# Schooling worth getting? School Efficiency and Human-Capital Accumulation in Italy's Provinces, 1861 – 1911

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**Abstract**

This paper sheds new light on the factors that fostered basic education in Italy between 1871 and 1911, while exploring how school efficiency – the capability to reach better educational outcomes given school inputs – evolved over time. We employ a new dataset on educational outcomes, school inputs, and socio-economic factors in the country's 69 provinces at ten-year intervals. First, a historical aggregate Education Production Function is estimated for each province, allowing us to assess to what extent growing inputs provided by Italy's public school system translated into increased literacy among school-age children (age 6 to 10) and youngsters (age 15 to 19) – and how much each input contributed to the overall output. We find that schooling was worth getting, as GERs and other inputs into primary schooling are always significantly correlated with literacy levels for both age groups. As a second step, we use Data Envelopment Analysis to estimate school-efficiency scores based on the relationship between school inputs and educational outputs. The efficiency scores obtained are used to investigate the role that non-discretionary inputs – i.e. demographic, geographic, and socioeconomic factors – played in determining school efficiency across the provinces of Italy in the late-19$^{th}$ century. Our results suggest that pre-unification school systems cast a long shadow on post-unification educational trends, but this historical legacy started to fade out at the turn of the 20$^{th}$ century – and even more when Italy started to slowly shift towards centralized primary education (1901 – 1911).

JEL codes: E02, H75, I25, N33.

Keywords: School efficiency, human capital, education inputs, economic history, Italy.

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## 1. Introduction

The problem of school efficiency is a pressing one in the context of today's development and education policy. The Millennium Development Goal of universal primary schooling brought about increased enrolments and attendance – yet it often compromised quality education. Economic historians have shown that European countries on the eve of the 20th century tackled similar issues. Indeed, schooling expanded rapidly; yet, this pattern of growth was characterized by large regional inequalities within and across countries: some areas, especially in southern Europe, remained characterized by limited improvements in literacy (Lindert 2004; Mitch 2013).

Recent research has focused on a number of European regions in the 19th century and up to World War I. Most contributions have explored the role that school policy, as well as a variety of socio-economic and institutional factors, played in the expansion of inputs into schooling (see e.g. Beltran Tapia and Martinez-Galarraga, 2015; Cappelli, 2016b; Cinnirella and Hornung, 2016 on Spain, Italy, and Prussia respectively). However, little is still known about the extent to which increased schooling translated into better educational outcomes. Was primary schooling worth getting? Within this broad issue, one aspect that calls for more research is that of improvements in school efficiency – i.e. increased outcomes given inputs – which may have been even more important for the expansion of mass primary education than inputs; yet, this remains an under-researched topic. Contemporary field research within the economics of education has focused on this issue. However, present-day studies can hardly trace the impact of public policies aimed to spread and improve education in the medium and long run, given the high costs associated with randomized controlled trials.

The case of Italy before the Great War is of interest to explore the relationship between school inputs and educational outcomes, to both economists and economic historians. Italy was not yet an industrialized country, and shared several features with today's developing world: remarkable regional disparities, an enormous share of its labour force in agriculture, very limited railway and road infrastructure, extensive poverty and land inequality, extremely poor literacy and – at least in some areas – limited political voice and institutions that were more likely to maintain the status quo than fostering structural change. Although some recent work has shed light on the factors that determined the country's trajectory of human capital accumulation and regional convergence in primary schooling (Felice and Vasta 2015; A'Hearn, Auria, and Vecchi 2011; Cappelli 2016a), a more thorough analysis of the impact of such development on literacy is still lacking. Furthermore, no attempt has been made to

combine the narrative based on school inputs with one focused on the management of primary schools, late-19th-century reforms and the administration of primary education – which likely had an impact on school efficiency more than on the quantity of schooling itself. We first test whether getting more public schooling was worth the financial effort, against the hypothesis that the development of literacy was driven mainly by demand-side factors. In a second step, we explore whether school-efficiency played a role in the development of literacy, and whether it depended on the functioning of local education systems or the social and economic context in which it existed. Our hypothesis is that regional education systems differed in their capability to convert inputs into educational outcomes,[3] and that this was due to different initial conditions inherited from pre-unification (pre-1861) institutions.

To investigate these issues, we employ a newly assembled dataset by Bozzano and Cappelli (2016), which presents data on educational outcomes, school inputs, as well as demographic, geographic and socio-economic factors in the country's 69 provinces at ten-year intervals between 1871 and 1911.[4] First, we define and estimate a historical aggregate Education Production Function (henceforth EPF) at the province level. This allows us to explore to what extent growing inputs provided by Italy's newly established public school system translated into increased literacy among school-age children (age 6 to 10) and youngsters (age 15 to 19), and how much each input contributed to the overall output. Inputs into schooling – especially the Gross Enrolment Ratio – are always strongly correlated with literacy rates: primary schooling was indeed worth getting. Second, we use Data Envelopment Analysis, a non-parametric linear programming technique which measures the relative efficiency of a set of homogenous Decision Making Units (i.e. our provinces) and determines the efficiency scores based on a comparison of school inputs and educational outputs. The school-efficiency scores obtained are then employed to analyze what role demographic, geographic and socio-economic factors (i.e. non-discretionary inputs) played in producing differences in efficiency across the provinces of Italy. Our results suggest that pre-unification school systems cast a long shadow on post-unification school efficiency, but this historical legacy started to fade out at the turn of the 20th century – and even more when Italy started to slowly shift towards centralized primary education (1901 – 1911).

The paper is organized as follows: section 2 briefly presents the literature on Education Production Functions, while section 3 describes Italy's education system in the period under

[3] The terms "outcome" and "output" are used interchangeably throughout this paper.

[4] 1871 represents the year of the first census after the completion of the country's unification, while 1911 represents the last census year before World War I.

study. Section 4 presents the data employed in the analysis and some relevant stylized facts. Section 5 describes the methods that we use and presents the results of our estimates with a discussion of some robustness checks. Section 6 introduces the two-step procedure to measure efficiency and investigate its determinants across provinces. Section 7 concludes.

## 2. Literature review

A broad field of the literature on the economics of education is devoted to EPFs and attempts to estimate them empirically. In the last two decades, many contributions have tried to assess to what extent school quantity and quality have an impact on educational outcomes and achievements. Most contributions rely on modern data. Hanushek (2006) has been one of the authors to analyze educational outcomes at both the individual and aggregate level, for developed and developing countries alike since the 1960s. He has focused on the relationship between resources into schooling (quantity) and student achievements to conclude that there exists little consistent relationship between them. Hanushek (2003) has also focused on the quality of schooling and highlighted how resources have a small role in producing improvements in student outcomes. Similarly, Card and Krueger (1992) underlined the positive role of school quality – i.e. the pupil-teacher ratio and individual characteristics of the teachers – on economic returns to education in the US. Finally, Hanushek and Woessmann (2011) have reviewed the economic literature on international educational achievements granted the new availability of international cross-country data. They have confirmed previous findings, which suggest that policies aimed to put more resources into schooling are unlikely to foster educational outcomes if they are not accompanied by complementary interventions.

Few authors have investigated the relationship between school inputs and outputs in a historical perspective. For example, Mitch (1984) has estimated the return to male literacy in Victorian England by focusing on government intervention and funding, while more recently Schueler (2016) has focused on the relationship between school inputs and subsequent earnings by using original data on Prussian counties between 1886 and 1891. This paper is therefore the first attempt to employ the EPF framework in a historical, long-term perspective, to explore whether more public schooling translated into more rapid human capital accumulation and whether school efficiency contributed to the pattern observed.

