.e. DMUs with efficiency values equal 1 ($\theta = 1$), shows an increasing trend with a higher share of municipalities labelled as efficient in 2014/2015 compared to 2012/2013. In general terms, we notice how the average level of efficiency is quite low in both cohorts (0.47 and 0.30, respectively), so large improvements towards more efficient use of resources are possible. As a result, this evidence shows a clear increase in inequality among municipalities, since polarization in the two extremes of the distribution of efficiency score increased over time.

Table 5. Order-*m* efficiency scores of local governments, overall analysis

	2012/2013	2014/2015
m=100		
Average efficiency score	0.47	0.30
% obs ($\theta = 1$)	0.32	0.11
% obs ($\theta > 1$)	2.16	1.35

Notes: Average efficiency score using m=100 and with bootstrap $D = 3000$. Theta indicates the efficiency score derived by the model. Shares of efficient municipalities ($\theta = 1$) and super-efficient ($\theta > 1$) are presented in rows 2-3.
Source: INVALSI-SOSE dataset. Author's elaborations.

For what concerns the DMUs with efficiency scores greater than 1 ($\theta > 1$), around 2% of municipalities in the sample are located beyond the production-possibility frontier (in output-oriented approach, superefficient DMUs show efficiency values smaller than unit i.e., $\theta < 1$).

The analysis of the efficiency scores can also be reported by geographical macroareas (Northern Italy, Central and Southern) and that allows investigating where efficient or inefficient DMUs are located. Table 6 presents the levels of efficiency across macroareas for both subjects and academic years. The pattern that emerges is counterintuitive as regions in the North show lower efficiency values (0.24-0.41) compared to regions in the Southern area (0.42-0.54). This phenomenon has a potential explanation; indeed, higher levels of expenditures of municipalities in Northern regions, which hence turn into lower levels of efficiency for any given level of output quantity. As mentioned, higher expenditures might also be associated to higher levels of quality – something we cannot explore with available data, though.

Table 6: Order-*m* efficiency scores of local governments, by geographical macroarea

	2012/2013			**2014/2015**		
Macroareas	Mean	Min	Max	Mean	Min	Max
North	0.41	0.13	1.57	0.24	0.05	1.54
Centre	0.41	0.16	1.45	0.21	0.06	1.30
South	0.54	0.14	1.47	0.42	0.06	1.60

Notes: author's elaborations based on $m = 100$
Source: INVALSI-SOSE dataset

6.2 Analysis of the determinants of the pupils' results: multilevel modelling

Results from the three-level multilevel modelling for the academic year 2012/13 and 2014/15 are presented in Table 7, so providing an answer to the second research question. The multilevel model estimates how much of the variance of students' test scores is attributable to structural differences between school-units and municipalities focusing on the statistical differences in test scores. The model includes pupils, schools and municipalities' level for reading and mathematics for the academic year 2012/2013 (columns 7.1 and 7.2) and for academic year 2014/2015 (columns 7.3 and 7.4). In the econometric specification, we control for geographical fixed effect areas (to keep structural unobservable differences into account) and the average income levels within municipalities (GDP mean).

Table 7. Factors associated with students' performance: econometric results from the three-level multilevel approach

