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

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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 model 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 is not explained by different efficiency levels of local government in producing ancillary services.

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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. Ancillary services are defined as: "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 central and critical for evaluating management practices and set up incentives, given the limitations in available budgets. Moreover, the government bodies in charge of providing them may vary in their level of efficiency and 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 - school meals and transportation from and to school - receiving financial transfers from municipalities. This institutional feature raised the need for a responsible and efficient use of resources, both by schools and municipalities. If local governments differ in their efficiency for producing such services, this might have an effect on the students' performance.

The objective of this study is to investigate whether the heterogeneous efficiency levels across municipalities in the provision of ancillary services have any effects on pupils' achievement. Starting from the EPF model proposed by Hanushek (1979), this work sheds a light in estimating the impact of inputs – meals and transportation to/from school jointly - on the educational outputs measured by reading and mathematics pupils' scores in 15 Italian regions with ordinary statutes.

The paper applies the nonparametric technique order-m in the first stage to determine the efficiency of municipalities as decision-making units (DMU). In a second stage, the efficiency scores are covariates in a multilevel model with a set of environmental variables to assess the relationship that these factors may have with student's achievement.

Our research is mainly motivated by the importance of measuring local government efficiency in key sectors such as education, social care and environmental protection. The European Commission (2008), among the others, recognises that monitoring the efficiency of local governments is a necessary condition for improving the quality of public finances, and thereby achieving a sustained long-run economic growth (for a general analysis of performance analysis methods in the sector of local governments see Giordano and Tommasino 2013; Porcelli at al. 2016; Lockwood and Porcelli 2013).

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Moreover, these policy actions, as recognised by the literature on fiscal federalism, are necessary to help citizens to hold governments and their agencies accountable for their actions. Traditionally, one of the main obstacles in the efficiency evaluation regards the measurability of outputs and inputs employed for the provision of local services, which highlights the importance of sophisticated statistical techniques and microdata collection suggested in our research.

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 direct correlation between the spending on ancillary services on pupils' achievement; *(ii)* it is the first study that applies a partial frontier analysis to evaluate the efficiency of municipalities in providing those services to schools; *(iii)* it combines for the first time, two different administrative database to have detailed information at student, school and municipality levels.

Anticipating the main findings, we do not find any correlation between spending efficiency on ancillary services and pupils' achievement. This result is partially driven by the municipality located in the richer Northern regions that show lower efficiency compared to municipality located in the poorer Southern regions. This counterintuitive result is explained by higher levels of expenditures of municipalities in Northern regions, which turn into lower levels of efficiency for any given level of output quantity because the quality usually associated to higher expenditure is not perfectly measured through the available indicators.

The results do not indicate that the role of local governments in affecting educational production is not important but it is possible that the effect is mediated by other factors. The efficiency in the provision of ancillary services may have more direct effects on the wellbeing of families, which in turn affects students' achievement. This measure is not readily available for this study. However, it deserves attention. Finally, our analysis highlights the importance of finding alternative methodologies for estimating the efficiency of public services to minimise the bias that may arise from the difficulty of capturing hidden information like service quality.

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. The existence of geographical differences in the level of efficiency as well as in the variability of pupils' test score within the country has been already investigated by Carboni and Russu (2018), Agasisti and Cordero-Ferrera (2013), Agasisti and Vittadini (2012) and Bratti et al. (2007). These studies provide an excellent background 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.

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The paper is organised as follows. Section §2 presents the theoretical framework, while Section §3 summarises the literature on (i) resources and ancillary services in education and (ii) the efficiency of local governments in Italy. Section §4 provides the background of Italian educational system, whereas Section §5 and §6 respectively present the data and the methodology. Section §7 reports and discusses the results, while Section §8 concludes.

2. Theoretical framework and motivation

Our research addresses the relationship between the efficiency of spending on ancillary services and student achievement. Thus, we specifically consider a subset of school resources that are employed to provide meals and transportation to/from school. In our analysis, we refer to a theoretical framework that derives from the economic literature and is labelled educational production function (EPF). The framework, proposed by Hanushek (1979), interprets the educational process as a black box in which only outputs and inputs are detectable. The output is represented by students' achievement (in cognitive and non-cognitive terms), while inputs are those factors affecting the output, i.e. all those elements under the control of policy makers – teaching staff, school characteristics, school curriculum – as well as those elements out of their control such as family background, peer influence and innate ability of the student (Hanushek 2008). The idea behind the concept of a "production function", thus, simplifies an extremely complex pedagogical process by focusing on its endpoints. In methodological terms, the EPF relies on the ability to maximise the educational output possible for a given amount of inputs (Pritchett and Filmer 1999).

Among the inputs under the school control, the EPF framework commonly considers classroom resources, such as teacher-pupil ratio, teacher experience or class size (Hanushek 2003; Angrist and Levy 1999), and aggregated measures of per pupil expenditure (Hanushek 2008). This latter measure usually regards governmental expenditure for education, whose usage as educational input is commonly considered to be subject to a high degree of inefficiency (Hanushek 2008; Pritchett and Filmer 1999). Thus, the extent to which school inputs are efficiently employed to maximise the educational output is a matter of interest. The current study builds on the previous considerations by focusing specifically on a specific set of resources in inputs to schools, namely the expenditure for ancillary services. Given the importance of understanding the degree of efficiency in the use of resources, we firstly estimate how efficiently resources are employed to produce ancillary services, and then we use that level of efficiency within an EPF design (together with a set of control variables, at student and school level) to estimate its impact on student achievement, net of the characteristics that, according to our framework, may have an impact on the output.

In line with our research motivation and theoretical framework, we expect to observe a certain degree of inefficiency in the use of resources for producing ancillary services. However, we do not have clear expectations about the relationship existing between that level of efficiency and student achievement, given that this association has not been exhaustively investigated in the literature, as clarified in the next Section §3.

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

The analysis conducted in this work has been informed by three main streams of the academic literature. First, it is important to understand how ancillary services influence educational results, within the framework of the EPF (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 the efficiency of local governments in the production of public services (Porcelli, 2015).