## 3. Italy's primary-education system, 1859 – 1911

Italy's unified education system was a result of the imprint given by the Casati Law, passed in the Kingdom of Sardinia (Sardinia and Piedmont) in 1859, and later extended to the newly annexed areas of the Kingdom of Italy – the unification of which was completed in 1871. As far as primary education was concerned, the system was very centralized, as the central government set all the formal rules regulating the primary schools. The Law stated that primary schooling had to be provided free of charge, for at least two years. Additional two years were compulsory in larger municipalities and where a secondary school had already been established. Despite centralized formal provisions, the funding and management of schooling was fully decentralized, being the responsibility of each municipality to comply with the state law by hiring teachers, paying them, building and running schools and enforce attendance. When it was set forth in 1859, the Casati primary-education Law lacked any redistributive mechanism to make up for large regional economic disparities, which translated into large regional inequalities in the capability to fund primary education. The Coppino Reform of 1877 strengthened the very weak sanctions for the families of children of compulsory-school age who never enrolled. Compulsory education was also brought to three years, yet this had little effect on enrolments and the growth of literacy – even though a weak system of subsidies aimed at the poorest municipalities was implemented. State intervention became more decisive at the turn of the 20th century, although a real step towards centralization was only taken in 1911 with the Daneo-Credaro Reform. Still, in 1903 and 1904 the Orlando and Nasi Laws increased teachers' salaries and improved their position vis-à-vis the city councils, which up to that point could discretionarily hire or lay-off them. With the first two reforms concerned with schooling of the early-20th century, the state had intervened more decidedly in matters related to primary education than ever before.

## 4. Province data on Italy's primary schooling (1871 – 1911) and stylized facts

The first challenge that our analysis tackles is that of identifying and measuring education outputs and inputs, together with school efficiency, which is far from straightforward in a historical perspective – mainly because of data scarcity and issues due to data quality. However, Italy's historical statistics and inquiries into the state of primary education in the second half of the 19$^{th}$ century provide a rich and reliable data source, which can be used to study the issues at hand in a long-term perspective. Indeed, we rely on a newly assembled

panel dataset (Bozzano and Cappelli, 2016) on educational outcomes and school inputs in late-19th-century Italy at provincial level (roughly today's NUTS-3). Data are collected from various sources such as population censuses, vital statistics, municipalities' balance sheets, and specific inquiries into primary education. The latter were published regularly from 1865 until well into the Fascist period, although the latest inquiry concerning the Liberal system of primary education was published in 1923. Most inquiries provided both very detailed data and vivid pictures of the state of Italy's primary schools across its regions. For example, the Torraca Inquiry (published in 1897) contains the reports of primary-school inspectors that portray the poor state of Italy's primary education. An inspector from Susa (Piedmont) mentioned schools set up in stables, where – unsurprisingly – the noise of animals was a constant source of distraction for the pupils. Another one reported about schools in Vasto (Abruzzi) that were lacking breathable air, light to study and teach, the walls of which were dripping moisture.

Literacy rates for children (aged 6 to 10) and youngsters (15 to 19), our dependent variables, have been calculated through the population censuses.[5] The inquiries provide information on the number of pupils enrolled in primary (state and private) schools, the number of teachers and the number of schools, from which we calculate the Gross Enrolment Ratio, the pupil-teacher ratio, and the density of state schools as the number of schools per squared km. We also calculate the ratio between pupils enrolled in private schools and those in state ones, which we use as a control. We collected information on expenditures on education from the municipalities' balance sheets (*Bilanci Comunali*), published by the Ministry of Agriculture, Industry and Trade (MAIC), used to calculate expenditure per pupil.

We also include variables that are not pertaining to the education system itself, and divide them into three groups: geography, demography, and socio-economic aspects. Geography controls include latitude, longitude, average temperature, and average rainfall.[6] Demographic variables include population density (residents per squared km), a proxy for the dependency ratio (children aged 6 to 10 as a share of total population), the infant mortality rate and the rate of outward migration (emigrants as a share of total residents). The latter is added to control for potential brain drain (see Gomellini and O'Grada, 2013, and Giffoni and Gomellini, 2015). Figures on emigrants are obtained from the Yearbook on Italian Migration (*Annuario della Emigrazione Italiana dal 1876 al 1925*). Infant mortality rates are calculated

[5] Since the Unification of Italy in 1861 censuses specifically inquired about the literacy of population. More specifically, the question about literacy was asked to the head of the family who answered for all components of the household.

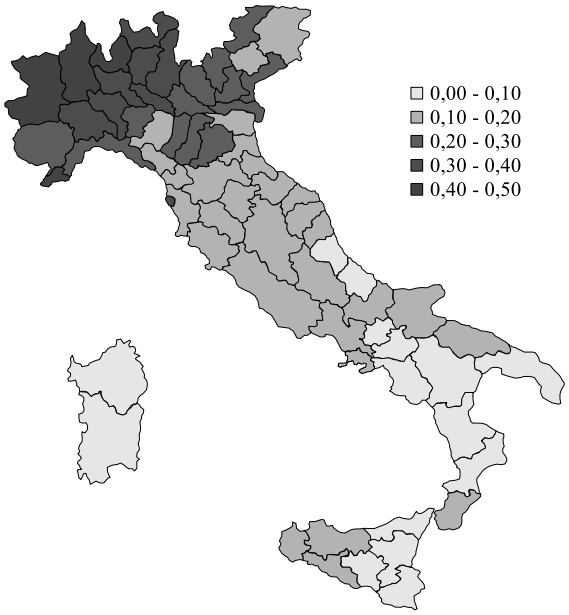
[6] Data on temperatures and rainfalls refer to provincial averages calculated in the period 2000-2009.

from vital statistics (*Movimento dello Stato Civile*), while population density and the dependency ratio are elaborations from census figures. Socio-economic variables include the height of conscripts[7] aged 20 organized by birth cohort, obtained from A'Hearn and Vecchi (2011), as a proxy for economic well-being; industrial Value Added per capita obtained by combining data from Ciccarelli and Fenoaltea (2013) with population figures; the share of the labour force in agriculture, thanks to data kindly provided by Missiaia (2014); electoral franchise, represented by the share of adult males (21+) entitled to vote in local (e.g. municipal) elections (Cappelli, 2016b); finally, we also include parental human capital thanks to data on the percentage of spouses who were able to sign wedding acts, from vital statistics (smoothed on three years and centered at the years of the censuses). All the socio-economic controls should capture features that may affect the expansion of education, like its opportunity cost, the fact the poorer provinces would not be able to fund primary schools, and the varying degree of support for the diffusion of mass education, which likely depended on enfranchisement and parental human capital (Lindert 2004). Our data cover 69 Italian provinces (at 1871 boundaries) for 5 points in time (1871, 1881, 1891, 1901, and 1911), spanning the initial fifty years of the unified Kingdom of Italy. These figures are uncommonly rich for a late-19$^{th}$-century country, and give us the precious opportunity to gain new insights into the performance of the Italian education system before more pervasive and coherent education policies were introduced starting during the first decade of the 20$^{th}$ century. More details on the definitions and sources of all variables, as well as on methodological issues, can be found in the Appendix.[8]

Selected descriptive statistics are reported in Table 1 below. The data show that, on average, of all children aged 6 to 10 only 18 percent were literate in 1871, and this share increased considerably throughout time. In 1911 more than half of all school-age children were literate. The average GER in 1871 was 0.62 and reached 1.10 by 1911. A similar pattern is revealed by the literacy rates of young people (aged 15-19), even though the level appears to have been generally higher – values changed from 34 percent in 1871 to 71 percent in 1911.
The map in Figure 1 reports literacy rates for children aged 6-10 in 1871. Darker areas are characterized by higher literacy rates.