VARIABLES	(7.1)	(7.2)	(7.3)	(7.4)
Gender (girl=1)	6.836***	-6.497***	3.733***	-6.329***
	(0.127)	(0.126)	(0.130)	(0.126)
Early enrolment (yes=1)	-1.028*	0.517	-2.491***	-1.637**
	(0.618)	(0.613)	(0.666)	(0.655)
Late enrolment (yes=1)	-14.800***	-9.780***	-14.393***	-11.333***
	(0.423)	(0.416)	(0.458)	(0.437)
First immigrant status (yes=1)	-17.612***	-11.341***	-13.316***	-8.562***
	(0.362)	(0.357)	(0.395)	(0.377)
Second immigrant status (yes=1)	-15.032***	-10.406***	-11.818***	-7.961***
	(0.285)	(0.281)	(0.262)	(0.253)
Highest education father (MA degree =1)	2.664***	2.934***	3.649***	2.837***
	(0.257)	(0.256)	(0.242)	(0.236)
Highest education mother (MA degree =1)	4.255***	4.152***	5.276***	4.437***
	(0.241)	(0.240)	(0.224)	(0.219)
ESCS	8.715***	8.209***	9.024***	8.767***
	(0.084)	(0.085)	(0.095)	(0.094)
% girls	0.004	0.028**	0.007	0.048***
	(0.012)	(0.014)	(0.013)	(0.013)
% First immigrant status	-0.054**	-0.080**	-0.020	-0.125***
	(0.027)	(0.033)	(0.033)	(0.033)
% Second immigrant status	0.048***	-0.011	-0.041**	-0.037*
	(0.017)	(0.021)	(0.021)	(0.020)
% 27 hours	0.016**	0.027***	0.008	-0.013
	(0.006)	(0.007)	(0.013)	(0.013)
% 28_30 hours	0.018***	0.024***	0.011***	-0.005
	(0.007)	(0.006)	(0.004)	(0.004)
% 31_39 hours	0.012	0.010	0.011***	-0.005
	(0.008)	(0.010)	(0.004)	(0.004)
% 40 hours	0.004	0.036***	-0.024	-0.094***
	(0.006)	(0.007)	(0.019)	(0.019)
% early enrolment	-0.053	-0.146***	-0.005	-0.011
	(0.042)	(0.050)	(0.045)	(0.047)
% late enrolment	-0.111***	-0.123***	-0.171***	-0.149***
	(0.035)	(0.042)	(0.040)	(0.040)
% highest education father	0.000	0.021	-0.018	-0.003
	(0.023)	(0.027)	(0.023)	(0.024)
% highest education mother	-0.021	-0.006	0.009	0.002
	(0.021)	(0.025)	(0.021)	(0.022)
ESCS school-unit	-0.590	-1.897***	-2.422***	-1.955***
	(0.441)	(0.540)	(0.560)	(0.581)
Efficiency score	-0.260	-0.453	-1.698	0.154
	(0.756)	(0.946)	(1.056)	(1.082)

VARIABLES	(7.1)	(7.2)	(7.3)	(7.4)
GDP municipality	0.015	0.125**	0.016	0.003
	(0.044)	(0.060)	(0.052)	(0.054)
Centre	-1.495***	-2.662***	0.830*	-1.112**
	(0.390)	(0.486)	(0.496)	(0.509)
South	-8.808***	-9.134***	-3.803***	-3.499***
	(0.390)	(0.484)	(0.507)	(0.519)
No. Obs.	309,576	311,376	303,511	318,502
No. municipality	4,063	4,067	4,324	4,429
No. school-units	9,541	9,587	10,395	10,748

Source: INVALSI-SOSE database
Notes: Robust standard errors are shown in brackets. Superscripts ***, ** and * denote that the effect is statistically significant at the 1, 5 and 10 per cent level respectively.
Model (7.1) refers to the reading test in the 2012/13 cohort. Model (7.2) refers to the mathematics test in the 2012/13 cohort. Model (7.3) refers to the reading test in the 2014/15 cohort. Model (7.4) refers to the mathematics test in the 2014/15 cohort.

The output of interest are the reading and mathematics scores normalized on a distribution with mean equals to 200 and s.d.=100. The main findings related to the analysis of the efficiency and the impact on pupils' score reveal the lack of statistically significant correlation between local governments' efficiency and test scores for both the cohorts. This indicates that an efficient of inefficient use of resources for ancillary services does not directly affect how well students perform at school, when measuring this construct through test scores in Reading and Mathematics.

When considering student and school level characteristics, our findings are in line with evidence from the literature, corroborating the robustness of the model employed in the present analysis. Being a girl has a positive correlation with the reading test score but negative correlation with the mathematic test score, coherently with previous literature on this topic. Being enrolled before the pupil turns the age of six shows a negative correlation on test scores and the negative phenomenon is even stronger when the pupil starts the school few months or years later. Being a late enrolled pupil might is associated with the reduction of the test score around 14 points. The same path emerges when the analysis is based on the immigration status and results are in line with the literature that says that being a pupil from the first generation of immigrants has a negative effect on test scores (approximately on average 13 points) compared to pupils who are the second generation of immigrants (on average 11 points).