3.1 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 transportation from/to school and the effect of school meals on educational results since the Coleman's report (Coleman et al. 1966). The first study that discussed the effect of transport service 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 pointed out the lack of an important predictor on pupils' score: the socio-economic background. The new results show that there is a non-significant impact of the service on pupils' score. Other qualitative studies highlight the negative impact of the time spent on the bus on test scores (Henderson 2009; Spence 2000; Zars 1998).

Scholars have studied with more interest the impact of the school meals on pupils' outcomes with several studies from the US and the UK, but also 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. Ells et al. (2008) review some studies in the UK proposing further analyses given that literature is scarce and in part, inconclusive. In Denmark, Sørensen et al. (2015) by a randomised-cluster trial in primary schools, they conclude that there is no effect of the change in the nutritional content on pupils' mathematics score. The School Breakfast Program (SBP) in US has led to new studies that show positive effects of the SBP on pupils' scores with an increase in mathematics outcomes around 8 percent (Frisvold 2015; Imberman and Kugler 2014; Leos-Urbel et al. 2013; Kleinman et al. 2002).

It is important to clarify, here, that the contributions mentioned in this section provide only a partial ground for our work. They substantially differ from our approach because they focus on specific nutrition interventions and not on the financial resources invested for providing the service, which is the main objective of our work. We do not have data about

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the quality of those services but we can provide insights about the efficiency of expenditures and the effects on students' achievement.

3.2 School resources and educational results

Despite decades of research about the relationship between school resources and students' results and the increasing push towards an effective allocation of school resources, the topic is still controversial (Hanushek 1989, Hanushek and Luque 2003, Woessmann 2003; Gundlach et al. 2001). Hanushek (1997) describes three categories of educational resources and relationship with students' output: (i) the real resources of the classroom related to teachers' quantity and quality; (ii) financial resources and (iii) other resources like school facilities. In his review, he highlights that there is small evidence of positive effects on student performance and policies to increase school resources might have limited impact. A meta-analysis for 60 studies by Greenwald et al. (1996) concludes that there are positive effects of resources on pupils' outcomes. Revisiting Hanushek's studies, Card and Krueger (1996) point out the existence of a positive relationship between school resources and student achievement.

It is worth to notice that the bulk of literature on the topic is USA-centred, while few studies run international comparisons. Woessman (2003) analyses 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 resources available. In closer connection to the current study, Heinesen (2004) analyses how local public schools' 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.

3.3 The efficiency of local governments in Italy

Some existing literature analyses the efficiency of Italian local governments to understand differences in the ability of local governments to provide services they are responsible for in an efficient manner. At the provincial level Giordano and Tommasino (2013) compute the level of public-sector efficiency for the 103 Italian provinces showing a strong positive impact of citizens' willingness to monitor public affairs on local policy-makers performance. More recently, Giordano et al. (2020) measure the efficiency of the public sector across Italian provinces and show the existence of a strong relationship between local government efficiency and the productivity of private sector firms.

In the context of our research, we focus on the municipal level. It 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 and, we selected some key papers.

Barone and Mocetti (2001), using data from Italian municipalities' balance sheets, investigate the relationship between public spending efficiency and tax morale showing a strong positive correlation between the two phenomena. Boetti et al. (2012) investigated how fiscal decentralisation is associated with higher levels of efficiency, considering around 260 municipalities in the area of Turin in 2005. They measure the proportion of revenues from local taxes on total current revenues and then, they correlate the indicator with efficiency in providing a set of local public services. The results suggest that fiscal autonomy is associated with lower inefficient spending. Their analysis demonstrates also a high heterogeneity in the level of municipalities' (in)efficiency.

Lo Storto (2013) studies the efficiency of 103 large municipalities in 2011 using as indicators for outputs the 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 showing 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 suggesting that efficiency gains are not associated with managing the service in aggregation between municipalities, in search of the optimal size for delivering services. The efficiency estimations are robust using alternative measures and methods 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 2011-2013. The findings reveal how some factors are indeed associated with efficiency – for example, the financial equilibrium, the structure of population by age, scale economies and, 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 for 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. The study confirms that municipalities in the selected Region also report very different efficiency scores.

From this specific review 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.

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4. 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 centralisation by the Ministry of Education responsible for hiring teachers and defining curricular programs. 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 centralised 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). In the Italian legislation, ancillary services for primary and secondary education - school meals and transportations - are defined as local services on individual demand supplied by the local governments. The services are regulated within the realm of the "right to study"[2], which specifies how financial resources for these services are to be transferred by the municipalities to the schools. Schools, then, can decide to directly provide the service or outsource it to external providers. The OECD (2015, 2016, 2017, 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
Italy	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 organised 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 transportation, the legislation provides for a free service to all the pupils whose

[2] Law n. 112/1998

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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 (heterogeneous) efficiency of local governments' expenditures for the two key services (transportations and meals), we would like to understand whether such differences are then reflected on systematic variability in students' test scores.

5. Data

To assess the impact of municipalities' resources for ancillary services on pupil achievement, the paper uses a unique dataset combined by two different sources of data. The adoption of this new dataset is a further contribution of this work in 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 (Italian Institute for the Evaluation of Schools), which is an institutional entity under the supervision of the Italian Ministry of Education, University and Research and yearly assesses skills of Italian pupils at given grades. 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. 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.*).[3] 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.[4]

Ancillary education services absorb, on average, 13% of total standard expenditure needs corresponding, in terms of current expenditure, to 706.82 euros per capita. This amount,

[3] 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.

[4] 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.

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multiplied by the target resident population of over 5.7 million children between 3 and 14, generates a total current expenditure of 4,039 million euros (2013 data). Education ancillary services provided by Italian municipalities and analysed for the evaluation of standard expenditure needs, are characterised 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, those 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.

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.

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 transportation. Information on the level of services and the amount of current expenditure have been collected for 2010 and 2013 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 the investments in ancillary services might have effect on later years, we consider (at least) a 2-years lag for data about municipality expenditures.