[7] Height is commonly employed in economic history as a proxy for wealth and living standard because it provides important information on the stock of nutritional investment and therefore on changes in the well-being of populations. For an in-depth presentation of the methodology, see A'Hearn, Peracchi, and Vecchi (2009).
[8] The Appendix is available upon request.

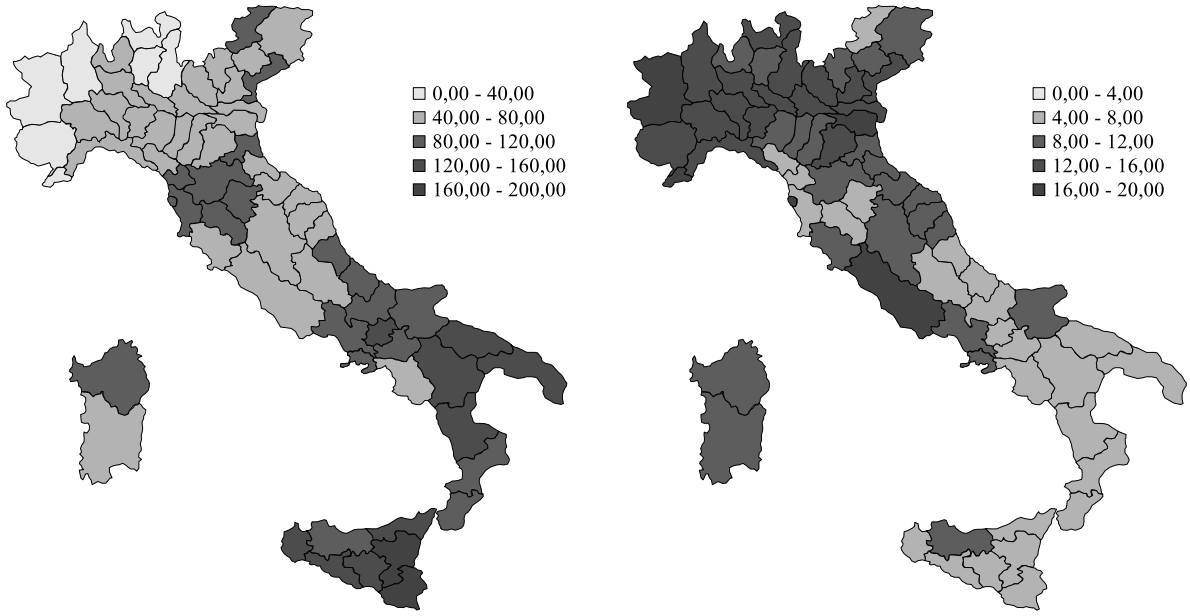
Figure 1 – Literacy rates for children aged 6 to 10 in 1871.




Note: the intervals have been re-scaled between 0.00 and 0.50. Source: see text.

Our data clearly show that the supply of primary schooling varied greatly across Italian provinces in the second half of the 19th century. Figure 2 plots the child-teacher ratio and municipal expenditure per child in 1871 (both are based on all school-age children, not just those enrolled).

Figure 2 – Supply of public schooling: child-teacher ratio and expenditure per child, 1871.

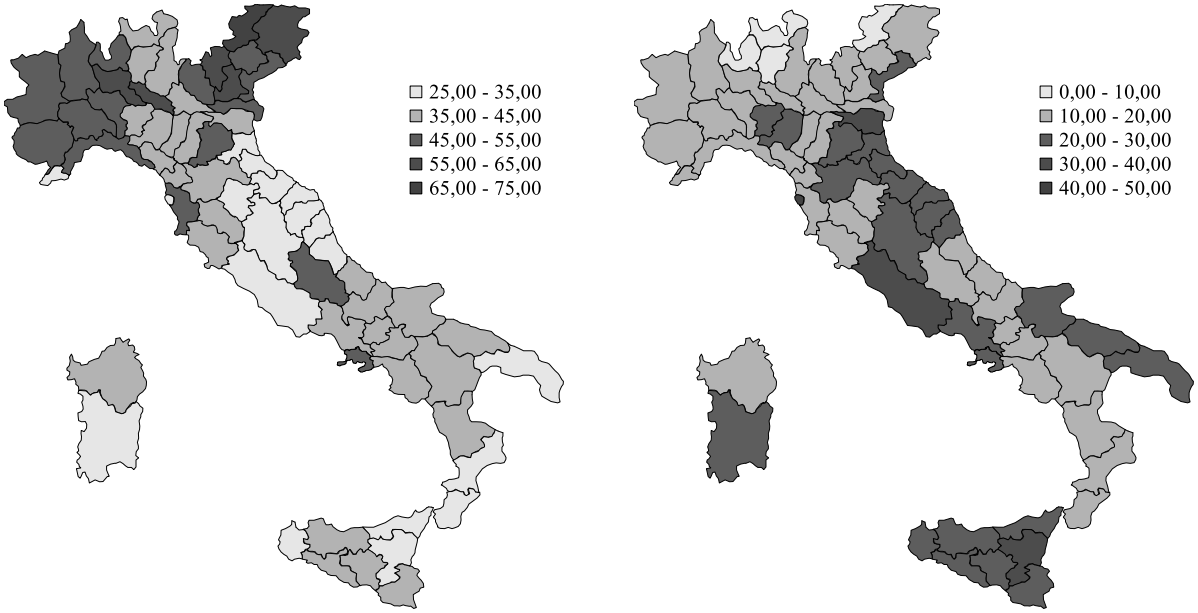



a) Child-teacher ratio b) Expenditure per child

Notes: the child-teacher ratio is measured as the number of children (aged 6 to 10) per primary-school (state) teacher while expenditure per child is calculated as municipal expenditure on education per child aged 6 to 10. Source: see text.

Despite large differences in the supply of public schooling, the regional distribution of inputs into schooling appears to have been far more homogeneous – partly because of the mediating effect of a lower demand for education in the poorer regions of the country. This becomes clear when looking at the pupil-teacher ratio and the expenditure per pupil (Figure 3). For this reason, it is crucial to control for demand-side aspects when estimating the EPFs.

Figure 3: Territorial distribution of school inputs: class size and expenditure per pupil, 1871




a) Class size b) Expenditure per pupil

Notes: Class size is measured by the number of pupils enrolled in state primary schools per teacher and expenditure per pupil is calculated as the amount of municipal expenditure on education per pupil enrolled in primary schools. Sources: see text.

Our measure of class size reveals that, on average, classes were composed by 41 pupils in 1871, and the ratio increased over time to reach 52 pupils per teacher in 1911. The literature on the economics of education often employs this measure to proxy for the quality of schooling. However, class size may not capture the same aspect in late-19$^{th}$ century Italy, where – as the historical inquiries reveal – other aspects were equally valuable to the development of human capital, such as the conditions of the schoolhouse and the capability of the teacher. Indeed, the best-performing regions in terms of literacy all exhibit high pupil-teacher ratios. This aspect can be linked to our attempt to estimate school efficiency: if inputs into schooling did not differ so much between the North and the South of the country, the use and management of the resources allocated to education may have been different across provinces – so that an assessment of school efficiency across Italy's provinces becomes crucial to shed light on the determinants of literacy.