There is also a significant difference among test scores and the socio-economic status of students. The socio-economic index shows that the socio-economic component of the family is the strongest determinant with an estimate of 9 points for each subject and academic year, in the production of pupil's scores compared to the individual determinants and to family characteristics such as the highest educational level of the father and mother. Mothers have more influence on pupils' score with respect to fathers and these findings are in line with the body of evidences about the influence of mothers' education and employment on student achievement (Ermisch and Francesconi 2000).

At school-unit level, some covariates do not seem to have any association with reading and math attainments (percentage of girls, percentage of first- and second-generation

immigrants, percentage of early enrolment students, percentage of fathers and mothers with high education). Being a student who attends the most reduced weekly school time is positively related to achievement, as well as the percentage of mothers who gained tertiary education. In this respect, results indicate that individual-level factors are in general more predictive than schools' features when analysing student achievement.

The geographical macroareas show evidence already demonstrated by the literature, as Southern regions underperform Northern ones, while Central regions performs in between (Ferraro and Põder 2018; Bratti et al. 2007). The performance of the Southern regions, however, shows a promising outcome as the cohort in the academic year 2014/15 illustrates a decreasing gap with other geographical areas. The multilevel modelling approach allows to capture the structural differences in reading and math scores between pupils, across areas given the other variables at student and school level. The assumption is that the marginal effects are identical with the education production function that does not differ across areas. The magnitude of the estimates associated to the dummy variables suggests that this is not the case and that there are different effects of macro areas (all else equal) on student achievement. When trying to explain such variability, the control variable represented by the average income level per municipality does not show significant results except for mathematics in 2012/2013, where a positive effect emerges (0.125).

The multilevel model is an approach that also allows to estimate how much of the variance of pupils' test scores is attributable to structural differences between school-units and municipalities. The variance equations, then, explain the observed variability between levels and show how much of this variability is attributable among individuals (within schools), among schools (within municipalities) and, finally, among municipalities. The difference in variance partitioning coefficient (VPC) (Goldstein 2011), that is obtained as the proportion of random effects variance over the total variation, for school-units and municipalities are, respectively:

$$VPC_{school-unit} = \frac{\sigma_u^2}{\sigma_u^2+\sigma_b^2+\sigma_e^2}; \quad VPC_{municipality} = \frac{\sigma_b^2}{\sigma_u^2+\sigma_b^2+\sigma_e^2} \tag{5}$$

where σ_u^2 represents the variance at school-unit level or between school-unit variance, σ_b^2 shows the variance at municipality level or between municipality and σ_e^2 is the variance at pupil level or within school-unit. Estimates of municipality and school-unit effects are derived from the maximum likelihood optimization.

The results of the variance decomposition are presented in Table 8[7]. First, the most considerable proportion of variance is explained within schools, meaning that a high level of heterogeneity is observed between students attending the same school unit, in the measure of 85-92% of the total variance. Second, part of the variance is attributed to differences between school-units within municipalities with higher values for math than reading within the range of 6-13% of the variance. From the analysis of the confidence

[7] As an additional check on our results, we present in Appendix A, Figure A.3, a visual representation of the frontier and efficient municipalities for the DEA approach with variable returns to scale (VRS) and FDH. DEA approach presents lower efficiency scores compared to order-m model (Table A.2).

interval, no zeros are contained meaning that there are statistically significant differences between academic years and subjects. At municipality level, finally, the variance explained is the lowest, but still in the range of 1-1.7 percent of the total. This last figure might seem indicating that variance at municipality level is not important, but this is not the case. Indeed, structural differences across municipalities after having controlled for individuals and schools' features, actually, are worth investigating as they can be targeted by local governments' policy-makers. By adopting adequate measures, policy-makers at local level can give their contribution to narrow the achievement gap, which is negatively affecting the overall situation of the Italian educational system.