OpenCivitas data provide for the first time a very accurate representation of the intensity of the two main ancillary education services of the Italian municipalities: school transportation and meals. These two variables are also two essential determinants of the standard expenditure needs employed, since 2015, in the evaluation of equalisation grants. Another advantage of using these data is the identification of the level of services provided by small municipalities that operate in association with other local authorities. To visualise the structure of the input and output data, Figure 1 that follows reports the distribution of transported pupils per 100 residents age 3-14, pupils with school meal service per 100 residents age 3-14 and total expenditure per residents age 3-14. For the sake of simplicity in the representation, we report the average values between 2010 and 2013. Figure 1 shows that

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current expenditure and the school meal service are more concentrated in the north of the country; instead, the school transportation service exhibits a more disperse distribution all over the peninsula and is more concentrate in the rural and mountain territories.

Figure 1 – Distribution of input and output variables

Current municipal expenditure for ancillary education services, euro per capita (average 2010-2013)

% of residents age 3-14 who receive the school meal services (average 2010-2013)

% of residents age 3-14 who receive the school transport service (average 2010-2013)

Sources: Opencivitas.it

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 the data with the average income level per municipality, as a proxy for the local communities' wealth, which is provided by Sole 24Ore[5].

The efficiency score that is estimated in the first stage is obtained 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. 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 services. A limitation in the database with respect to the inputs, is the lack of a quality-related 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 (students) 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. The outputs used are reading and mathematics test scores administered by INVALSI and expressed as net scores and scores are standardised with mean equals to 200 and standard deviation of 100. We focus on grade 5, the last year of

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

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primary school in Italy. Additional covariates at student, school and municipality level are listed in Table 3, while descriptive statistics are provided in Table A.1-A.6 of the Annex A.

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
	Transportation	Transportation from/to school
Controls	GDP_municipality	Average GDP for municipality

Source: Authors' elaborations on INVALSI-SOSE data and SOLE24 Ore.

6. Methodological approach

The methodological approach proposed is developed in two steps. In a first stage, the efficiency score of municipalities in providing ancillary services is estimated by means of an order-m approach. In a second stage, the efficiency scores are included as an explanatory

factor for the variability of test scores across municipalities applying a three-level multilevel model.

6.1 The efficiency of municipalities in funding ancillary services for education

To evaluate 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 (maximisation of output) *or* the minimum level of inputs for a given level of output (minimisation 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 transportation provided) with an input orientation (Cazals et al. 2002).

Order-m is a generalisation of basic non-parametric methodologies like DEA and FDH[6] and it adds a layer of randomness to the computation of efficiency scores. The main idea is to benchmark a DMU against a sample of m peers and not against the best-performing observations from the whole population, as in DEA and FDH. It mitigates the impact of (potential) outliers in the observed sample S (Cazals et al. 2002). Moreover, it does not use all sample values 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 generalised model is expressed as following:

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

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 $(X_1, \dots, X_m)$ generated by the conditional p-variate distribution function $\Psi_{x|y}(x|y)$.

The order-m efficiency score can be defined as $\theta_m(x, y) = {\varphi_m(y)}/{x}$ that can also have a value greater than 1. As $m \to \infty$, the m-frontier approaches the true frontier and the efficiency score approaches to the true efficiency (Tauchmann 2012, Gnewuch and Wohlrabe 2018). 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:

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

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

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

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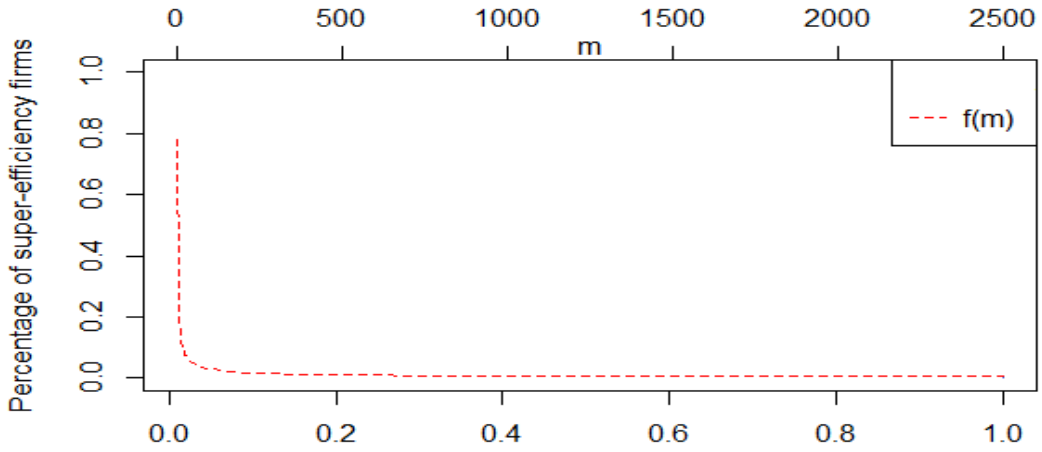
replication would be possible that the DMU i may or may not be a peer for other DMUs. For this work, the baseline model uses $m = 100$ and bootstrap $D = 3000$, parameters chosen by consulting the Receiver Operating Characteristic (ROC) curve illustrated in Figure 2. The ROC curve computes the percentage of DMU – municipalities in this study – according to the parameter m. By constructing the graph, it is possible to choose the value of m that corresponds to the desired degree of robustness or, in other words, the percentage of high performers of the DMU we would like to exclude for a more realistic comparison. It is, hence, 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 2. 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).

As discussed by Cazals et al. (2002) and Daraio-Simar (2005) order-m technique is very related to usual FDH and DEA nonparametric envelopment estimators but is more robust to extreme values, noise or outliers, since it does not envelop all the data points. By choosing m appropriately as a function of the sample size n, order-m estimator, as an estimator of the frontier itself, recovers the typical FDH/DEA asymptotic properties.