As far as expenditure per pupil is concerned, it equalled 18.33 Lire (at current prices) in 1871 and increased to nearly 45 in 1911. Italy's municipalities were the main source of funding for education, as the central government did not step in until the first years of the 20th century. On average, municipalities destined 15 percent of their total expenditure to education in 1881 – the value being equal to 17 percent in the North and 13 percent in the South (unweighted average from provincial data). Most of the resources came from local taxation. Land and property taxes were particularly important to the development of schooling, although their importance declined towards the end of the 19th century (see A'Hearn, Auria, and Vecchi 2011, Cappelli 2016b).

Table 1: Descriptive Statistics of Dependent Variables and School Inputs: 1871-1911

| | 1871 | | 1881 | | 1891 | | 1901 | | 1911 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Mean | St.Dev. | Mean | St.Dev. | Mean | St.Dev. | Mean | St.Dev. | Mean | St.Dev. |
| Literacy Rate 6-10 | 0.183 | 0.109 | 0.292 | 0.162 | 0.399 | 0.189 | 0.507 | 0.218 | 0.565 | 0.168 |
| Literacy Rate 15-19 | 0.343 | 0.195 | 0.428 | 0.222 | 0.514 | 0.224 | 0.601 | 0.231 | 0.719 | 0.202 |
| GER 6-10 | 0.626 | 0.360 | 0.810 | 0.348 | 0.840 | 0.313 | 0.934 | 0.288 | 1.087 | 0.254 |
| Pupil-teacher ratio | 41.71 | 9.436 | 44.308 | 9.834 | 45.068 | 9.090 | 47.841 | 7.955 | 51.591 | 8.126 |
| Expenditure per pupil | 18.33 | 6.977 | 30.02 | 11.238 | 32.45 | 10.04 | 38.555 | 13.38 | 44.99 | 22.086 |
| Mun. schools per sq. Km | 0.141 | 0.103 | 0.177 | 0.131 | 0.201 | 0.153 | 0.238 | 0.189 | 0.282 | 0.237 |

## 5. Aggregate Education Production Function: new estimates

First, we define and estimate a historical aggregate EPF at the province level. This allows us to examine how well the schooling system produced literacy and how much each input contributed to the overall output. Our province aggregate production function is presented as:

$$Q_{pt} = f_{pt}\,(SC_{pt}, X_{pt}, ST_{pt}) + \varepsilon \text{ , (1)}$$

which produces the output $Q_{pt}$ by combining educational inputs ($SC_{pt}$), province-specific environmental characteristics ($X_{pt}$), and social or parental inputs ($ST_{pt}$).

We assume a simple linear specification as follows:

$$Q_{pt} = \beta_0 + \beta 1\, SC_{pt} + \beta 2\, X_{pt} + \beta 3\, ST_{pt} + \varepsilon_{pt} \text{ , (2)}$$

where $Q_{pt}$ is represented in our framework by the literacy of either children aged 6-10 or 15-19. When the latter class is concerned, all school inputs are taken as a first lag (ten years earlier), so that we employ data for 1861 as well.

The inputs $SC_{pt}$[9] included in the regression analysis are the Gross Enrolment Rate (GER) of children 6-10, the pupil-teacher ratio, expenditure per pupil, and school density – along with other demographic and socio-economic variables in $ST_{pt}$ and $X_{pt}$. We apply White-Huber standard errors to deal with potential heteroscedasticity.[10]

The estimation of the EPF presents several challenges, which our dataset allows to tackle. The most important concern omitted variable, selection and endogeneity biases (Hanushek and Woessmann, 2011). Thanks to the panel structure of our data we can employ lagged inputs into the EPF regressions to limit the endogeneity and reverse-causality bias, at least for the age group 15-19. Furthermore, since we use provincial aggregated data based on the whole population we can reduce selection and self-selection at the individual or school level, as well as control for differences in ability across individuals – since any bias will be offset at the aggregate level. Finally, we can address the common problem of omitted variable bias by including a rich and comprehensive array of controls (see Schwartz and Zabel, 2013, for an overview).

We estimate the EPF in five separate cross-section regressions spanning the entire period under examination. Table 2 reports our results for literacy rates of children aged 6-10, while Table 3 presents those concerning young people aged 15-19. We regress literacy for each of the two age classes on school inputs (which are lagged when using the age class 15 to 19) in a simple model in Columns 1 to 5, whereas Columns 6 to 10 include an additional set of covariates aimed to capture geography, demography, and economic and social features – as presented in the previous section.

By doing so, we aim to provide a preliminary assessment of whether getting more public schooling was worth the financial effort, against the hypothesis that the development of literacy was mainly driven by demand-side factors (e.g., economic and social development).

Table 2 shows that there is a significant and positive correlation between literacy rates (age 6-10) and the GER in primary schools. The correlation with the pupil-teacher ratio appears to have been weaker, the coefficient being statistically significant only in 1901. The expenditure per pupil is characterized by a positive coefficient, which is significant at the 1-percent level

[9] We explore the potential non-linearity of inputs by including in a separate set of specifications squared terms as well as interaction terms of input variables at our disposal. However, according to specific tests on the significance of such non-linearities we decided not to include them in the main specification because not significant according to our data. Results are available upon request.

[10] POLS in table 4 data are not clustered at the provincial level. However, applying clustering does not change the significance of our results. Results are available upon request.

in the first three benchmark years. In line with the education literature, more resources into schooling mattered when schooling and human capital accumulation was limited.

The marginal contribution of school density is more varied over time, but in general this input is positively correlated with literacy rates.

Table 2: Education Production Function: Literacy Rates 6-10, OLS, 1871-1911

| | (1) 1871 | (2) 1881 | (3) 1891 | (4) 1901 | (5) 1911 | (6) 1871 | (7) 1881 | (8) 1891 | (9) 1901 | (10) 1911 |
|---|---|---|---|---|---|---|---|---|---|---|
| Estimation technique: OLS | Literacy Rate 6-10 | | | | | | | | | |
| GER municipal sch. | 0.262*** | 0.457*** | 0.588*** | 0.720*** | 0.559*** | 0.090** | 0.297*** | 0.421*** | 0.428*** | 0.186*** |
| | (0.036) | (0.036) | (0.050) | (0.056) | (0.051) | (0.045) | (0.072) | (0.063) | (0.077) | (0.067) |
| Pupil-Teacher ratio (mun.) | 0.001 | 0.001 | 0.000 | -0.003** | -0.002 | 0.002** | 0.002 | 0.001 | -0.003* | -0.002 |
| | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.002) | (0.001) |
| Expenditure per pupil | 0.004*** | 0.003*** | 0.003*** | 0.000 | 0.000 | 0.004*** | 0.004*** | 0.002** | 0.000 | 0.000 |
| | (0.001) | (0.001) | (0.001) | (0.001) | (0.000) | (0.001) | (0.001) | (0.001) | (0.001) | (0.000) |
| Mun. schools per sq. km | 0.275** | 0.180 | 0.166 | 0.181*** | 0.135*** | 0.620*** | 0.850** | 0.793*** | 0.272 | 0.134 |
| | (0.135) | (0.134) | (0.100) | (0.064) | (0.036) | (0.188) | (0.322) | (0.219) | (0.238) | (0.165) |
| Geography | No | No | No | No | No | Yes | Yes | Yes | Yes | Yes |
| Demography | No | No | No | No | No | Yes | Yes | Yes | Yes | Yes |
| Economic and social controls | No | No | No | No | No | Yes | Yes | Yes | Yes | Yes |
| Observations | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 |
| Adjusted R-squared | 0.879 | 0.902 | 0.926 | 0.913 | 0.772 | 0.921 | 0.930 | 0.963 | 0.953 | 0.904 |

Notes: OLS estimates are reported with White-Huber robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. A constant is always included. All control variables when included are: latitude, longitude, average temperature, average rainfalls, population density, dependency ratio, infant mortality rate, height, share of labour force in agriculture, rate of outward migration, industrial VA per capita, electoral franchise, parental literacy rate.