Table 8. Estimated impact of the efficiency scores on student achievement and variance explained at each level of the multilevel regression model

	Efficiency scores			
Variables	2012/2013		2014/2015	
	(8.1)	(8.2)	(8.3)	(8.4)
Efficiency scores	-0.260	-0.453	-1.698	0.154
	(0.756)	(0.946)	(1.056)	(1.082)
Between municipality variance	1.03	1.72	1.35	1.63
Between school-units variance	6.64	11.17	12.18	13.10
Within school-units variance	92.33	87.11	86.47	85.27
No. obs	309,576	311,376	303,511	318,502
No. municipality	4,063	4,067	4,324	4,429
No. school-units	9,541	9,587	10,395	10,748

Source: INVALSI-SOSE database
Notes: Robust standard errors are shown in brackets. Superscripts ***, ** and * denote that the effect is statistically significant at the 1, 5 and 10 per cent level respectively.
Columns (8.1) and (8.3) refer to the reading test. Columns (8.2) and (8.4) refer to the mathematics test.

7. Concluding remarks and implications

This study uses a two-stage approach to explore the efficiency of Italian municipalities in transferring resources to primary schools for the provision of meals and transports from and to school. In the first stage, efficiency scores are generated using the bootstrapping order-*m* approach, with the aim of catching the efficiency in the production of ancillary services at municipality level. Then, a multilevel modelling is adopted using the municipalities' efficiency scores as a covariate to analyse the determinants of pupils' achievements and the impact of resources on their attainment, once controlled for individual and school characteristics.

As a result, we observe that when regressing the level of municipalities' efficiency in the production of ancillary services on student achievement (by means of an appropriate multilevel model), estimates are not statistically significant. The results do not indicate that the role of local governments in affecting educational production is not important,

though. It may be the case that the effect is highly mediated by a number of factors that make the direct estimation of the effect not statistically relevant. Indeed, the efficiency in the provision of ancillary services may have more direct effects on the wellbeing of families, which in turn affects student achievement. This measure is not readily available for this study but deserves attention in the future. Moreover, it can be the case that ancillary services are actually correlated with outputs not measured by test scores in Reading and Mathematics, such as dimensions of non-cognitive skills (like grit, self-confidence, etc. – all factors that go along with the serenity of pupils and their families).

Results show that part of the heterogeneity across students' achievement is explained at municipality level. In such respect, identifying the determinant(s) which drive the differential among students' results is an important empirical issue. Moreover, the variance across regions but also within the same region might show features at local government level which also deserve a deeper investigation in order to provide further conclusions. To the light of our results, however, it has been illustrated that differentials across students' results are not driven by economic factors such as the GDP at local level or by efficiency levels of the local public expenditures in education.

Finally, the most important message emerging from our empirical analysis is that local governments present different levels of efficiency and extensive room for improvement, which have implications in terms of public economic analysis that may be considered as the policy implication of the present study. All else equal, higher efficiency levels of municipalities in their operations might lead to savings that can be invested, for example, in core quality activities of educational institutions.

Further investigations might require information on the quality of ancillary services or the quality of educational inputs such as teachers to enrich the second stage analysis. These might constitute important and relevant elements to collect as differences among students, regions and local governments and, differences in efficiency might also be explained by different school factors or environmental factors and deserve future attention of research in this field.

References

Agasisti, T., Dal Bianco, A. and M. Griffini (2016). The public sector efficiency in Italy: The case of Lombardy municipalities in the provision of the essential public services. *Economia Pubblica*, vol. 1, pp. 59-84.

Agasisti T. and J.M. Cordero-Ferrera (2013). Educational disparities across regions: A multilevel analysis for Italy and Spain. *Journal of Policy Modeling,* vol. 35, no. 6, pp. 1079-1102.

Agasisti T. and G. Vittadini (2012). Regional Economic Disparities as Determinants of Pupils' Achievement in Italy. *Research in Applied Economics*, vol. 4, no. 1, pp. 33-53.

Anderson, M. L., Gallagher, J. and E. R. Ritchie (2017). *School lunch quality and academic performance* (No. w23218). National Bureau of Economic Research.

Banker, R. D., Charnes, A. and W. W. Cooper (1984). Some models for estimating technical and scale inefficiencies in data envelopment analysis. *Management science*, vol. 30, no. 9, pp. 1078-1092.

Belot, M. and J. James (2011). Healthy school meals and educational outcomes. *Journal of Health Economics*, vol. 30, no. 3, pp. 489-504.

