SPRU Science Policy Research Unit
Working Paper Series
SWPS 2017-20 (October)

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UNIVERSITY OF SUSSEX

SPRU Working Paper Series (ISSN 2057-6668)

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Abstract

We explore whether investment in state school infrastructure affects students' achievement. We use data on extra funding to state high schools after the 2012 Northern Italy earthquake and apply a quasi-experimental design and an instrumental variable strategy. We find that spending on school infrastructure increases standardized test scores in mathematics and Italian language, and the effect is stronger for lower-achieving students and in mathematics. These results provide evidence in favor of a positive impact of capital spending in improving the learning environment and performances of high school students.

Keywords: education; school infrastructure spending; high school.
JEL Classification: I22, I24, H75.

1 Introduction

Whether or not school spending has an impact on student outcomes is a highly debated issue in economics (Card & Krueger, 1996). The contemporary literature has been pioneered by Coleman's (1966) in a prominent report published by the US Government in 1966, whose main conclusion is that school funding does not play a central role in determining students' achievement. A wealth of studies follow in the footsteps of Coleman (1966) and explore the relation between resources and educational outcomes (see e.g., Neilson & Zimmerman, 2014; Jackson *et al.* , 2016). Overall, there is a lack of agreement on the impact of funding on students' performances. Whereas in a meta-analysis Greenwald *et al.* (1996, p.384) conclude that "school resources are systematically related to student achievement and that these relations are large enough to be educationally important," many subsequent studies find little or no effect (see e.g., Hanushek, 1996; Card & Krueger, 1996).

This disagreement is perhaps not very surprising as most of these studies face severe difficulties in attempting to unravel a causal relationship between school spending and educational outcome. Counterfactual outcomes are sensitive to the choice of the estimator and the identification strategy to address the endogeneity of school resources. Although previous studies have made a good deal of progress in dealing with the joint determination of educational inputs and outputs, modest estimated effects of school spending could be a consequence of unresolved endogeneity biases (see Jackson *et al.* , 2016). At the same time, studies often explore very heterogeneous inputs of the educational production process. Jones & Zimmer (2001) note that most of the literature focuses on school-specific inputs, school organization inputs (e.g., class size), environmental characteristics and socioeconomic (family) characteristics, but neglects capital inputs such as school infrastructure. In fact, there are only a handful of studies on the school infrastructure-students' learning relationship and they focus preponderantly on the US School System. Aaronson & Mazumder (2011) investigate the impact of the so-called "Rosenwald initiative" in the US between 1914 and 1931 and find that substantial improvements to school quality and access in relatively deprived environments are followed by large productivity gains. Neilson & Zimmerman (2014) find strong evidence that school construction programs led, among other outcomes, to sustained gains in reading scores for elementary and middle school students. Yet, Cellini *et al.* (2010) and Martorell *et al.* (2016), who focus more specifically on school facility investments, find little evidence that spending on facilities generates improvements in student achievement.

Against this background, we explore whether spending on physical infrastructure affects student outcomes by focusing on test scores in mathematics and Italian language using data on Italian state high schools. The issue of school capital funding features prominently in the public debate, and in many countries the lack of investment remains a pressing priority for state schools, where many governors believe that schools are not "fit for purpose" (Guardian, 27/01/2015).[1] In Italy, school principals have long lamented that poorly maintained school facilities and a lack of funding to conduct essential repairs prevent schools from delivering their curriculum (Corriere della Sera, 18/07/2017). This squares with the theoretical arguments put forward by educational researchers, social psychologists and sociologists on the importance of the physical environment of schools and the condition of their facilities in explaining variation in students' learning across schools (Earthman, 2002; Mendell & Heath, 2004; Bakó-Biró *et al.* , 2012; Haverinen-Shaughnessy *et al.* , 2015).

In terms of the specific mechanism mapping school infrastructure into students' learning, this literature has stressed the role of social norms, conformity, and social signaling in the school environment (Branham, 2004). On the one hand, a safe and clean school environment provides important signals to students that the school is well managed, that teachers enforce discipline in the classroom, and that e.g., bully behavior is not tolerated. On the other hand, unhealthy and unsafe buildings, with e.g., broken windows, graffiti, nonfunctioning toilets, poor lighting, inoperative heating and cooling systems, leaking roofs, signal a lack of attention and respect for the students, who either put less efforts or distract colleagues and disrupt the learning environment, as they perceive lower costs and risks of detection. This so-called "*broken windows theory*" (Wilson & Kelling, 1982) is based on the premise that the school environment "communicates" to students and that "good signals" correlate with a more efficient learning process. Students in well-maintained schools are therefore more likely to focus on academic challenges than those who are distracted or depressed by the poorly maintained facilitates. By the same token, physical conditions also affects teachers' feelings of effectiveness and sense of personal safety in the classrooms. Lawrence (2003) reviews a number of studies exploring how the condition of the school facility