Table 3 shows that, when the age group 15-19 is concerned, the GER is also strongly and consistently correlated with our educational outcome, mostly at the 1-percent level of significance. The pupil-teacher ratio and school density are positively correlated with literacy, especially between 1871 and 1891. The expenditure per pupil and the density of schools also exhibit positive coefficients. As we outlined before, the positive coefficient of the pupil-teacher ratio suggests that there may have been economies of scale for education in 19$^{th}$-century Italy.

To sum up, our estimates provide evidence that getting more schooling (GER) was important to improve literacy, and that putting more resources into the school system was also relevant for the growth of literacy.

Table 3: Education Production Function: Literacy Rates 15-19, OLS, 1871-1911

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1871 | 1881 | 1891 | 1901 | 1911 | 1871 | 1881 | 1891 | 1901 | 1911 |
| Estimation technique: OLS | Literacy Rate 15-19 | | | | | | | | | |
| GER municipal sch. (lag 10) | 0.343*** | 0.511*** | 0.573*** | 0.643*** | 0.623*** | 0.078 | 0.102* | 0.229*** | 0.204*** | 0.244*** |
| | (0.032) | (0.068) | (0.049) | (0.059) | (0.053) | (0.058) | (0.059) | (0.051) | (0.056) | (0.064) |
| Pupil-Teacher ratio (municipal) (lag 10) | 0.005*** | 0.004*** | 0.002 | 0.004** | 0.001 | 0.003*** | 0.002* | 0.002** | 0.001 | 0.001 |
| | (0.002) | (0.002) | (0.002) | (0.002) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) |
| Expenditure per pupil (lag 10) | 0.004** | 0.007** | 0.003** | 0.004*** | 0.001 | 0.001 | 0.006*** | 0.002*** | 0.001 | 0.001 |
| | (0.002) | (0.003) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.000) |
| Mun. schools per sq. km (lag 10) | 0.491*** | 0.369 | 0.238 | 0.175 | 0.127** | 0.310** | 0.656*** | 0.293* | 0.133 | 0.091 |
| | (0.143) | (0.231) | (0.178) | (0.113) | (0.049) | (0.154) | (0.223) | (0.173) | (0.166) | (0.177) |
| Geography | No | No | No | No | No | Yes | Yes | Yes | Yes | Yes |
| Demography | No | No | No | No | No | Yes | Yes | Yes | Yes | Yes |
| Economic and social controls | No | No | No | No | No | Yes | Yes | Yes | Yes | Yes |
| Observations | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 |
| Adjusted R-squared | 0.823 | 0.863 | 0.886 | 0.887 | 0.904 | 0.970 | 0.970 | 0.979 | 0.977 | 0.972 |

Notes: OLS estimates are reported with White-Huber robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. A constant is always included. All control variables when included are: latitude, longitude, average temperature, average rainfalls, population density, dependency ratio, infant mortality rate, height, share of labour force in agriculture, rate of outward migration, industrial VA per capita, electoral franchise, parental literacy rate.

In Table 4 we estimate the EPF again by pooling our cross sections – exploiting the panel structure of our data. Columns 1 and 3 include time fixed effects while Columns 2 and 4 further include macro-region fixed effects to control for common shocks and other common features of the areas concerned.

As the pooled OLS estimates show, the GER and the expenditure per pupil are consistently and positively correlated with educational outcomes at the 1-percent level of significance – no matter the age group. The pupil-teacher ratio is positively correlated with literacy rates only for the age group 15-19, while the result for school density is mixed. Overall, the results seem to hold, especially for the importance of the relationship between the GER and literacy rates: school inputs mattered for the development of human capital in late-19$^{th}$ century Italy. Among the controls, we find parental literacy rates to have been a strong determinant of literacy, the coefficients being statistically significant at the 1-percent level;[11] our proxy for socio-economic well-being, height, is positively correlated with literacy – which seems to stand as evidence backing up the so-called modernization hypothesis, namely the claim that as a society becomes wealthier and more industrialized puts more emphasis on education and

[11] This result confirms with historical data the already significant association of students' achievement and family background as highlighted by Hanushek and Woessmann (2011).

human capital accumulation; the share of people employed in agriculture is also strongly and negatively correlated with literacy, providing evidence that the opportunity cost of education was still pressing at that time; finally, electoral franchise, i.e. the share of males entitled to vote in local elections, is positively correlated with literacy, as expected.[12] The macro-region dummies, included in Columns 2 and 4, show that provinces located in the North of the country were characterized by a positive premium on literacy rates with respect to the Centre and – even more – the South, which is not explained by any of the factors included in our EPF. This calls for a further exploration of regional disparities in school efficiency, which is performed in the next section of the paper.

Table 4: Education Production Function: POLS, 1871-1911

| Estimation technique: POLS | (1) | (2) | | (3) | (4) |
|---|---|---|---|---|---|
| | Literacy rate 6-10 | | | Literacy rate 15-19 | |
| GER municipal sch. | 0.254*** | 0.151*** | GER municipal sch. (lag 10) | 0.214*** | 0.136*** |
| | (0.034) | (0.030) | | (0.019) | (0.019) |
| Pupil-Teacher ratio | -0.000 | -0.000 | Pupil-Teacher ratio (lag 10) | 0.002*** | 0.003*** |
| | (0.001) | (0.001) | | (0.000) | (0.000) |
| Expenditure per pupil | 0.001*** | 0.001*** | Expenditure per pupil (lag 10) | 0.001*** | 0.001*** |
| | (0.000) | (0.000) | | (0.000) | (0.000) |
| Mun. schools per sq. km | 0.139* | -0.077 | Mun. schools per sq. Km (lag 10) | 0.054 | -0.022 |
| | (0.072) | (0.056) | | (0.045) | (0.041) |
| Geography | yes | yes | | yes | yes |
| Demography | yes | yes | | yes | yes |
| Economic and social controls | yes | yes | | yes | yes |
| Year dummies | yes | yes | | yes | yes |
| Macro-regions | no | yes | | no | yes |
| Observations | 345 | 345 | | 345 | 345 |
| Adjusted R-squared | 0.931 | 0.949 | | 0.978 | 0.945 |

Notes: OLS estimates are reported with White-Huber robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. A constant is always included. All control variables when included are: latitude, longitude, average temperature, average rainfalls, population density, dependency ratio, infant mortality rate, height, share of labour force in agriculture, rate of outward migration, industrial VA per capita, electoral franchise, parental literacy rate.

