THE CAUSAL EFFECT OF CLASS SIZE ON PUPILS' PERFORMANCE: EVIDENCE FROM ITALIAN PRIMARY SCHOOLS

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The Causal Effect of Class Size on Pupils' Performance: Evidence from Italian Primary Schools

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Abstract

In this study, we attempt to estimate the causal effect of class size on pupils performance using the data from Italian public primary schools. Since, in 2008/09, primary schools in Italy were subject to the maximum class size of 25 pupils, we observe a discontinuous relation between class size and enrolment that we exploit to estimate the class-size effect on pupils' performance in the context of regression discontinuity design. Using a standard fuzzy RD model, we focus attention on the pupils whose schools are in the small intervals around cut-off values of enrolment. Though we do not find any clear evidence, which would support class-size reduction policy, we observe that class size is largely used in Italian primary public schools as a kind of compensatory policy.

JEL classification: J21, J24, H52

Key words: pupils' performance; class size; regression discontinuity design; sorting; Italy.

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1 Introduction

Despite economic educational research has consistently investigated the relation between class size and education attainment, the existing evidence is still contrasting. Hanushek (1995, 2003), after reviewing a great number of estimates, concludes that there is no significant evidence about the existence of a positive effect of smaller classes on pupils' performance. Krueger (2003) and Kremer (1995) argue that many studies, rejecting the existence of relation between class size and pupils performance, have been mostly based on cross-section investigations, which are known to be subject to multiple sources of bias.

In the last decade, quasi-experimental studies dominated the economic research on the class-size effect. Starting with Angrist and Lavy (1999), numerous studies, largely based on the regression discontinuity (here after, RD) design, have been conducted using the data from schooling systems in different countries (among others, Hoxby, 2000; Dobbelsteen *et al.*, 2002; Woessman, 2005; Urquiola, 2006; Leuven *et al.*, 2008). In the context of RD designs, originally proposed by Thistlewaite and Campbell (1960), Angrist and Lavy (1999) exploit the Maimonides' rule in Israel schooling system, according to which when school's enrolment at grade level exceeds multiples of 40, another classroom should be added there. Since the application of this threshold rule generates a discontinuous relation between class size and enrolment, the authors look at the differences in test performance of pupils, whose schools' enrolment is close to cut-off values at which class size tends to drop. Using test results of pupils in large classes as a valid counterfactual of the performance of "treated" pupils in reduced classes, they find an evidence of a positive effect of class-size reduction on performance.

Recently, Urquiola and Verhoogen (2009) analyse some critical points about the use of RD designs when studying the class-size effect. Exploiting the data from Chilean schools, they found evidence that schools, subject to the exogenous maximum-class-size rule and staying in the regression discontinuity intervals, may exercise selection policy on enrolment generating discontinuities in the relation between enrolment and pupils/schools characteristics other than between class size ("treatment") and enrolment ("forcing variable"). As in a randomized experiment, this condition undermines strongly the validity of RD results.[1] Accordingly, the authors have suggested caution when using RD design, especially in application to private schools which may have a better than public schools control over enrolment, being able to exercise selection policy of enrolment in order to avoid adding an additional classroom. In this regard, Zada *et al.* (2009) found evidence that in secondary public schools in Israel discontinuities exist between pupils' household characteristics

[1] Lee, 2008; see also Hahn *et al.*, 2001.

and enrolment too, whereas this is not true among Israeli primary public schools (*i.e.* in the latter case manipulation of the forcing variable is not likely to occur).

In this paper we use RD design to estimate the class size effect in Italian primary public schools. A limited research has been done on this issue in Italy. Among the studies, Biagi and Fontana (2008) identify the factors that determine significant variations in class size across Italian regions calling for rationalization of public spending.[2] Bratti *et al.* (2007) identify the factors that influence education attainment of Italian students in secondary schools ("superiori" schools) in PISA test. They use class size as a control variable, which reveals statistically not significant. However, this study does not control for the class size that 15 years old students in the first grade of superiori had during five years of primary and three years of media school, though the educational research indicates that class size effect may be particularly important in early schooling producing then a cumulated effect (Nye *et al.*, 2000). Brunello and Checchi (2005), using the data of cohorts born in Italy before 1970, find that the lower pupil-teacher ratio calculated at regional level is positively correlated with higher educational attainment and its effect is stronger for those individuals who were born in the regions and cohorts with poorer family background.

Research on the relation between class size and pupils performance in Italian primary schools has been previously hampered by data limitations. Starting in 2004/05, INVALSI agency provides the results of tests on pupils in II and V grades in primary schools.[3] We conduct our study using the outcomes of INVALSI test of V grade pupils in 2008/09, and, to our best knowledge, there has been no study done using INVALSI data. With this study, we want to fill also this gap.