Boetti, L., Piacenza, M. and G. Turati (2012). Decentralization and local governments' performance: how does fiscal autonomy affect spending efficiency?. *FinanzArchiv: Public Finance Analysis*, vol. 68, no. 3, pp. 269-302.

Bratti M., Checchi D. and A. Filippin (2007). Geographical Differences in Italians Pupils' Mathematical Competencies: Evidence from PISA 2003. *Giornale degli Economisti e Annali di Economia,* vol. 66, no. 3, pp. 299-333.

Bryk, A. S. and S. W. Raudenbush (1992). *Hierarchical linear models: Applications and data analysis methods*. Sage Publications, Newbury Park, CA.

Card, D. and A. B. Krueger (1996). School resources and pupil outcomes: an overview of the literature and new evidence from North and South Carolina. *Journal of Economic Perspectives*, vol. 10, no. 4, pp. 31-50.

Cazals, C., J. P. Florens and L. Simar (2002). Nonparametric frontier estimation: A robust approach. *Journal of Econometrics*, vol. 106, no. 1, pp. 1-25.

Charnes A, Cooper W. W. and E. Rhodes (1978). Measuring the efficiency of decision making units. *European Journal of Operational Research*, vol. 2, no. 6, pp. 429–444.

Checchi, D. (2004). Da dove vengono le competenze scolastiche?, *Stato e Mercato*, vol. 3, pp. 413-454.

Coleman, J. S., Campbell, E., Hobson, C., McPartland, J., Mood, A., Weinfeld, F. and York, R. (1966). The Coleman Report. *Equality of Educational Opportunity*.

D'Inverno, G., Carosi, L. and L. Ravagli (2018). Global public spending efficiency in Tuscan municipalities. *Socio-Economic Planning Sciences*, vol. 61, pp. 102-113.

Ells, L. J., Hillier, F. C., Shucksmith, J., Crawley, H., Harbige, L., Shield, J. and C. D. Summerbell (2008). A systematic review of the effect of dietary exposure that could be achieved through normal dietary intake on learning and performance of school-aged children of relevance to UK schools. *British Journal of Nutrition*, vol. 100, no. 5, pp. 927-936.

Ensaff, H., Russell, J. and M. E. Barker (2013). Meeting school food standards–pupils' food choice and free school meals. *Public Health Nutrition*, vol. 16, no. 12, pp. 2162-2168.

Ermisch, J., and M. Francesconi (2000). The effect of parents' employment on children's educational attainment (No. 215). IZA Discussion paper series.

Ferraro, S. and K. Põder (2018). School-level policies and the efficiency and equity trade-off in education. *Journal of Policy Modeling,* vol. 40, pp. 1022-1037.

Figlio, D. N. and J. Winicki (2005). Food for thought: the effects of school accountability plans on school nutrition. *Journal of Public Economics*, vol. 89, no. 2-3, pp. 381-394.

Frisvold, D. E. (2015). Nutrition and cognitive achievement: An evaluation of the School Breakfast Program. *Journal of Public Economics*, vol. 124, pp. 91-104.

Fuller, B. and P. Clarke (1994). Raising school effects while ignoring culture? Local conditions and the influence of classroom tools, rules and pedagogy. *Review of Educational Research*, vol. 64, no. 1, pp. 122-131.

Gnewuch, M. and K. Wohlrabe (2018). Super-efficiency of education institutions: an application to economics departments. *Education Economics*, vol. 26, n. 6, pp. 610-623.

Goldstein, H. (2011). *Multilevel statistical models* (Vol. 922). John Wiley & Sons.

Greenwald, R., Hedges, L. V. and R. D. Laine (1996). The effect of school resources on pupil achievement. *Review of Educational Research*, vol. 66, no. 3, pp. 361-396.

Gundlach, E., Wossmann, L. and J. Gmelin (2001). The decline of schooling productivity in OECD countries. *Economic Journal*, vol. 111, no. 471, pp. 135-147.

Hanushek, E. A. and J. A. Luque (2003). Efficiency and equity in schools around the world. *Economics of Education Review*, vol. 22, no. 5, pp. 481-502.