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.7 in Appendix A (the full set of results are not presented in the main article but are available upon request) and can be compared to the DEA-VRS average efficiency scores reported in table A.8. As expected, increasing the parameter "m" the average order-m efficiency scores decrease and converge toward the DEA-VRS value that represents a sort of lower-bound value.

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6.2 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. 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)*[7] and school-units nested within municipalities. This paper adopts a three-level multilevel approach with random intercept (Snijders and Bosker 2012; Goldstein 2011; Bryk and Raudenbush 1992) with pupils are at Level 1, school-unit at Level 2 and municipalities at Level 3. This approach accounts for the intragroup correlation of observations and, hence, it takes into proper account the hierarchical structure of data (Cheah, 2009). The aim is to estimate the relationship between a response variable and a set of explanatory variables nested at different levels. It is also a very innovative formulation because it considers municipalities as a level in itself, while usually studies about schools' performance, only consider two levels (students and schools).

The econometric model is specified as follows:

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

where y_{ijk} is the observed score for pupil ith in school-unit j and municipality m. The first part of the model $\beta_0 + \beta_1 \boldsymbol{X}_{ijm} + \phi \boldsymbol{S}_{mt} + \gamma \boldsymbol{M}_t$ 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 measure how the variation is distributed between the three different levels.

7. Results from the empirical analysis

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

[7] 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.

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The estimated values of local governments' efficiency scores are presented in Table 4 and show two different paths. First, the average efficiency scores decrease between the two academic years (2012/13 and 2014/15) meaning that, on average, more municipalities moved away from the production-possibility frontier becoming less efficient. Second, we notice how the average level of efficiency is quite low in both cohorts (0.47 and 0.30, respectively), so large improvements towards a more efficient use of resources are possible. Overall, the answer to the first research question of this paper confirms that Italian local governments are actually inefficient in providing the ancillary educational services.

Moreover, this evidence shows a clear increase in inequality among municipalities, since polarisation in the two extremes of the distribution of efficiency scores increased over time. The analysis of the efficiency scores has been reported by geographical macroareas (Northern Italy, Central and Southern) to investigate where efficient or inefficient DMUs are located. The pattern that emerges is counterintuitive with respect to the usual North/South divide reported in many areas of Italian social and economic development. Specifically, Northern regions show lower efficiency values (0.27-0.44) compared to regions in the Southern area (0.39-0.57).

This phenomenon has a potential explanation related to higher levels of expenditures of municipalities in Northern regions, which 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. Finally, given the share of super-efficient municipalities (especially, in the South) the results confirm the methodological importance of using an order-*m* approach to mitigate the impact of outliers.

Table 4. Order-*m* efficiency scores of local governments, overall analysis

	2012/2013			**2014/2015**		
Efficiency level	*North*	*Centre*	*South*	*North*	*Centre*	*South*
Mean	0.44	0.42	0.57	0.27	0.26	0.39
Min	0.13	0.16	0.15	0.05	0.06	0.06
Max	1.57	1.45	1.47	1.53	1.29	1.58
Efficient units $(\boldsymbol{\theta = 1})$						
Number of obs.	12	3	15	5	9	4
Share of the total	0.53%	0.45%	1.34%	0.20%	1.18%	0.31%
Super-efficient units $(\boldsymbol{\theta > 1})$						
Number of obs.	35	9	59	26	2	44
Share of the total	1.54%	1.36%	5.27%	1.02%	0.26%	3.46%

Notes: Average efficiency score using m=100 and with bootstrap $D = 3000$. Theta indicates the efficiency score derived by the model. Efficient ($\theta = 1$) and super-efficient ($\theta > 1$) municipalities are presented by number of observations and by share over the total number of municipalities in the macro-area.
Source: INVALSI-SOSE dataset. Author's elaborations.

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

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Results from the three-level multilevel modelling for the academic year 2012/13 and 2014/15 are presented in Table 5, 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 across school-units and across 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 2012/13 and for academic year 2014/15. We control for geographical fixed-effect areas (to keep structural unobservable differences into account) and the average income levels within municipalities (GDP mean).

Table 5. Factors associated with students' performance: econometric results from the three-level multilevel approach

VARIABLES	Reading 2012/13	Math 2012/13	Reading 2014/15	Math 2014/15
Gender (girl=1)	6.836***	-6.497***	3.715***	-6.357***
	(0.127)	(0.126)	(0.128)	(0.125)
Early enrolment (yes=1)	-1.028*	0.517	-2.466***	-1.665**
	(0.618)	(0.613)	(0.660)	(0.649)
Late enrolment (yes=1)	-14.799***	-9.780***	-14.242***	-11.301***
	(0.423)	(0.416)	(0.451)	(0.431)
First immigrant status (yes=1)	-17.612***	-11.341***	-13.335***	-8.499***
	(0.362)	(0.357)	(0.389)	(0.371)
Second immigrant status (yes=1)	-15.032***	-10.406***	-11.766***	-8.026***
	(0.285)	(0.281)	(0.258)	(0.249)
Highest education father (MA degree =1)	2.664***	2.934***	3.658***	2.930***
	(0.257)	(0.256)	(0.238)	(0.233)
Highest education mother (MA degree =1)	4.255***	4.152***	5.291***	4.417***
	(0.241)	(0.240)	(0.221)	(0.216)
ESCS	8.715***	8.209***	9.023***	8.747***
	(0.084)	(0.085)	(0.094)	(0.092)
% girls	0.004	0.028**	0.007	0.048***
	(0.012)	(0.014)	(0.012)	(0.013)
% First immigrant status	-0.054**	-0.080**	-0.022	-0.129***
	(0.027)	(0.033)	(0.033)	(0.033)
% Second immigrant status	0.048***	-0.011	-0.034*	-0.029
	(0.017)	(0.021)	(0.020)	(0.020)
% 27 hours	0.016**	0.027***	0.010	-0.012
	(0.006)	(0.007)	(0.013)	(0.013)
% 28_30 hours	0.018***	0.024***	0.011***	-0.004
	(0.006)	(0.006)	(0.004)	(0.004)
% 31_39 hours	0.012	0.010	0.012***	-0.005
	(0.008)	(0.010)	(0.004)	(0.005)
% 40 hours	0.004	0.036***	-0.027	-0.093***
	(0.006)	(0.007)	(0.019)	(0.019)
% early enrolment	-0.053	-0.146***	-0.012	-0.013
	(0.042)	(0.050)	(0.044)	(0.046)
% late enrolment	-0.111***	-0.123***	-0.173***	-0.153***
	(0.035)	(0.042)	(0.039)	(0.039)
% highest education father	0.000	0.021	-0.019	-0.001
	(0.023)	(0.027)	(0.023)	(0.023)
% highest education mother	-0.021	-0.006	0.008	-0.001
	(0.021)	(0.025)	(0.021)	(0.021)
ESCS school-unit	-0.590	-1.897***	-2.228***	-1.825***
	(0.441)	(0.540)	(0.552)	(0.574)
Efficiency score	-0.260	-0.458	-1.827*	0.159