[1]For example, in 2017, the Australian government will bring forward \$200 million in capital investment to fast track state school infrastructure throughout Queensland (`https://goo.gl/GGe1Pf`). In 2015-16, the UK Department for Education spent GBP 4.5 billion in capital funding, and the National Audit Office has predicted that it will take a further GBP 6.7 billion investment to bring all schools up to scratch (`https://goo.gl/SQzHDE`). In Germany, Martin Schulz, leader of the Social Democrats, vowed to pour billions into crumbling schools infrastructure in campaigning for 2017 September's election (see FT, 17/07/2017).

affects the health and morale of staff. This interpretation may help to clarify the apparently conflicting results seen in the literature so far and identifies a potential pathway to explain the direction of educational outcome's change in response to infrastructure spending.

To handle the endogeneity of idiosyncratic changes in school funding, we use two strategies. First, we employ a quasi-experimental design and make use of information on the extra funding that a specific group of schools received in the aftermath of the 2012 Northern Italy earthquake. In May 2012, the seismic events in Northern Italy caused considerable damages to state buildings and prompted specific interventions for the mitigation of the seismic risk. As a result, a large number of undamaged schools, but close enough to the areas affected by the earthquake, received large extra funds to modernize and improve the quality of their buildings as well as to mitigate their vulnerability to the earthquakes. We compute the differential effect of receiving extra funds on the treatment group, i.e., undamaged schools outside the earthquake area, that were awarded special funding, versus a control group of schools in neighboring municipalities. The schools in the control group are in areas sufficiently far from the earthquake epicenter and at low risk of future seismic activities; therefore these schools are both undamaged as well as unfunded. This strategy allows us to estimate whether being a recipient of funding increases students' achievement. Second, to evaluate the elasticity of test scores with respect to funding, we implement an instrumental variables (IV) identification strategy. In particular, we use seismic hazard maps and exploit exogenous values of peak ground acceleration (henceforth PGA), which explains much of the variation in the amount of funds received. Taken together, our results suggest that improving the quality of school buildings has a positive effect on students' achievements. Moreover, we find that low-achieving students benefit the most from improved physical infrastructure.

2 Data

2.1 The 2012 Northern Italy earthquake and school funding

Deciphering the impact of school resources on achievements is complicated by the fact that students' performance and the selection of funded schools, or the spending levels, are potentially simultaneously determined. We address this issue by using data on school funding provided after a natural disaster. On May 20, 2012 an earthquake of magnitude 6.1, followed by a second one on May 29, hit a territory of 3.5 thousands squared kilometers in the Northern part of Emilia-Romagna, a region near the borders with Veneto and Lombardia. Before the 2012 seismic events, this area was generally not considered at risk of seismic activities.[2]

In the aftermath of the earthquake, the Italian government made available more than 24.4 millions of euros to several state buildings in the affected municipalities, including 276 high schools, with the aim of reconstructing damaged buildings, renewing and maintaining all school buildings as well as keeping undamaged buildings safe from future seismic threats. In fact, this extra funding was given to both damaged schools as well as to schools considered at risk for earthquakes in the future. We use several legislative acts to assemble data on the amount of extra funding to state schools in the region.[3] As the earthquake could have had a direct effect on the learning environment and on students' performances, we use information on the volume of damaged buildings in each municipality, estimated by the INGV (National Institute of Geophysics and Volcanology) in the aftermath of the seism using a macroseismic survey. For our empirical analysis, we only select municipalities where the level of damage of their buildings was assessed by the INGV as "negliglible" (D1) or lower.[4]

In more details, we collect data for a total of 236 municipalities, as shown on the map in Figure 1. Out of 236, 69 are discarded as they had a level of damage greater than D1 (see grey shaded areas in Figure 1). Out of the 167 remaining municipalities, only 43 have at least one high school, for a total of 173 schools (white dots in Figure 1). The treated schools are those located in treated municipalities (shaded areas in Figure 1) and make up a good portion of the total number of schools, 39% (68). Although these schools reported no damage, they received about 3.6 millions of euros to improve the quality of their buildings.

Summary statistics, reported in Table B1 in the Appendix, show that

[2]With the exception of the seismic sequence of Ferrara in 1570, Argenta in 1624 and Bologna in 1929 (Vannoli *et al.* , 2015), few other small intensity earthquakes had had an impact on its inhabitants' collective memory. As a result, the perception of a seismic risk was comparably very small relative to the rest of Italy. In fact, PGA values in this area are, on average, only 20% of those characterizing the nearby Apennine mountain chain. See http://zonesismiche.mi.ingv.it/

[3]Starting from June 2012, the deputy commissioner enacted a series of legislative acts with specific guidelines for securing school buildings as well as the criteria for assigning available funds. See `https://goo.gl/Lqm8Uk`. A list of funds awarded in Emilia-Romagna is available at `https://goo.gl/94vnVH`. We have tracked the implementation of every reparation project using information released by each Province at the end of work.