Hanushek, E. A. (1997). Assessing the effects of school resources on pupil performance: An update. *Educational Evaluation and Policy Analysis*, vol. 19, no. 2, pp. 141-164.

Hanushek, E. A. (1989). The impact of differential expenditures on school performance. *Educational researcher*, vol. 18, no. 4, pp. 45-62.

Hanushek, E. A. (1981). Throwing money at schools. *Journal of Policy Analysis and Management*, vol. 1, pp. 19-41.

Hanushek E.A. (1979). Conceptual and Empirical Issues in the Estimation of Educational Production Functions. *Journal of Human Resources,* vol. 14, no. 3, pp. 351-388.

Heinesen, E. (2004). Determinants of local public school expenditure: a dynamic panel data model. *Regional Science and Urban Economics*, vol. 34, no. 4, pp. 429-453.

Henderson, B. B. (2009). The school bus: A neglected children's environment. *Journal of Rural Community Psychology* vol. *E*, no. 12, pp. 1-11.

Jackson, C. K., Johnson, R. C. and C. Persico (2016). The effects of school spending on educational and economic outcomes: Evidence from school finance reforms. *The Quarterly Journal of Economics*, vol. 131, no. 1, pp. 157-218.

Kleinman, R. E., Hall, S., Green, H., Korzec-Ramirez, D., Patton, K., Pagano, M. E. and J. M. Murphy (2002). Diet, breakfast, and academic performance in children. *Annals of Nutrition and Metabolism*, vol. 46, (Suppl. 1), pp. 24-30.

Imberman, S. A. and A. D. Kugler (2014). The effect of providing breakfast in class on pupil performance. *Journal of Policy Analysis and Management*, vol. 33, no. 3, pp. 669-699.

Lafortune, J., Rothstein, J. and D. W. Schanzenbach (2018). School finance reform and the distribution of pupil achievement. *American Economic Journal: Applied Economics*, vol. 10, no. 2, pp. 1-26.

Leos-Urbel, J., Schwartz, A. E., Weinstein, M. and S. Corcoran (2013). Not just for poor kids: The impact of universal free school breakfast on meal participation and pupil outcomes. *Economics of education review*, vol. 36, pp. 88-107.

Lo Storto, C. (2013). Evaluating technical efficiency of Italian major municipalities: a Data Envelopment Analysis model. *Procedia-Social and Behavioral Sciences*, vol. 81, pp. 346-350.

Lo Storto, C. (2016). The trade-off between cost efficiency and public service quality: A non-parametric frontier analysis of Italian major municipalities. *Cities*, vol. 51, pp. 52-63.

LU, Y. C. and L. Tweeten (1973). The impact of busing on pupil achievement. *Growth and Change*, vol. 4, no. 4, pp. 44-46.

OECD (2015), *Education at a Glance 2015: OECD Indicators,* OECD Publishing, Paris.

OECD (2016), *Education at a Glance 2016: OECD Indicators*, OECD Publishing, Paris.

OECD (2017), *Education at a Glance 2017: OECD Indicators*, OECD Publishing, Paris.

OECD (2018), *Education at a Glance 2017: OECD Indicators*, OECD Publishing, Paris.

Porcelli, F. (2015). The Evaluation of Standard Expenditure Needs: the Case of Social Care Services in Italy. *Economia Pubblica*, no. 3, pp. 123-157.

Settimi, C., Vidoli, F., Fusco, E. and D. Ballanti (2014). Estimating technical efficiency in the Italian municipalities. *Procedia Economics and Finance*, vol. 17, pp. 131-137.

Snijders, T.A.B. and R. J. Bosker (2012). Multilevel Analysis: An Introduction to Basic and Advanced Multilevel Modeling, second edition. London etc.: Sage Publishers, 2012. London.

Spence, B. (2000). Long School Bus Rides: Stealing the Joy of Childhood.

Sørensen, L. B., Dyssegaard, C. B., Damsgaard, C. T., Petersen, R. A., Dalskov, S. M., Hjorth, M. F., ... & Lauritzen, L. (2015). The effects of Nordic school meals on concentration and school performance in 8-to 11-year-old children in the OPUS School Meal Study: a cluster-randomised, controlled, cross-over trial. *British Journal of Nutrition*, vol. 113, no. 8, pp. 1280-1291.