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	(0.756)	(0.946)	(1.042)	(1.066)
GDP municipality	0.015	0.125**	0.001	0.014
	(0.044)	(0.060)	(0.051)	(0.053)
Centre	-1.495***	-2.662***	0.743	-1.205**
	(0.390)	(0.486)	(0.484)	(0.497)
South	-8.808***	-9.134***	-3.698***	-3.490***
	(0.390)	(0.484)	(0.494)	(0.508)
No. Obs.	309,576	311,376	313,498	328,246
No. municipality	4,063	4,067	4,576	4,641
No. school-units	9,541	9,587	10,780	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.

The main findings reveal the lack of statistically significant correlation between local governments' efficiency and test scores. This indicates that an efficient of inefficient use of financial resources to produce ancillary services does not directly affect how well students perform at school, when measuring this construct through test scores. The only coefficient that is slightly significant (at 8%) is negative in sign and refers to the correlation with the reading test score. The sign of the coefficient may be related to the fact students' test scores tend to be higher in Northern regions, where the level of efficiency is on average lower, while the opposite trend holds for Southern regions. Thus, this contrasting relationship between efficiency and test scores may be reflected in the observed coefficient. The lack of a strong significant correlation between the level of efficiency in the use of resources for ancillary services and the students' test score may be interpreted in two ways. On the one side, this can be actually reflecting the absence of a direct relationship between efficiency and students' results. On the other side, the lack of statistical correlations might indicate the need to measure efficiency differently, possibly taking into account both the efficiency and the quality of services. By adopting the current measurement of efficiency, the lack of a significant relationship should be interpreted cautiously.

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 usual cohort (age 6) 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 be associated with the reduction of the test score by around 14 points. The same tendency emerges regarding the immigration status: 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 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 evidence 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 enrolled students, percentage of fathers and mothers with high educational level). Being a student who attends the most reduced weekly school time is positively related to achievement, as well as having a mother who attained 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 (slightly) decreasing gap with other geographical areas.

The multilevel model 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 optimisation.

The results of the variance decomposition are presented in Table 6[8]. 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 – 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 interval, statistically significant differences between academic years and subjects can be confirmed. 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 indicate that the variance at municipality level is limited, yet consistent

[8] As an additional check on our results, we present in Appendix A, Figure A.2, 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.4).

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across different models. Moreover, structural differences across municipalities, after having controlled for individuals and schools' features, 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 6. Estimated impact of the efficiency scores on student achievement and variance explained at each level of the multilevel regression model

	Efficiency scores			
	Reading 2012/13	Math 2012/13	Reading 2014/15	Math 2014/15
Efficiency scores coefficient	-0.260 (0.756)	-0.453 (0.946)	-1.698 (1.056)	0.154 (1.082)
Between municipality variance (%)	1.03	1.72	1.36	1.62
Between school-units variance (%)	6.64	11.17	12.16	13.04
Within school-units variance (%)	92.33	87.11	86.49	85.34
No. obs	309,576	311,376	313,498	328,246
No. municipality	4,063	4,067	4,576	4,641
No. school-units	9,541	9,587	10,780	10,748

Source: INVALSI-SOSE database
Notes: Robust standard errors are shown in brackets. Superscripts ***, ** and * denote 1, 5 and 10 per cent significance level respectively.

8. 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 transportation from and to school. 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 a 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 a (small) part of the heterogeneity across students' achievement is explained at municipality level. Identifying the determinant(s) which drive the differential

among students' results is an important conceptual and 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. However, our results illustrate 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, an 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.

The results contribute to the conceptual definition of the elements influencing student achievement in an EPF framework, by enlarging the scope of school resources in order to explicitly include the amount of expenditure to provide peripheral services (Hanushek, 2008). Resources, in turn, may be employed with heterogenous levels of efficiency, and this should be properly taken into account when studying the elements that influence student achievement. On the empirical side, we contribute by highlighting (i) the large room for improvement towards an efficient provision of ancillary services, and (ii) the portion of variance in student achievement that may be explained by differences across municipalities, an intermediate level of grouping often neglected in the educational literature. The existence of such a level of variability should capture the attention of policy-makers when designing school policies, stressing the role of the school as part of a larger ecosystem that, in its entirety, influences the educational success.