[4]See Appendix A for a through description of the macroseismic survey and the levels of damage.

these schools received on average 198 euros per student, about 100% of the annual amount in capita expenditure spent in 2013 in Italy (see OECD, 2016).[5] Our control group is made up of 105 schools that received no extra-funding and were not affected by the earthquake, but they are located in municipalities proximate to the treated areas (i.e., they either share borders with the treated areas or there is no more than one municipality between them and the treated areas, see dashed areas in Figure 1).

The map also contains information on the PGA values, gathered from the INGV database. The color bar shows the gradient of PGA for each municipality, from low to high. PGA is the maximum ground acceleration during earthquakes and it is commonly used as an index for seismic hazard intensity, i.e., the higher the PGA the larger will be the intensity of possible earthquake in a specific geographic area. This translates into a higher probability to suffer a damage on physical infrastructures and buildings in areas affected by an earthquake with higher PGA. In our sample, the PGA varies between 0.087 and 0.207, with an average intensity of 0.155. The amount of extra funding per student in the treated areas was mostly driven by the necessity of safeguarding school buildings from future seismic threats and minimize potential damages to school infrastructure, hence is a function, among other things, of PGA levels.[6]

2.2 Test scores

Information on test scores is taken from the Italian National Institute for the Evaluation of the Educational System (INVALSI). Since the academic year 2010/2011, tenth graders in Italian high schools take standardized assessments on the same day (May 9). The participation of all state schools is compulsory and the assessment encompasses only mathematics and Italian language skills. Our dependent variable is the percentage of correct answers for each high school. From the same database, we also take information on school size and on the shares of male and native students in each school.[7]

[5] According to the OECD report, the average total spending per student in Italy in 2013 was 9,174 euros; but only 2% (i.e., 184 euros) was devoted to school capital. This amount is very small if one compares it with that funding transferred to schools in other European countries of the same size: capital expenditure in Germany, for example, was about 1,300 euros, and about 1,200 euros in France.

[6] See the first decrees enacted by the deputy commissioner, i.e., ODC #2 (16 June 2012) and the ODC #4 (3 July 2012).

[7] We refer the interested reader to Angrist *et al.* (2017) and Battistin & Meroni (2016) for a thorough description of the test and a more comprehensive overview than we can possibly give here. Battistin & Meroni (2016) also offer a novel study on instruction time and students' performance in Italy, using the same data.

For each school, we also compute average test scores for low-achieving and high-achieving students, the fraction of students in the 5th/10th percentile of the score distribution and in the 90th/95th percentile, respectively. We assemble school-level annual data over six academic years, from 2011 to 2016.

3 Empirical strategy

Our identification strategy is twofold. First, we use the quasi-experimental setting induced by the 2012 Northern Italy earthquake to get a handle on the direction of causation in the infrastructure spending – students' achievement relationship. Using information from the map in Figure 1, we can measure the impact of receiving additional resources on test scores by comparing the evolution of test scores before and after the allocation of funds in the recipient areas as compared to those that did not receive extra-funds.[8] We start with a simple empirical research design, a difference-in-differences estimation strategy, which takes the following form:

$$\begin{aligned} log\, y_{it} = \alpha_0 + \alpha_1 D_i + \alpha_2 P_{t-1} + \alpha_3 D_i * P_{t-1} + X'_{it}\alpha_4 + \\ + \mu_i + \eta_p * P_t + \theta Trend + \varepsilon_{it} \end{aligned} \tag{1}$$

where the outcome variable y_{it} denotes the average test score in either mathematics or Italian language in school i in year t; D_i is a dummy that takes value one if the school belongs to the treated area; P_t is a dummy that takes value one if the observation is in the post-treatment period (i.e., post 2012);[9] X_{it} is a vector of school covariates which includes the school size, the shares of male as well as the share of native students in each school; μ_i is the school fixed effect, which absorbs school-specific constant (or slow-moving) features; as provinces could have implemented local interventions after the earthquake, we interact province fixed effect η_p with P_t to control for province-specific policies after 2012;[10] θ is the coefficient of a school-specific time trend variable and ε_{it} is an error or disturbance term. $D_i * P_t$ is the interaction between the treatment schools D_i and P_t, the dummy variable equal to one in the post-treatment period; therefore, α_3 is our parameter of interest, the difference-in-differences estimates of the impact of receiving

[8]Tables B2 and B3 in the Appendix report the pre-treatment differences in test scores and covariates, respectively, between treated and control group.

[9]We lag the treatment by one year to allow time for the funding to be invested.

[10]A province is an administrative division between a municipality and a region, and constitute the third NUTS administrative level. Provinces have, among other functions, the local planning and the coordination of schools activities. In our sample, we have a total of 10 provinces.

funding on students' achievement. Note that, for small values of the coefficient, 100*α_3 can be interpreted as the percentage increase in the test score when schools receive extra funding.