Tauchmann, H. (2012). Partial frontier efficiency analysis. *The Stata Journal*, vol. 12, no. 3, pp. 461-478.

Vermeersch, C. and M. Kremer (2005). *School meals, educational achievement, and school competition: evidence from a randomized evaluation* (Vol. 3523). World Bank Publications. Washington.

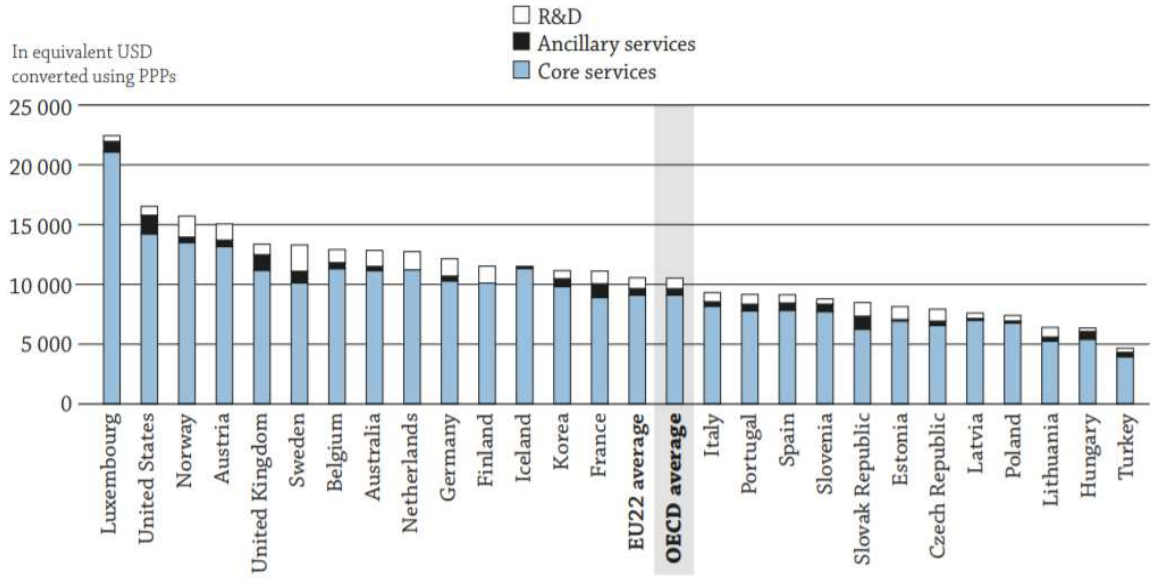
Woessmann, L. (2003). Schooling resources, educational institutions and pupil performance: the international evidence. *Oxford Bulletin of Economics and Statistics*, vol. 65, no. 2, pp. 117-170.

Zars, B. (1998). Long Rides, Tough Hides: Enduring Long School Bus Rides, pp. 1-8.

Zoloth, B. S. (1976). The impact of busing on pupil achievement: Reanalysis. *Growth and Change*, vol. 7, no. 3, pp. 43-47.

APPENDIX A

Figure A.1. Annual expenditure per pupil by educational institutions, by type of service (2011)



Source: OECD/UIS/Eurostat (2018), Table C.1.2 Education at a Glance 2018 See Source section for more information and Annex 3 for notes (http://dx.doi. 1org/10.1787/eag-2018-36-en 2). https://doi.org/10.1787/888933804185
Notes: In equivalent USD converted using PPPs, based on full-time equivalents, for primary through tertiary education. Countries are ranked in descending order of expenditure per pupil by educational institutions for core services.