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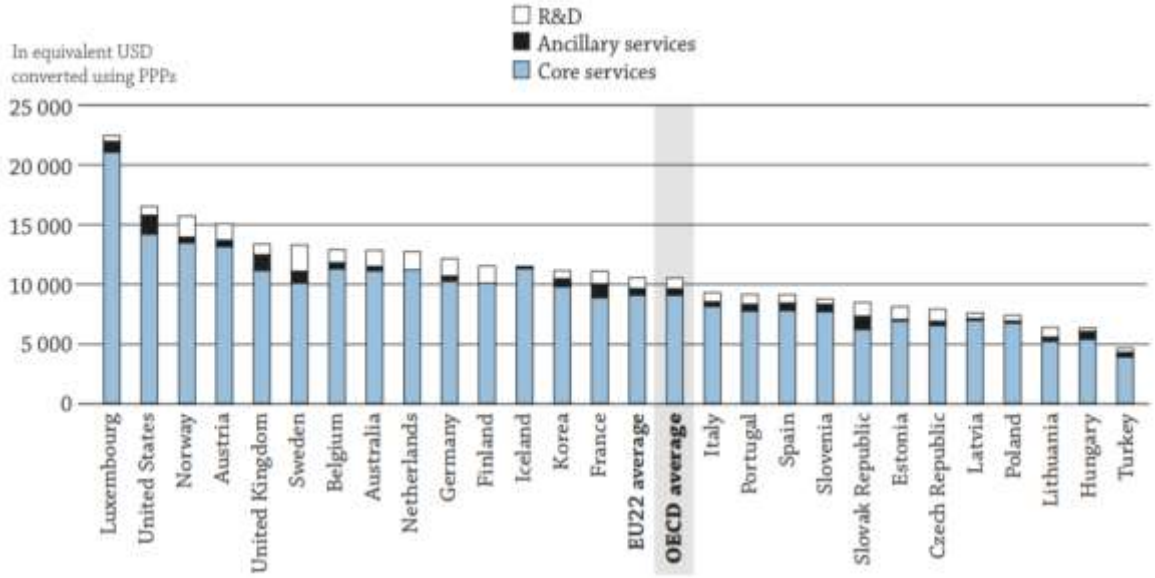
APPENDIX A

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. Descriptive Statistics academic year 2012/2013 for macroarea North

	Reading 2012/2013				**Mathematics 2012/2013**			
Variables	Obs	Mean	Min	Max	Obs	Mean	Min	Max
Test score	147,810	207.99	1.11	351.23	148,844	210.50	-5.56	388.49
Girl	147,810	0.50	0	1	148,844	0.50	0	1
Early enrolment	147,810	0.01	0	1	148,844	0.00	0	1
Late enrolment	147,810	0.03	0	1	148,844	0.03	0	1
First immigration status	147,810	0.05	0	1	148,844	0.05	0	1
Second immigration status	147,810	0.08	0	1	148,844	0.08	0	1
Highest education father	147,810	0.10	0	1	148,844	0.10	0	1
Highest education mother	147,810	0.12	0	1	148,844	0.12	0	1
ESCS	147,810	0.07	-3.11	2.60	148,844	0.09	-3.10	2.60
% girls	147,810	49.83	0	93.75	148,844	49.71	0	94.12
% first immig. status	147,810	5.31	0	60	148,844	5.37	0	60
% second immig. status	147,810	7.93	0	86.67	148,844	7.97	0	86.67
% 27 hours	147,810	14.00	0	100	148,844	14.03	0	100
% 28_30 hours	147,810	40.33	0	100	148,844	40.28	0	100
% 31_39 hours	147,810	3.90	0	100	148,844	3.91	0	100
% 40 hours	147,810	30.60	0	100	148,844	30.52	0	100
% early enrolment	147,810	0.29	0	81.25	148,844	0.29	0	75

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% late enrolment	147,810	3.37	0	61.11	148,844	3.41	0	61.11
% highest educ. father	147,810	10.11	0	78.95	148,844	10.08	0	73.68
% highest educ. mother	147,810	11.99	0	86.67	148,844	11.96	0	86.67
ESCS school-unit	147,810	0.07	-1.41	1.97	148,844	0.09	-1.36	1.99
Meals	147,810	0.28	0.01	0.63	148,844	0.28	0.01	0.63
Transportations	147,810	0.14	0.01	0.86	148,844	0.14	0.01	0.86
Efficiency scores	147,810	0.41	0.13	1.57	148,844	0.41	0.13	1.58
GDP_municipality	147,810	20.22	11.91	54.32	148,844	19.96	11.91	42.12

Source: Authors' elaborations on INVALSI-SOSE data.

Table A.2. Descriptive Statistics academic year 2012/2013 for macroarea Center

	Reading 2012/2013				**Mathematics 2012/2013**			
Variables	Obs	Mean	Min	Max	Obs	Mean	Min	Max
Test score	61,873	208.37	1.11	351.22	62,890	210.64	-5.55	388.49
Girl	61,873	0.49	0	1	62,890	0.49	0	1
Early enrolment	61,873	0.01	0	1	62,890	0.01	0	1
Late enrolment	61,873	0.03	0	1	62,890	0.03	0	1
First immigration status	61,873	0.05	0	1	62,890	0.05	0	1
Second immigration status	61,873	0.09	0	1	62,890	0.09	0	1
Highest education father	61,873	0.10	0	1	62,890	0.10	0	1
Highest education mother	61,873	0.12	0	1	62,890	0.12	0	1
ESCS	61,873	0.11	-3.10	2.60	62,890	0.13	-2.77	2.60
% girls	61,873	49.42	0	87.5	62,890	49.33	0	86.96
% first immig. status	61,873	5.29	0	100	62,890	5.40	0	100
% second immig. status	61,873	9.01	0	100	62,890	9.21	0	100
% 27 hours	61,873	12.57	0	100	62,890	12.57	0	100
% 28_30 hours	61,873	44.28	0	100	62,890	43.83	0	100
% 31_39 hours	61,873	4.30	0	100	62,890	4.23	0	100
% 40 hours	61,873	25.55	0	100	62,890	25.91	0	100
% early enrolment	61,873	0.62	0	44.12	62,890	0.62	0	45.45
% late enrolment	61,873	3.41	0	28.57	62,890	3.48	0	30.77
% highest educ. father	61,873	9.70	0	81.82	62,890	9.60	0	81.82
% highest educ. mother	61,873	12.25	0	83.33	62,890	12.15	0	83.33
ESCS school-unit	61,873	0.11	-1.58	1.67	62,890	0.13	-1.62	1.70
Meals	61,873	0.29	0.03	0.59	62,890	0.29	0.03	0.59
Transportations	61,873	0.19	0.01	0.84	62,890	0.19	0.01	0.84
Efficiency scores	61,873	0.41	.16	1.45	62,890	0.41	0.15	1.45
GDP_municipality	61,873	20.26	12.73	41.30	62,890	20.06	12.62	41.30

Source: Authors' elaborations on INVALSI-SOSE data.