Second, we want to offer estimates of the elasticity of test scores with respect to spending per capita. Yet, as noted above, idiosyncratic changes in school spending are likely endogenous as the amount of funding allocated to each school can be correlated with unobservable school-level characteristics. To quantify this relation, we estimate 2SLS models where we instrument for school spending with the values of peak ground acceleration (PGA), the maximum ground acceleration during the earthquakes. Recall that funding was allocated to schools to reduce the vulnerability of their buildings to earthquakes and more funding per capita was granted to schools in municipalities with higher earthquake risks. The proposed instrument is thus strongly correlated with school funding. At the same time, it is uncorrelated with school-level unobservables that might affect test scores. Thus, PGA offers a valid instrument.

The second stage of the IV estimation is given by:

$$log\, y_{it} = \beta_0 + \beta_1 \widehat{FUND}_{it-1} + X'_{it}\beta_2 + \mu_i + \eta_p * P_t + \theta Trend + \varepsilon_{it} \qquad (2)$$

where the outcome variable y_{it}, the vector of controls at the school level, the trend variables and the fixed effects are the same as in equation (1). $\widehat{FUND}_{it}$ is the estimated funding per pupil as predicted by the first stage. The equation we estimate in the first stage uses the PGA level in the area where the school is located as an instrument for actual funding. Given the log-linearity of the model, the interpretation of β_1 is that of a proportional change in the test score given a unit change in funding, holding all else constant.

4 Results

In Table 1 we present the relation between funding and student scores in mathematics, whereas in Table 2 we focus on Italian language. In column 1 of each table we use as dependent variable the average score for all students, in columns 2 and 3 the test scores for students in the 5th and 10th percentile of the score distribution (i.e., low-achieving students), and in columns 4 and 5 the test scores for students in the 90th and 95th percentile (i.e. high-achieving students).

In panel A we show a naive OLS estimation, which reveals a positive correlation between funding per pupil and test scores. If for purely illustrative purposes one interprets the OLS estimates as causal, then, according to the estimates, a one-unit increase in school infrastructure spending per student (that is, 10 euros) is associated with an estimated increase in test scores in mathematics in the range of 0.1% to 0.7%, holding all else constant. The relation is insignificant at conventional levels when we replace test scores in mathematics with those in Italian language (Panel A, Table 2).[11]

In panel B we turn to our quasi-experimental design and we uncover a positive effect of receiving extra funding on test scores, although the relation is still not significantly different from zero for Italian language. In more details, test scores will increase by 10% overall if a school is a recipient of funding, and the effect is substantially larger for low-achieving students (between 26% and 33%).

Turning to the elasticity of student outcomes with respect to the amount of resources devoted to school infrastructure, recall that in panel A our main coefficients of interest are most certainly contaminated by endogeneity from uncontrolled confounding variables. Therefore in panel C we turn to the estimated coefficient of school funding in the second stage of our 2SLS. We use the PGA, an index of seismic hazard, as exogenous instrument. As we can see, the coefficients are now substantially larger than those of the naive regressions in panel A and they are all statistically different from zero. Distributing an extra 10 euros per pupil to schools will produce an estimated test score gains in mathematics in the range of 0.7% to almost 6.3%.[12] Again, we find that the marginal return to investment in school infrastructure is greater the lower the grade of the students. Interestingly, we now obtain similar results with test scores in Italian language and the estimated magnitudes of the relationship between funding and students' achievement are not only statistically significant but also economically meaningful.

In panel D we show the reduced form and the first stage estimates. As expected, we find that an increase in the PGA level has a sizable impact on students' scores. At the same time, the first stage reveals that the PGA level leads to a higher amount of infrastructure funding received by the school. We report the Kleinbergen-Paap F-Statistic, which is similar to the conventional F-statistic, but takes into account the clustering of the standard errors. The

[11] Note that all models include the share of males, of native students and the total number of students in each school as well as school fixed effects, time trends and interactions between province fixed effects and post-treatment period dummy. Using linear trends, quadratic trends, cubic polynomial in time (i.e., t, t^2, and t^3) or year dummies produce similar results.

[12] These results are not driven by the upper tail of funds and are robust to the exclusion of the top 5% of the schools from the sample, i.e. those that received more than 800 euros per student.

values are all above conventional levels characterizing weak instruments.

To dig deeper into the relationship between school funding and students' standardized test scores, Figure 2 shows the relation between the estimated coefficient β_1 in equation (2) and the quantiles of the distribution of the test scores. As the figure clearly reveals, allocating additional funding to schools' infrastructure has higher marginal effects on the achievement of students with the lowest scores on the standardized tests. Whereas in Italian language the pattern is less clear-cut, in mathematics the estimated effect decreases monotonically as we move from the 10th to the 90th percentile of the standardized test score distribution. Results are overall similar when we look at relation between the estimated coefficient α_3 in equation (1) and the quantiles of the distribution of test scores (see Figure A2). We can conclude from these two tables that the previous results using a difference-in-differences approach are strongly borne out by this new set of empirical results. The effect of school funding on students' achievement is overall quantitative large, statistically significant and robust, in particular in mathematics and for low-achieving students.