Since Italian primary schools in that period were subject to the maximum class-size rule of 25 pupils, there exists a strong and discontinuous relation between class size and grade enrolment. We estimate the relation between test results and class size using a *fuzzy* RD model focusing attention on the pupils whose schools are in the small intervals around cut-off values of enrolment (multiples of 25). Though we do not find any evidence which would support class-size reduction policy, we observe class size is largely used in Italian primary public as a kind of compensatory policy.

The remainder of the paper is organized as follows. The next section describes the institutional setting of public primary schools in Italy. It is followed by the description of data in Section 3. Section 4 presents the RD design and reports our main results and Section 5 concludes.

[2]In accomplishment of the fiscal federalism reform, which provides for the decentralization of educational system versus the increasing role of regional governments, national education standards, including class size, should be established. Furthermore, since Italian students showed to do badly in international comparisons as Pisa test, PIRLS and TIMSS (see Cipollone and Sestito, 2007), though studied for longer and in smaller classes, in 2009 the important reform bill was approved in Italy providing among other things to increase class size.

[3]INVALSI is the Italian's agency for standardized testing of pupils performance.

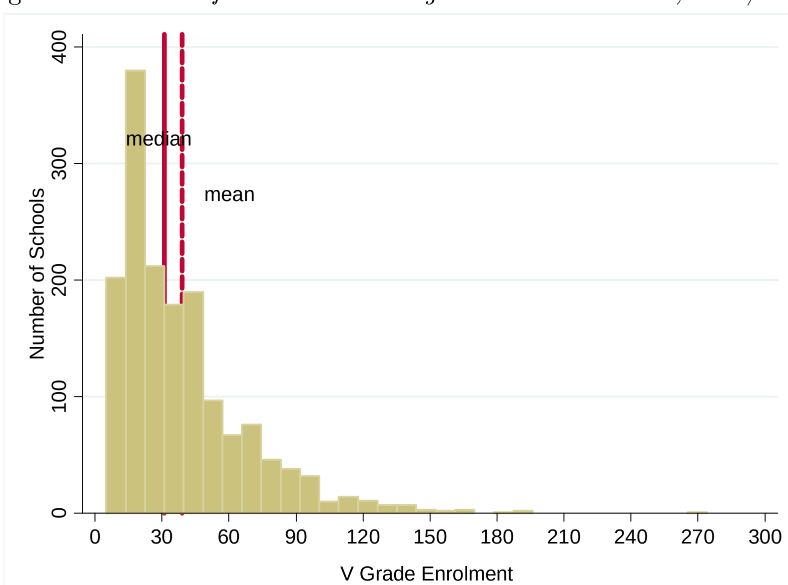
2 Italian setting

Primary schools in Italy provide education to pupils from 6 to 10 years old. They are mostly public, free of charge, and the only criteria to be used in deciding admission of a pupil is age. Parents have a right of admission of their children in neighbourhood public school, but they can choose another public school unless it is oversubscribed. Alternatively, they may send their children to private schools, which in 2008/09 accounted for about 9.8 percent of all primary schools in Italy.

Though public schools are designed and financed centrally, and the assignment of teachers to them occurs through the central administrative mechanism based upon seniority rules, they exhibit important variations in terms of class size.[4] Table 1 (see Appendix) reports the regional distribution of average class size in V grade in primary public schools in 2008/09.

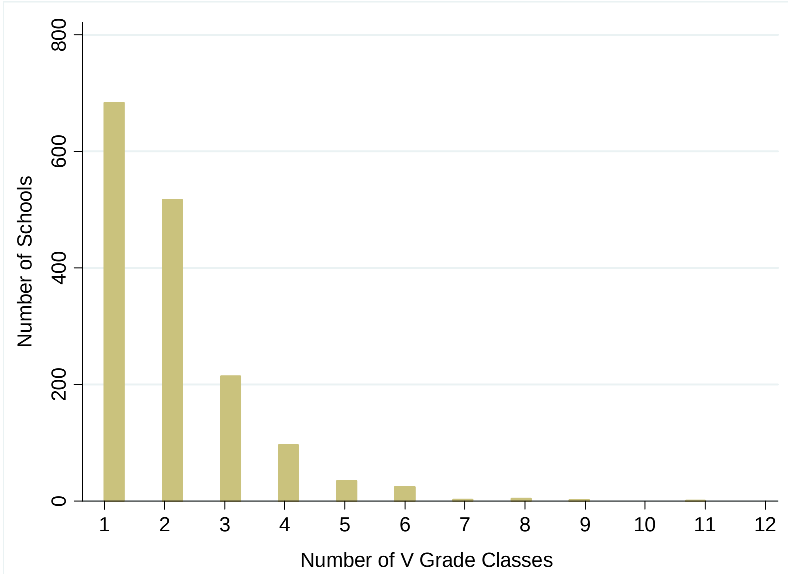
Average class size in primary public schools in Italy varies from about 15 to 20 pupils per class, and its average level is about 18 pupils per class (Column (1)). Our data includes schools whose average V grade class size is 19.41 (Column (2)). Figure1 below illustrates the distribution of the average class size in V grade in our data, clearly showing that the majority of schools is of small dimension, whereas the median V grade enrolment is around 30 pupils. This fact is coherent with the national data patterns because primary schools in Italy are not large and, as Figure 2 illustrates, they run relatively few classes per grade.[5]