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Table A.3. Descriptive Statistics academic year 2012/2013 for macroarea South

	Reading 2012/2013				**Mathematics 2012/2013**			
Variables	Obs	Mean	Min	Max	Obs	Mean	Min	Max
Test score	99,893	205.38	1.11	351.22	99,642	210.17	-5.55	388.49
Girl	99,893	0.49	0	1	99,642	0.49	0	1
Early enrolment	99,893	0.03	0	1	99,642	0.03	0	1
Late enrolment	99,893	0.02	0	1	99,642	0.02	0	1
First immigration status	99,893	0.02	0	1	99,642	0.02	0	1
Second immigration status	99,893	0.02	0	1	99,642	0.02	0	1
Highest education father	99,893	0.09	0	1	99,642	0.09	0	1
Highest education mother	99,893	0.10	0	1	99,642	0.10	0	1
ESCS	99,893	-0.13	-3.11	2.60	99,642	-0.10	-3.10	2.60
% girls	99,893	49.39	0	91.67	99,642	49.26	0	91.67
% first immig. status	99,893	1.75	0	35.71	99,642	1.78	0	38.46
% second immig. status	99,893	1.85	0	100	99,642	1.85	0	100
% 27 hours	99,893	15.53	0	100	99,642	15.62	0	100
% 28_30 hours	99,893	71.35	0	100	99,642	71.27	0	100
% 31_39 hours	99,893	1.76	0	100	99,642	1.75	0	100
% 40 hours	99,893	7.42	0	100	99,642	7.42	0	100
% early enrolment	99,893	2.64	0	60	99,642	2.67	0	60
% late enrolment	99,893	1.94	0	41.67	99,642	1.96	0	41.67
% highest educ. father	99,893	8.68	0	72.41	99,642	8.67	0	72.41
% highest educ. mother	99,893	10.15	0	83.33	99,642	10.15	0	89.29
ESCS school-unit	99,893	-0.13	-2.24	1.85	99,642	-0.10	-2.24	1.85
Meals	99,893	0.13	0.01	0.60	99,642	0.13	0.01	0.60
Transportations	99,893	0.13	0.01	0.88	99,642	0.13	0.01	0.86
Efficiency scores	99,893	0.54	0.14	1.47	99,642	0.54	0.15	1.47
GDP_municipality	99,893	20.10	12.62	74.74	99,642	20.06	12.28	36.24

Source: Authors' elaborations on INVALSI-SOSE data.

Table A.4. Descriptive Statistics academic year 2014/2015 for macroarea North

	Reading 2014/2015				Mathematics 2014/2015			
Variables	Obs	Mean	Min	Max	Obs	Mean	Min	Max
Test score	160,533	207.91	-23.41	392.90	167,718	207.62	14.58	364.75
Girl	160,533	0.49	0	1	167,718	0.49	0	1
Early enrolment	160,533	0.00	0	1	167,718	0.00	0	1
Late enrolment	160,533	0.03	0	1	167,718	0.03	0	1
First immigration status	160,533	0.04	0	1	167,718	0.04	0	1
Second immigration status	160,533	0.10	0	1	167,718	0.10	0	1
Highest education father	160,533	0.12	0	1	167,718	0.12	0	1
Highest education mother	160,533	0.15	0	1	167,718	0.15	0	1
ESCS	160,533	0.05	-2.84	2.27	167,718	0.05	-2.84	2.27
% girls	160,533	49.33	0	100	167,718	49.17	0	100
% first immig. status	160,533	4.10	0	66.67	167,718	4.23	0	66.67
% second immig. status	160,533	9.75	0	100	167,718	9.88	0	100
% 27 hours	160,533	1.92	0	100	167,718	1.86	0	100
% 28_30 hours	160,533	24.67	0	100	167,718	24.66	0	100
% 31_39 hours	160,533	27.17	0	100	167,718	26.95	0	100
% 40 hours	160,533	0.44	0	100	167,718	0.42	0	100
% early enrolment	160,533	0.30	0	100	167,718	0.30	0	100
% late enrolment	160,533	2.62	0	100	167,718	2.70	0	100
% highest educ. father	160,533	12.03	0	100	167,718	11.92	0	88.24
% highest educ. mother	160,533	15.23	0	100	167,718	15.12	0	100
ESCS school-unit	160,533	0.05	-1.71	1.86	167,718	0.05	-1.71	1.86
Efficiency scores	160,533	0.24	0.05	1.54	167,718	0.24	0.05	1.54
GDP_municipality	160,533	16.78	6.35	42.42	167,718	16.74	7.09	51.40

Source: Authors' elaborations on INVALSI-SOSE data.

Table A.5. Descriptive Statistics academic year 2014/2015 for macroarea Center

	Reading 2014/2015				Mathematics 2014/2015			
Variables	Obs	Mean	Min	Max	Obs	Mean	Min	Max
Test score	75,178	211.53	-23.41	392.90	81,386	210.55	14.58	364.75
Girl	75,178	0.49	0	1	81,386	0.49	0	1
Early enrolment	75,178	0.01	0	1	81,386	0.01	0	1
Late enrolment	75,178	0.02	0	1	81,386	0.03	0	1
First immigration status	75,178	0.03	0	1	81,386	0.04	0	1
Second immigration status	75,178	0.08	0	1	81,386	0.08	0	1
Highest education father	75,178	0.13	0	1	81,386	0.13	0	1
Highest education mother	75,178	0.17	0	1	81,386	0.17	0	1
ESCS	75,178	0.13	-2.84	2.27	81,386	0.13	-2.84	2.27
% girls	75,178	48.76	0	100	81,386	48.56	0	100
% first immig. status	75,178	3.45	0	100	81,386	3.64	0	100
% second immig. status	75,178	7.72	0	100	81,386	7.98	0	100
% 27 hours	75,178	0.97	0	100	81,386	0.93	0	100
% 28_30 hours	75,178	25.30	0	100	81,386	25.03	0	100
% 31_39 hours	75,178	24.45	0	100	81,386	23.46	0	100
% 40 hours	75,178	0.37	0	100	81,386	0.34	0	100
% early enrolment	75,178	0.94	0	100	81,386	0.91	0	100
% late enrolment	75,178	2.53	0	100	81,386	2.68	0	100
% highest educ. father	75,178	13.36	0	100	81,386	13.08	0	100
% highest educ. mother	75,178	17.01	0	100	81,386	16.67	0	100
ESCS school-unit	75,178	0.13	-2.48	1.79	81,386	0.13	-2.48	1.82
Efficiency scores	75,178	0.21	0.06	1.28	81,386	0.21	0.06	1.29
GDP_municipality	75,178	16.43	8.77	33.73	81,386	17.92	8.10	42.42