5 Conclusion

In this paper we explore the impact of school infrastructure investments on students' achievement. We use data on school funding provided after a natural disaster, a magnitude 6.0 earthquake that hit the Northern part of Emilia Romagna region in May 2012, affecting an area of 3,500 squared kilometers. We use information on the allocation process (whether schools received funding or not) and on the amount of funding that each school received (function of pre-determined seismic risks) to implement two intertwined yet different identification strategies, so as to give our regression estimates a causal interpretation.

Our empirical results suggest that doubling school infrastructure spending reflects onto an increase of students' test score up to 6.3% for mathematics and low-achieving students. A set of facts, peculiar to the Italian school system, may help us reconciling our findings with recent contributions that specifically use US data. Contrary to the United States, few resources are spent in school capital in Italy, about 184 euros per student in 2013, which places Italy near the bottom of school infrastructure spending (OECD, 2016). Whereas the average condition of school infrastructure is quite poor (by one estimate, more than 39% of school buildings need urgent maintenance, see e.g., Antonini *et al.* , 2015) interventions on school facilities are likely to affect the health, safety and morale of students and teachers and in turn their ability to learn and teach. As such, our study outlines the role of physical capital spending in improving the learning environment of high schools and offers potential policy prescriptions for investing in school infrastructure.

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Figure 1: Treated and control areas

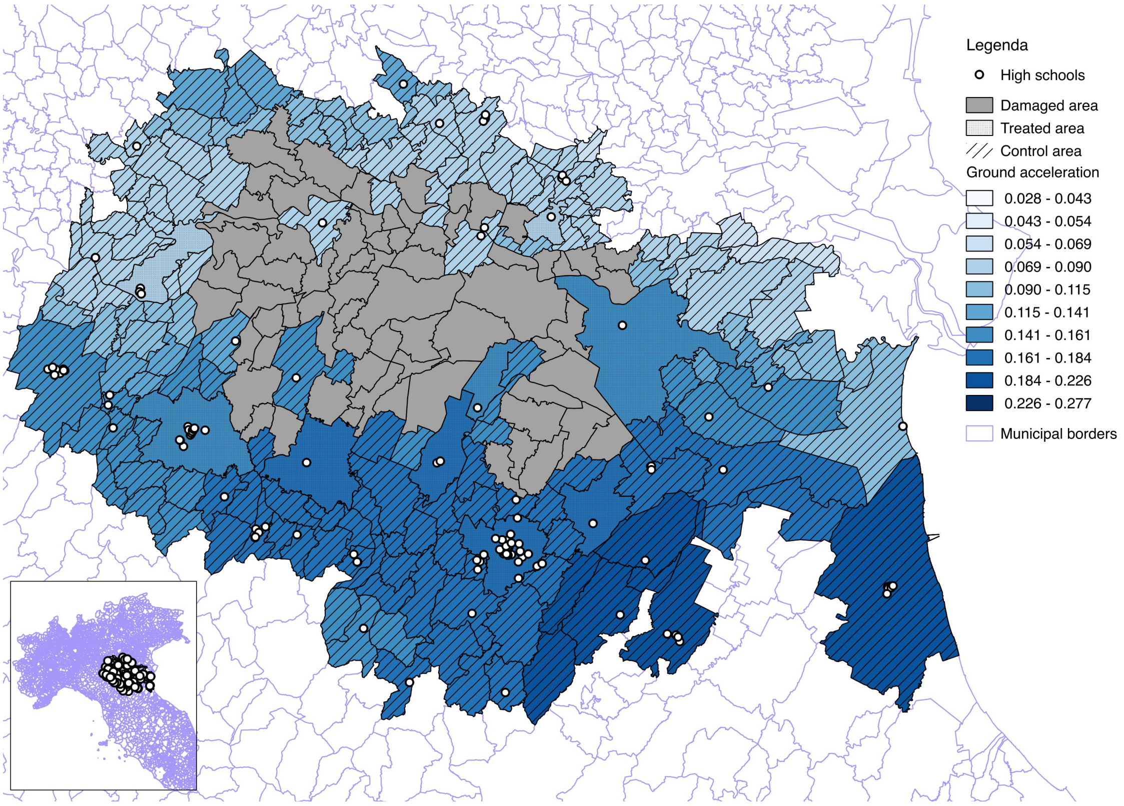
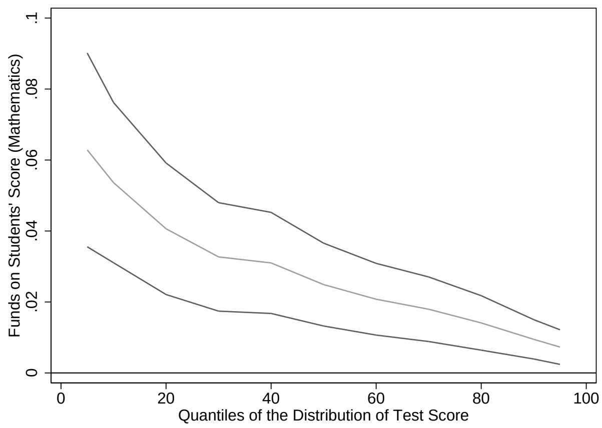
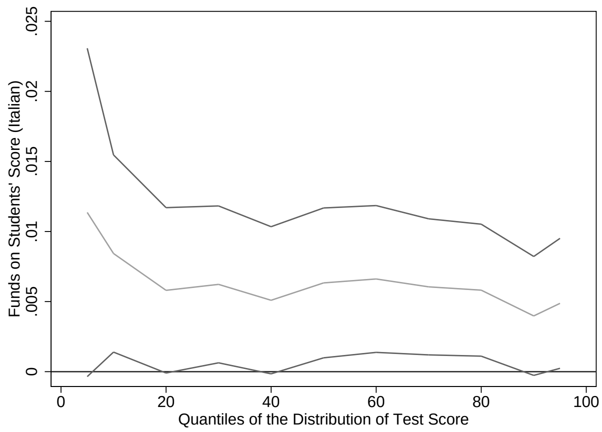