Figure 1: *Number of Schools According V Grade Enrolment, 2008/2009*



[4] See Biagi and Fontana (2008).
[5] When we say schools, we intend school units ("plessi").

Figure 2: Distribution of Schools according Number of V Grade Classes, 2008/09



3 Data

We conduct our study using information from two sources. The first is the INVALSI test results of V grade pupils in primary schools in 2008/09. These results are available for 150,000 pupils coming from 5,303 public and private primary schools ("circoli didattici") from all Italian regions.[6] We restrict our analysis to the public schools whose testing procedure was assisted by INVALSI supervisors. The second source of information is school-level administrative data from the Italian Ministry of Education (MIUR).

Our analysis begins by matching the sample of INVALSI data with the dataset on school characteristics and class size coming from MIUR. Since the Ministerial data do not contain information about schools in regions with a special statute as "Val d'Aosta" and "Trentino Alto Adige", we lose data about their pupils. In addition, the linked data set decreases considerably because of many missing data about pupils characteristics in INVALSI data. At the end, we have 25,407 pupils coming from 1,561 school units ("plessi"), which do not include combine schools, schools for adults, schools run in hospitals and other unusual places.

In our analysis, the unit of observation is pupil. The linked data set includes information about each pupil's test score in math and Italian language; personal information as sex, citizenship,

[6]"Circolo didattico" is an administrative aggregation of school units ("plessi") having the same administrative body and situated, as a rule, in the same town. However, "circolo didattico" may include "plessi" from more than one neighborhood little own

country of birth, grades in math and Italian language in the first semester of 2008/09. In our data, all pupils having foreign citizenship are also pupils who were born out of Italy and vice versa.

Pupils families' characteristics include information about parent's country of birth, education attainment and job characteristics (ISEI index). Family characteristics include information about siblings; whether pupil lives with both parents, with one of them permanently or temporary, and with others (intact family status); whether pupil speaks in family Italian, one of local dialects, or foreign language; the possession of a PC and Internet access at home.

At class level, we know the average class size in V grade; whether pupil is from full-time or normal-time class.[7] We do not know whether the class has pupil/s with special educational needs or not unless the school has exactly one V grade class. However, given that in the presence of such pupils class size can be modified, we calculate the average number of pupils with special educational needs at grade level.

Since in 2008/09, INVALSI tested only a representative sample of pupils in V grade in school with supervisors, we can not distinguish between pupils coming from the same class unless the school has only one V grade class. As a result, we can not control for peer effect at class level. At school level, we know total and V grade enrolment. We are able to control for some town characteristics as population and whether it has a mountain status: partial (1) or total (2). We have no information about teachers. All information used in this study pertains to the same year of the INVALSI test.[8] Table 2 presents descriptive statististics for the main variables in our data.

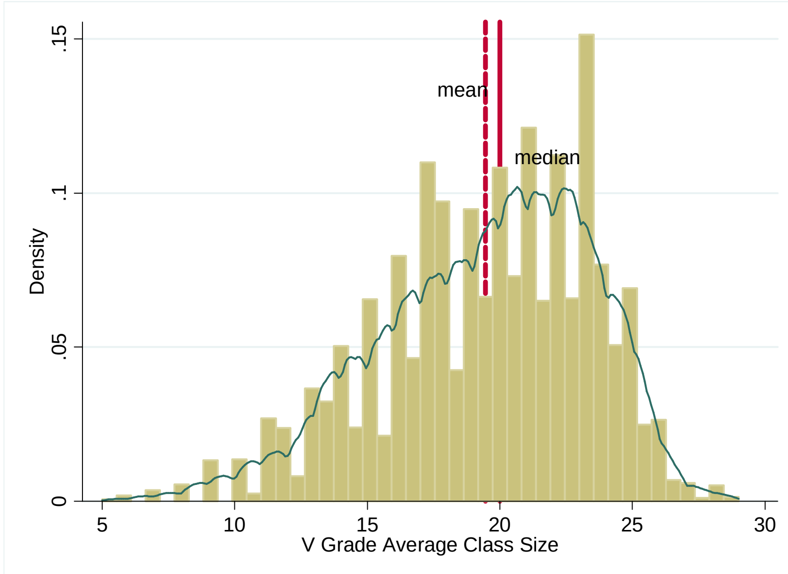
Since we are concerned with estimating class-size effect on pupils performance, our most important dependent variable is class size. We calculate the average class size in V grade at school level.[9] Figure 3 illustrates the distribution of average V grade class in our data. We can see that it is not distributed randomly in pupils population, as there are many observations concentrated on the left side from the mean value of class size.