Source: Authors' elaborations on INVALSI-SOSE data.

Table A.6. Descriptive Statistics academic year 2012/2013 for macroarea South

	Reading 2014/2015				**Mathematics 2014/2015**			
Variables	Obs	Mean	Min	Max	Obs	Mean	Min	Max
Test score	77,787	211.30	-23.41	392.90	79,142	213.57	14.58	364.75
Girl	77,787	0.49	0	1	79,142	0.49	0	1
Early enrolment	77,787	0.03	0	1	79,142	0.03	0	1
Late enrolment	77,787	0.02	0	1	79,142	0.02	0	1
First immigration status	77,787	0.02	0	1	79,142	0.02	0	1
Second immigration status	77,787	0.02	0	1	79,142	0.02	0	1
Highest education father	77,787	0.10	0	1	79,142	0.10	0	1
Highest education mother	77,787	0.13	0	1	79,142	0.13	0	1
ESCS	77,787	-0.15	-2.84	2.27	79,142	-0.13	-2.84	2.27
% girls	77,787	48.95	0	100	79,142	48.78	0	100
% first immig. status	77,787	1.67	0	100	79,142	1.72	0	100
% second immig. status	77,787	2.21	0	100	79,142	2.26	0	100
% 27 hours	77,787	0.75	0	100	79,142	0.75	0	100
% 28_30 hours	77,787	43.95	0	100	79,142	44.08	0	100
% 31_39 hours	77,787	35.79	0	100	79,142	35.53	0	100
% 40 hours	77,787	0.59	0	100	79,142	0.58	0	100
% early enrolment	77,787	2.55	0	66.67	79,142	2.53	0	50
% late enrolment	77,787	1.81	0	100	79,142	1.82	0	100
% highest educ. father	77,787	10.12	0	100	79,142	1.00	0	100
% highest educ. mother	77,787	12.58	0	100	79,142	12.49	0	100
ESCS school-unit	77,787	-0.15	-2.00	1.63	79,142	-0.13	-2.07	2.18
Efficiency scores	77,787	0.42	0.06	1.59	79,142	0.43	0.06	1.59
GDP_municipality	77,787	16.83	7.09	51.40	79,142	16.54	6.35	32.52

Source: Authors' elaborations on INVALSI-SOSE data.

Table A.7. 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

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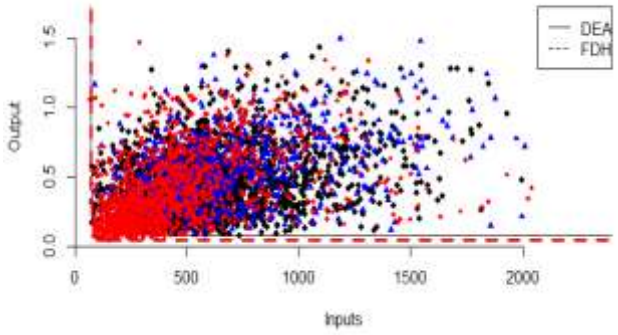
Table A.8. DEA – VRS efficiency analysis (overall analysis)

	2012/2013	2014/2015
Efficiency score	0.32	0.18

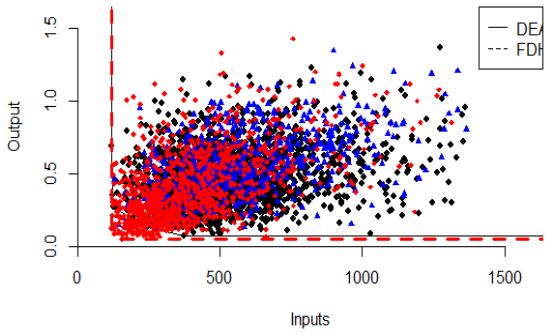
Notes: Average efficiency values
Source: INVALSI-SOSE dataset

Figure A.2. DEA-VRS and FDH frontiers

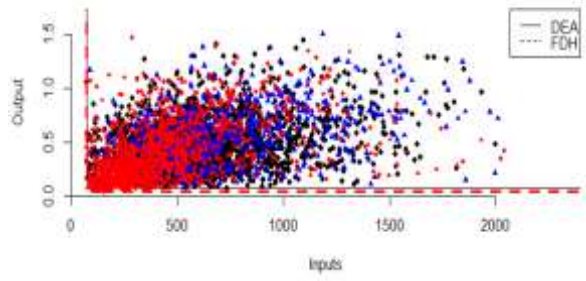
Panel A



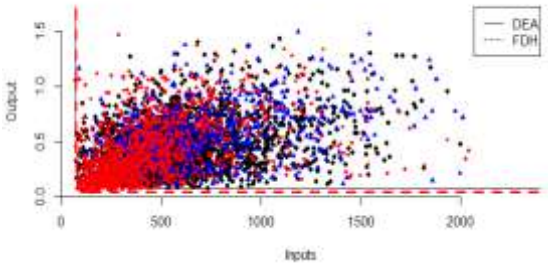
Panel B



Panel C



Panel D



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).

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