Figure 2: Estimated impact of school funding on test scores by quantiles of the distribution of test scores



(a) Mathematics



(b) Italian Language

Table 1: Secondary School, Mathematics: funding and students scores

	(1) Score (mean)	(2) Score (p5)	(3) Score (p10)	(4) Score (p90)	(5) Score (p95)	(6) Funding p.c. (*log*)
Panel A OLS Estimation.						
Funding p.c. (*log*)	0.002***	0.007**	0.005**	0.001**	0.001***	
	(0.001)	(0.003)	(0.002)	(0.000)	(0.000)	
Panel B OLS Estimation.						
Spending dummy	0.099***	0.329***	0.262***	0.043**	0.040*	
	(0.024)	(0.094)	(0.063)	(0.021)	(0.021)	
Panel C IV Estimation – Second Stage.						
Funding p.c. (*log*)	0.023***	0.063***	0.054***	0.009***	0.007***	
	(0.005)	(0.014)	(0.012)	(0.003)	(0.002)	
KP F-Statistic	17.324	17.324	17.324	17.324	17.324	
Panel D Reduced Form and First Stage.						
Seismic hazard	1.204***	3.284***	2.803***	0.495***	0.381***	52.255***
	(0.101)	(0.441)	(0.291)	(0.093)	(0.099)	(12.140)
Observations	692	692	692	692	692	692
N_i	173	173	173	173	173	173

Notes: School Fixed-effect models. All regressions include fraction of males, fraction of native students, and number of students in the tenth cohort as well as linear trend and province dummies interacted with P_t. Funding per student are expressed in 10 euros. Standard errors are clustered at the school level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 2: Secondary School, Italian: funding and students scores

	(1) Score (mean)	(2) Score (p5)	(3) Score (p10)	(4) Score (p90)	(5) Score (p95)	(6) Funding p.c. (*log*)
Panel A OLS Estimation.						
Funding p.c. (*log*)	0.000	0.003	0.001	0.000	0.000	
	(0.001)	(0.003)	(0.002)	(0.001)	(0.000)	
Panel B OLS Estimation.						
Spending dummy	0.020	0.073	0.051	0.008	0.005	
	(0.022)	(0.064)	(0.042)	(0.019)	(0.019)	
Panel C IV Estimation – Second Stage.						
Funding p.c. (*log*)	0.006^{**}	0.011^{*}	0.008^{**}	0.004^{*}	0.005^{**}	
	(0.002)	(0.006)	(0.004)	(0.002)	(0.002)	
KP F-Statistic	14.771	14.771	14.771	14.771	14.771	
Panel D Reduced Form and First Stage.						
Seismic hazard	0.328^{***}	0.623^{*}	0.462^{**}	0.218^{**}	0.267^{**}	54.827^{***}
	(0.113)	(0.345)	(0.197)	(0.106)	(0.109)	(13.773)
Observations	696	696	696	696	696	696
N_i	173	173	173	173	173	173

Notes: School Fixed-effect models. All regressions include fraction of males, fraction of native students, and number of students in the tenth cohort as well as linear trend and province dummies interacted with P_t. Funding per student are expressed in 10 euros. Standard errors are clustered at the school level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Supplementary materials