In a series of robustness checks, we run models that expand on the one reported in Table 4, Columns 1 and 3, by adding more controls. We start by adding additional variables one by one, while eventually we enter them simultaneously. First, we control for the contribution of private schooling to literacy including the ratio of private to public enrolment rates; secondly, we include life expectancy for children aged 0-1 in order to control for the trade-off between quality and quantity of children in the development process; thirdly, since increased social capital is often correlated with increased literacy, we include an index of trust and

[12] Results are unchanged when in Table 4, Models 3 and 4, we introduce a lag of literacy in the previous grade is considered.

cooperative norms as elaborated by Cappelli (2017); finally, because education may be delayed by landed elites, we also include an index of land inequality as elaborated by Cappelli (2016b). Overall, our previous results remain unchanged.

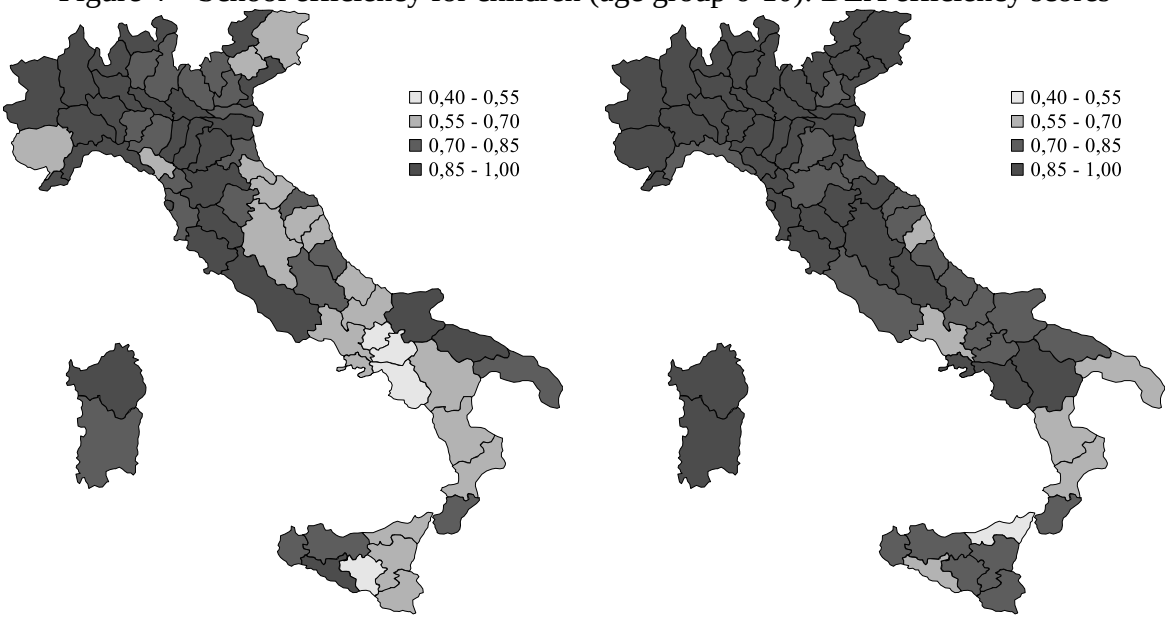
## 6. The Efficiency of Italy's education system, 1871-1911: DEA efficiency scores and the role of non-discretionary variables

The EPF presented in the previous section have provided estimates of the contribution of each input to the development of literacy. However, the pooled-OLS results showed that the issue of school efficiency – i.e. the capability to improve outcomes given the existent inputs – is worth a further exploration, since part of the differences in literacy rates across provinces of 19$^{th}$-century Italy remain unexplained by inputs into schooling or other environmental factors. This section deals with this by relying on Data Envelopment Analysis, a non-parametric linear programming technique elaborated by Farrel (1957) and then by Charnes et al. (1978). DEA captures the relative efficiency of a set of homogenous Decision Making Units (in our case the province) and determines the efficiency scores relating education inputs to outputs. In a second stage, we explore the determinants of school efficiency through a methodology devised by Simar and Wilson (2007) which connects the environmental (non-discretionary) variables to the DEA scores, to give further insights into the drivers of school efficiency in the first fifty years after Italy's unification.[13]

DEA analysis assumes the existence of a convex production frontier. This frontier is basically constructed using linear programming methods, the term "envelopment" being used because the frontier envelops the set of observations. DEA allows the calculation of technical efficiency measures that can be either input or output oriented. We choose the output-oriented estimates under the assumption of constant returns to scale (CRS), because we are interested in how much literacy is likely to grow given the "quantity" of inputs observed.[14] Estimates are reported in the map in Figure 4 for school efficiency when school-age children (from 6 to 10) are concerned, in 1871 and 1911. Instead, Figure 5 reports efficiency scores for the 15-19 group in the same two benchmark years.[15] A value of 1 represents provinces on the estimated efficiency frontier, while sub-efficient units are within the 0-1 range.

[13] Afonso and Aubyn (2006) apply the same approach for the measurement of efficiency in contemporary secondary education across Europe.
[14] We apply the DEA command in Stata as elaborated by Ji and Lee (2010).
[15] Provincial estimates for all benchmark years are provided in the Appendix (available upon request).

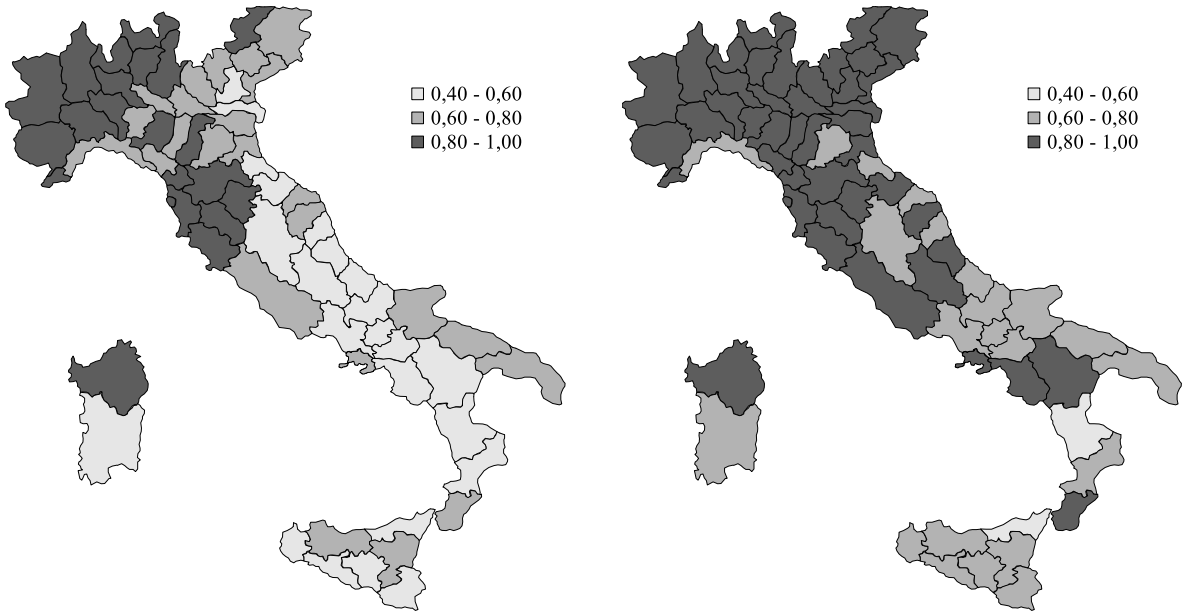
Figure 4 – School efficiency for children (age group 6-10): DEA efficiency scores




1871 1911

Notes: the outcome is literacy rates for the age group 6-10. The school inputs employed in the calculations are GER, pupil-teacher ratio, expenditures per pupil, and school density. Source: see text.