Table A.1. Order-m efficiency scores (overall analysis)

	2012/2013	2014/2015
m		
20	0.63	0.55
50	0.53	0.39
150	0.44	0.26
200	0.43	0.24

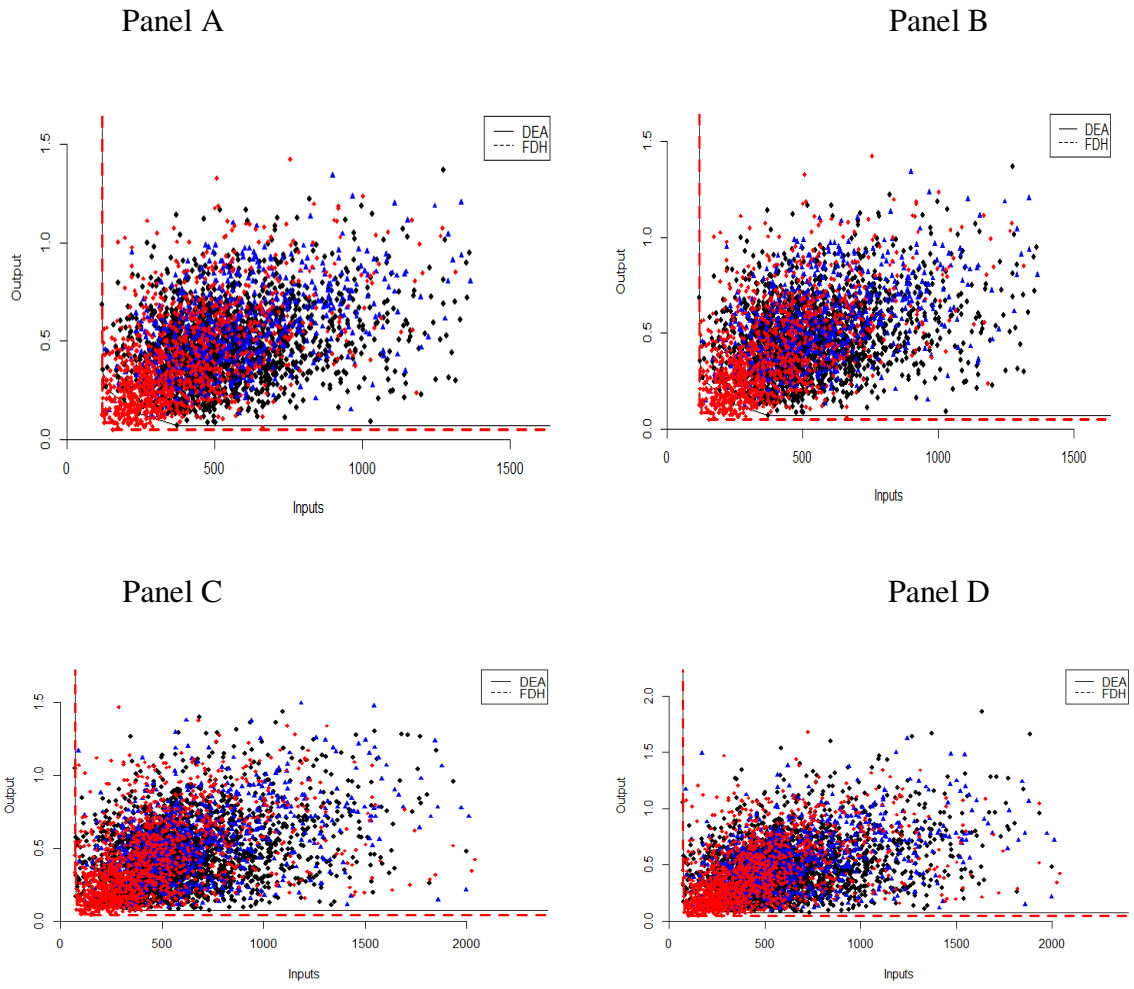
Notes: Mean values using with bootstrap $D = 3000$. Author's elaborations
Source: INVALSI-SOSE dataset

Table A.2. DEA – VRS efficiency analysis (overall analysis)

	2012/2013	2014/2015
Efficiency score	0.32	0.18

Notes: Average efficiency values
Source: INVALSI-SOSE dataset

Figure A.3. DEA-VRS and FDH frontiers



Notes: production frontiers: north (black), centre (blue), south (red). From left to right: Panel A and B indicate reading and mathematics for academic year 2012/2013 while Panel C and D for academic year 2014/2015. Solid line is DEA, dash line is Free Disposal Hull (FDH).