A The INGV macroseismic survey

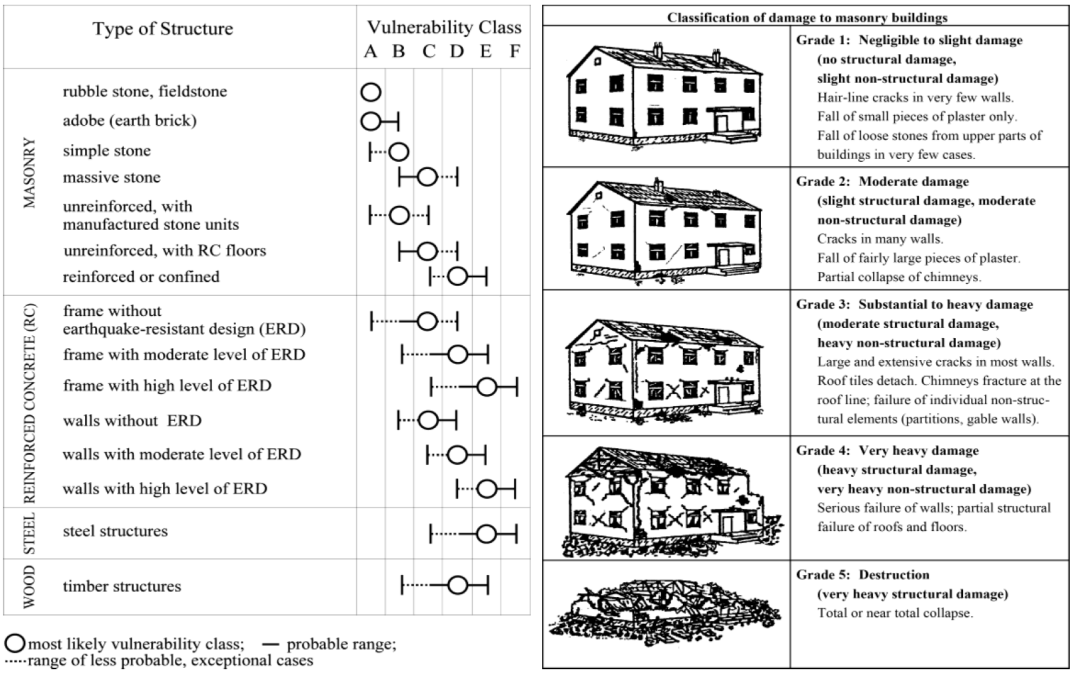
At the heart of our identification strategy is the comparison of the evolution of the test scores in mathematics and Italian language of schools located in municipalities not affected by the earthquake with those located in neighboring (and not hit) municipalities. As we discussed in the paper, we select the first group of municipalities using information from the INGV macroseismic survey. In this section, we illustrate how this survey has been implemented. For more details we refer to Galli *et al.* (2012).

The INGV macroseismic survey matches information from the macroseismic intensity values, measured through the EMS-98 scale,[13] and the level of vulnerability of the buildings in the municipality, that varies across six classes of vulnerability (A, highest vulnerability, to F, lowest vulnerability) in relation to the structural characteristics of the buildings (e.g. typological and morphological information and age of construction of the buildings). Figure A1(a), from Grünthal (1998), illustrates the likelihood that a building lies in a given vulnerability class based on its structure, whose information are gathered from the 2011 census.

Combining the macroseismic intensity values with the level of vulnerability of the buildings, the INGV macroseismic survey provides estimations of the volume of buildings with a certain level of damage in a given municipality (see Meroni *et al.* (2017) for a technical description). As illustrated in Figure A1(b), the INGV macroseismic survey classifies potential damage in 5 classes. Buildings with a damage of grade 1 (class D1) reported negligible or slight damages that, even in the worst scenario, have not affected the structure of the building. These buildings counted one or two hair-line cracks in the walls or small pieces of plaster broke off the wall. When the cracks in the walls become numerous, or there are large pieces of plaster broke off from the walls, buildings are classified as D2. Although the building does not have yet any structural damage, its use becomes less appropriate for any activity. Buildings with damages of grade higher than D2 feature heavy (and structural) damages. Those of class D3 report moderate structural damage, whereas those of class D4 are seriously damaged. Finally, buildings with a damage of class D5 are destroyed.

[13]The intensity values of the earthquake for the damaged localities are collected by the Italian Civil Protection Department (DPC) supported by other institutions such as the National Research Council (CNR) or the National Institute of Geophysics and Volcanology (INGV).

Figure A1: Vulnerability class and classification of damage to buildings. *Source:* Grünthal (1998, pp. 14-15)



(a) (b)

To give an example, if a municipality is given a macroseismic intensity value of IX along the EMS-98 scale, it means that many buildings with medium vulnerability level (class B) and few buildings of vulnerability level C are heavily damaged (D4) whereas most buildings with higher vulnerability levels (e.g., class A) are completely collapsed (D5). For each class of damage, the INGV macroseismic survey then provides the percentages of buildings in each class in every municipality.

In our analysis, we keep only schoolhouses located in municipalities where the percentage of buildings is classified at most as D1, as hair-line cracks in the walls or small pieces of plaster broke off does not affect negatively the learning process of the students.