Figure 5 – School efficiency for youngsters (age group 15-19): DEA efficiency scores




1871 1911

Notes: the outcome is literacy rates for the age group 15-19. The school inputs employed in the calculations are GER, pupil-teacher ratio, expenditures per pupil, and school density, all taken with a lag of 10 years. Source: see text.

As the results show, DEA estimates suggest that the North was clearly ahead of other regions within the country in 1871, yet the advantage did tend to fade out in the long run. However, it is worth noting that, as the trends presented in Figure 6 and 7 show, clear convergence did not occur until the first decade of the 20$^{th}$ century. This means that early weak education reforms that amended formal rules but did not affect the management and the level of school autonomy in the system – like the Coppino Law of 1877 – had little impact on Italy's education. Instead, convergence in efficiency accelerated remarkably when the state stepped in more decidedly into matters related to primary schooling, in the early-20$^{th}$ century. The pattern of persistence that we find may be linked to the long shadow that pre-unification school systems cast on post-unification Italy. We put forward the hypothesis that the North of the country – where public compulsory schooling had been established well before 1861 – had a cognitive advantage in the development of education, whereas the South – where public schooling had long been absent before unification – experienced a deficit in that sense.

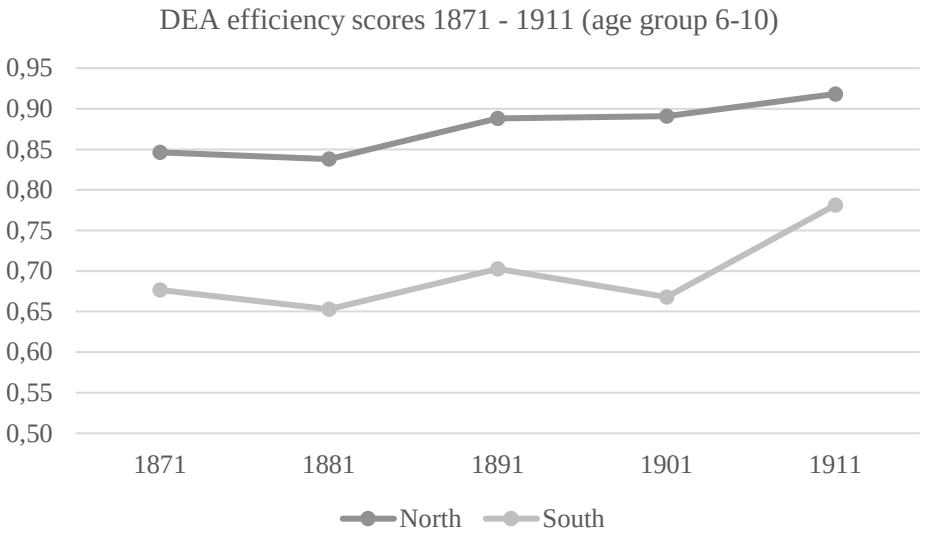



Figure 6 – Unweighted average of DEA efficiency for the North and the South of Italy, the outcome is literacy rates for the age group 6-10. Source: see text.

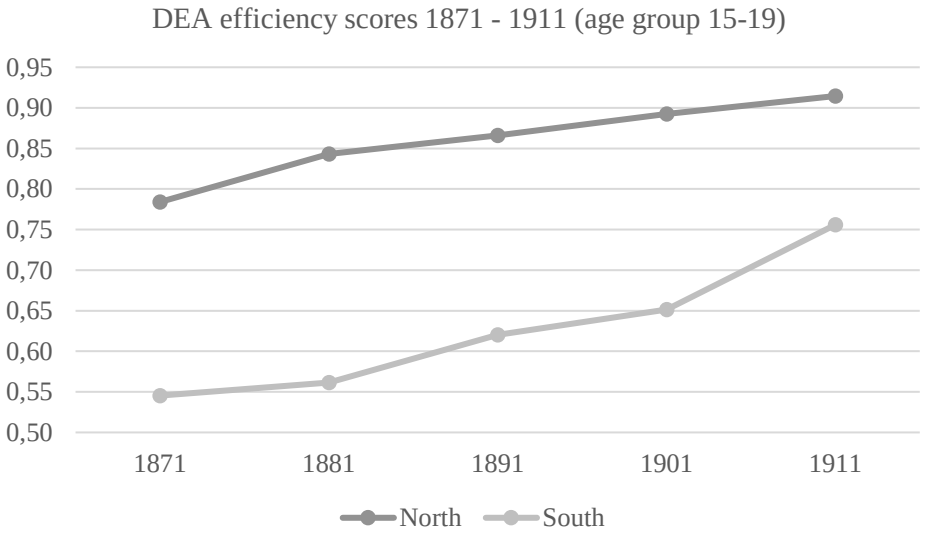



Figure 7 – Unweighted average of DEA efficiency for the North and the South of Italy, the outcome is literacy rates for the age group 15-19. Source: see text

In order to explore the role played by the aforementioned historical legacies, we test the impact of early-19th-century literacy rates from pre-unification states on the efficiency scores previously estimated, using the Simar-Wilson specification previously discussed.[16] Early-19th-century literacy rates are measured by Ciccarelli and Weisdorf (2016) using the age structure of the population, through a birth-cohort analysis.[17] We include all factors taken into account in the EPFs, i.e. geography (latitude, longitude, temperature, and rainfall), demography (population density, the proxy for the child-dependency ratio, and the infant mortality rate), and socio-economic controls (height, industrial VA per capita, the share of LF in agriculture, the outward migration rate, and parental literacy). Since efficiency can be thought of as a residual measure with respect to these features – as the EPFs previously estimated suggest – we do not expect to find a strong correlation between them and school efficiency.

Indeed, when efficiency within public-school system is concerned (ages 6 to 10) as shown in Table 5, no systematic pattern emerges from geography, demography, or socioeconomic features. However, for early-19th-century literacy we find a consistent correlation with school efficiency up to the end of 1800. When we look at the efficiency in generating literacy for those who have already left school (aged 15 to 19) in Table 6, a different pattern emerges. The post-school efficiency is again systematically affected by historical legacies before 1901, but to a lesser extent – the coefficients being smaller, on average. Instead, the correlation between post-school efficiency and parental literacy is significant up to 1901, right before the primary-school system was first changed by state intervention, not only with more funding but also with a stronger protection of the rights of the teachers – a first institutional reform that somehow paved the way for increased centralization starting in 1911. We interpret this difference between the two specifications as being due to the fact that parental human capital mattered more for those who had already left school, i.e. less affected by the changes in the education system itself.

[16] Simar and Wilson (2007) estimate the role of non-discretionary inputs on efficiency scores using a truncated regression with bootstrapped robust standard errors.

[17] In order to reduce measurement bias, we use an average of the values of literacy calculated by the authors in 1821 and 1831, the earliest available years.