B Additional Tables and Figures

Table B1: Summary Statistics

	mean	sd	min	max	count
Panel A – Treatment and IV					
Spending dummy	0.39	0.49	0.00	1.00	173
Funds per capita ($\times$ 10)[a]	7.79	20.58	0.00	161.29	173
Funds per capita ($\times$ 10)[b]	19.82	29.07	1.45	161.29	68
Seismic hazard (PGA)	0.16	0.03	0.09	0.21	173
Panel B – Mathematics					
Score (mean)	3.80	0.33	2.79	4.46	692
Score (p5)	3.09	0.62	0.00	4.30	692
Score (p10)	3.28	0.50	0.00	4.32	692
Score (p90)	4.15	0.28	3.11	4.59	692
Score (p95)	4.22	0.26	3.11	4.59	692
Panel C – Italian Language					
Score (mean)	4.10	0.27	1.59	4.50	696
Score (p5)	3.57	0.60	0.00	4.39	696
Score (p10)	3.73	0.47	0.00	4.44	696
Score (p90)	4.34	0.20	1.59	4.58	696
Score (p95)	4.38	0.18	1.59	4.59	696
Panel D – Controls					
% Male	0.56	0.26	0.00	1.00	692
% Native	0.82	0.14	0.21	1.00	692
Cohort Size	88.57	77.39	3.00	372.00	692

Notes: [a] All sample. [b] Only treated.

Table B2: Pre-treatment Scores

	Score (mean)	Score (p5)	Score (p10)	Score (p90)	Score (p95)
Panel A Mathematics.					
T-C	1.575	0.803	0.620	2.370	1.908
	(2.177)	(1.840)	(1.925)	(2.535)	(2.621)
Control	47.490***	27.683***	32.177***	63.329***	67.599***
	(1.376)	(1.164)	(1.195)	(1.618)	(1.652)
Panel B Italian language.					
T-C	3.955**	5.298**	4.303*	3.023**	2.322*
	(1.899)	(2.612)	(2.464)	(1.456)	(1.349)
Control	66.643***	45.274***	51.292***	80.476***	83.372***
	(1.295)	(1.636)	(1.585)	(1.078)	(0.989)
Observations	270	270	270	270	270

Standard errors clustered at the school level in parentheses.

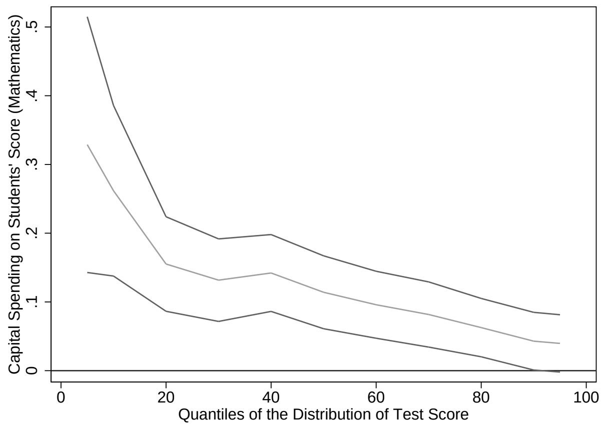
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table B3: Pre-treatment Covariates

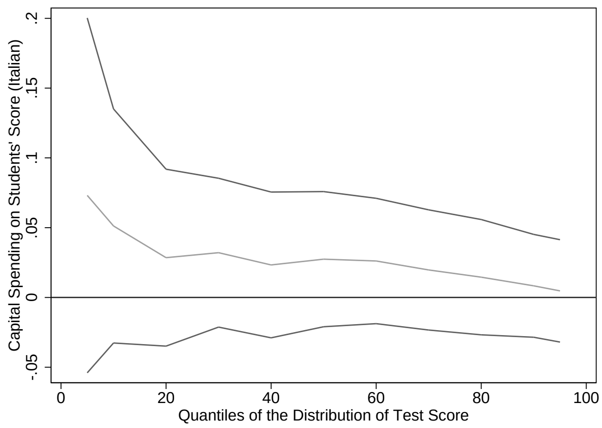
	% Males	% Natives	Cohort size
T-C	-0.067	0.017	7.961
	(0.044)	(0.025)	(13.058)
Control	0.589***	0.826***	80.848***
	(0.027)	(0.015)	(7.332)
Observations	270	270	270

Standard errors clustered at the school level in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Figure B1: Estimated impact of receiving extra-funding on test scores by quantiles of the distribution of test scores



(a) Mathematics



(b) Italian Language

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Suggested citation:
Alessandro Belmonte, Vincenzo Bove, Giovanna D'Inverno and Marco Modica (2017). *School Infrastructure Spending and Educational Outcomes in Northern Italy*. SPRU Working Paper Series (SWPS), 2017-20: 1-23. ISSN 2057-6668. Available at: www.sussex.ac.uk/spru/swps2017-20

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