Table 5 – Determinants of school efficiency, 1871 – 1911, age group 6-10

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| | Efficiency scores, children | | | | |
| | 1871 | 1881 | 1891 | 1901 | 1911 |
| Latitude | 0.0502*** | 0.0233 | 0.0171 | 0.0156 | 0.0146 |
| | (0.015) | (0.016) | (0.013) | (0.012) | (0.013) |
| Longitude | -0.0135 | -0.0085 | -0.0154 | -0.0458*** | -0.0199** |
| | (0.010) | (0.011) | (0.010) | (0.011) | (0.009) |
| Av. temperature | 0.0238* | 0.0272* | 0.0282** | 0.0031 | -0.0219* |
| | (0.013) | (0.014) | (0.012) | (0.012) | (0.013) |
| Av. rainfalls | -0.0000 | -0.0002 | -0.0002 | 0.0001 | -0.0002 |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| Pop. density | -0.0003** | -0.0002 | -0.0002* | 0.0001 | -0.0007** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| Dependency ratio | 3.5117 | 4.7789* | -6.2124* | 0.5038 | 7.5613*** |
| | (2.342) | (2.601) | (3.238) | (2.687) | (2.687) |
| Infant mortality rate | -0.3296 | 0.0668 | -0.0462 | 1.2649*** | 0.5551* |
| | (0.256) | (0.276) | (0.255) | (0.407) | (0.322) |
| Height | -0.0254 | -0.0190 | 0.0134 | 0.0246* | -0.0006 |
| | (0.018) | (0.018) | (0.015) | (0.013) | (0.016) |
| Share of LF in agriculture | -0.0054*** | -0.0011 | -0.0019 | 0.0002 | 0.0012 |
| | (0.002) | (0.002) | (0.002) | (0.002) | (0.003) |
| Rate of outward migration | -0.0010 | 0.0031 | 0.0012 | 0.0016 | -0.0019 |
| | (0.003) | (0.002) | (0.001) | (0.001) | (0.002) |
| Industrial VA per capita | -0.0003 | -0.0012 | -0.0010 | -0.0007 | 0.0003 |
| | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) |
| Electoral Franchise | -0.5329 | -1.1319*** | -0.0810 | 0.1662 | 0.0792 |
| | (0.505) | (0.410) | (0.256) | (0.224) | (0.156) |
| Parental literacy rate | 0.0011 | 0.0058** | 0.0007 | -0.0015 | -0.0023 |
| | (0.002) | (0.003) | (0.002) | (0.002) | (0.002) |
| Literacy early 19th C. | 0.5729* | 0.8730*** | 0.8508*** | 0.2951 | 0.1317 |
| | (0.325) | (0.306) | (0.252) | (0.244) | (0.232) |
| Constant | 2.7061 | 2.1627 | -1.6535 | -3.8655** | 0.3895 |
| | (2.532) | (2.571) | (2.072) | (1.955) | (2.444) |
| | 0.0856*** | 0.0909*** | 0.0813*** | 0.0769*** | 0.0647*** |
| | (0.009) | (0.009) | (0.008) | (0.008) | (0.007) |
| Observations | 69 | 69 | 69 | 69 | 69 |

Notes: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 6 – Determinants of school efficiency, 1871 – 1911, age group 15-19

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| | Efficiency scores, youngsters | | | | |
| | 1871 | 1881 | 1891 | 1901 | 1911 |
| Latitude | 0.0093 | 0.0011 | 0.0103 | 0.0064 | 0.0168 |
| | (0.014) | (0.014) | (0.009) | (0.010) | (0.016) |
| Longitude | -0.0049 | -0.0217** | -0.0159*** | -0.0203** | -0.0167 |
| | (0.009) | (0.009) | (0.006) | (0.008) | (0.012) |
| Av. temperature | 0.0148 | 0.0144 | 0.0124 | 0.0002 | -0.0108 |
| | (0.012) | (0.012) | (0.009) | (0.008) | (0.016) |
| Av. rainfalls | -0.0002 | -0.0003* | -0.0001 | 0.0003 | 0.0004 |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| Pop. density | -0.0002 | -0.0002 | -0.0000 | 0.0002** | -0.0001 |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| Dependency ratio | 2.8005 | -1.8411 | 2.3487 | 3.3489 | 3.5100 |
| | (2.282) | (2.400) | (2.430) | (2.259) | (3.165) |
| Infant mortality rate | -0.0952 | -0.3279 | 0.0288 | 0.3246 | 0.2956 |
| | (0.255) | (0.254) | (0.165) | (0.314) | (0.426) |
| Height | -0.0038 | 0.0029 | -0.0001 | -0.0067 | -0.0096 |
| | (0.016) | (0.016) | (0.012) | (0.010) | (0.019) |
| Share of LF in agriculture | -0.0003 | -0.0002 | -0.0003 | -0.0004 | -0.0029 |
| | (0.002) | (0.001) | (0.001) | (0.002) | (0.003) |
| Rate of outward migration | -0.0013 | 0.0077*** | 0.0013 | -0.0016 | -0.0042* |
| | (0.003) | (0.003) | (0.001) | (0.002) | (0.002) |
| Industrial VA per capita | -0.0005 | -0.0009 | -0.0009 | -0.0015** | -0.0010 |
| | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) |
| Electoral Franchise | -0.3930 | -0.5100 | 0.0234 | 0.0445 | 0.0345 |
| | (0.449) | (0.388) | (0.185) | (0.199) | (0.214) |
| Parental literacy rate | 0.0066*** | 0.0057** | 0.0035** | 0.0045*** | 0.0004 |
| | (0.002) | (0.003) | (0.002) | (0.002) | (0.003) |
| Literacy early 19th C. | 0.6046** | 0.6224** | 0.5475*** | 0.1303 | -0.0410 |
| | (0.272) | (0.247) | (0.160) | (0.186) | (0.275) |
| Constant | 0.4072 | 0.5083 | -0.0771 | 1.0573 | 1.7220 |
| | (2.368) | (2.347) | (1.594) | (1.514) | (2.905) |
| Sigma | 0.0892*** | 0.0819*** | 0.0581*** | 0.0611*** | 0.0854*** |
| | (0.008) | (0.008) | (0.006) | (0.006) | (0.009) |
| Observations | 69 | 69 | 69 | 69 | 69 |

## 7. Conclusions

This paper provides the first estimate of an Education Production Function for Italy in the late-19$^{th}$ and early-20$^{th}$ centuries (1871 – 1911). The country, which was lagging behind the levels of education and economic development of Europe's first comers, represents an interesting case study towards a better understanding of the relationship between school inputs, school efficiency and educational outcomes in a developing country. Thanks to a fine

historical dataset, we explore to what extent school inputs mattered for the growth of literacy vis-à-vis demand-side factors. We find that school was worth getting, as more expenditure per pupil, a higher enrolment rate and school density are correlated with higher human capital. Curiously, we find class size to be positively correlated with literacy, a result possibly connected to the benefit of economies of scale in education at that time. The EPF framework allows us to include macro-region fixed effect. Their significant coefficient suggests that school efficiency affected literacy beyond school inputs and demand-side factors. For this reason, the second step in our analysis sought to capture differences in school efficiency across Italy's provinces. The DEA efficiency scores show that differences were indeed large, and that they did not decline up to the eve of the 20th century. This is an important result, as one may put forward that early education reforms that tried to make the education system more effective failed, insofar as they did not affect the decentralized management of schooling, the administrative organization of the school system or funding. Partly for this reason, we posit that school efficiency was largely a historical legacy of pre-unification states. The strong, positive correlation between early-19th century literacy and human capital five to eight decades later confirms that the large pre-unification differences cast a long shadow. Interestingly, only when the state started to limit the choices of the municipalities – for example by limiting their discretionary power concerning hiring and layoff of teachers, which was often used for reinforcing patronage networks – did the regions of Italy start to converge in terms of school efficiency.

## 8. Appendix

A data appendix is available upon request.

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