[7]In our data, we do not include pupils from multi-grade classes, which combine children of different age, because these classes in 2008/09 were subject to the maximum class size of 11 pupils.

[8]In Italian primary schools grade retention almost never occurs so that most of pupils in our data have attended school for the same period of time. Furthermore, in primary schools the number of classes organized at the moment of subscription remains almost unchanged during all five years due to a particular mechanism through which teachers are assigned to schools. As a result, size of single classes may vary due to new pupils and pupils moving to other schools, but average class size at grade level does not change substantially in these cases given that classes are not to be aggregated or divided. We may conclude that most of pupils in our data have attended school for the same period of time and have been exposed to the same average grade class size during all five years.

[9]In our data, full-time classes are larger than normal-time classes. Their average class sizes are, respectively, 20.33 and 19.26. This result reflects the increasing demand of families for full-time classes.

Figure 3: Distribution of Class Size in Pupils Population, 2008/09



4 Regression Discontinuity Design and Estimations

It is well known that class size is a potentially endogenous variable because it can be influenced by decisions of schools and/or parents. Table 5 below reports results of the regression of class size on some selected observables describing pupils, schools and town characteristics, and regional dummies. Pupils characteristics as ISEI index of father, non-working mother and pupils' cohabiting status result strongly correlated with class size in Column (1). The statistical significance of these regressors, however, decreases or disappears as we add to the estimation equation town caracteristics and regional dummies - see Column (3) - which may mean that the selection problem related with class size may be a result of the aggregation of schools across regions, rather than of behavioral pattern of schools and/or parents.

Until 2008/09, primary schools in Italy were subject to the maximum class-size of 25 pupils, whose application consisted in adding a class each time grade enrolment exceeded the multiples of 25 pupils.[10] [11] Given the rule, we expect that class size is discontinuously related with grade

[10]Actually, the rule is applied in I grade at the moment of subscription because, as it has been already mentioned, in Italian public primary schools the number of classes organized in I grade remains almost unchanged during all five years of elementary school due to the particular procedure through which teachers are assigned to schools.

[11]Schools could deviate from the maximum-class rule in a number of cases. Namely, they could reduce the number of pupils in classes under 25 when classes had pupil/s with special educational needs; when schools were situated in small islands, mounting towns, towns with linguistic minorities and in zones with high rates of adolescent deviant behaviour. Finally, the Ministry of Education provided that schools might have smaller and larger than 25 pupils classes depending on the number of tenured teachers. For more on this, see Decreto Ministeriale 24 luglio 1998, n.331. The school reform proposed by Gelmini in 2008 elevated the maximum size of class in primary schools to 28

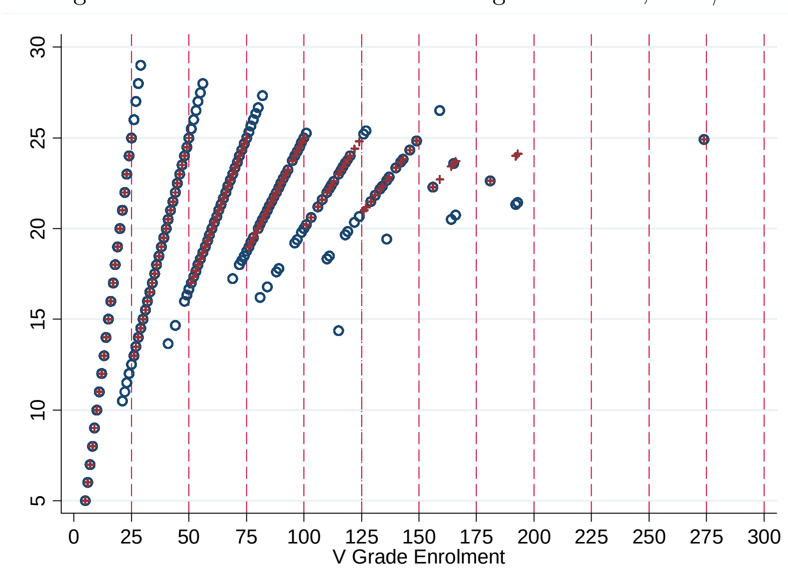
enrolment. In order to see it, we calculate the predicted class size in V grade, which is the average class size that schools would have if they applied the rule perfectly. The predicted level is calculated applying the formula as in Angrist and Lavy (1999):

$$PC_{ist} = \frac{\Phi_{ist}}{int[(\Phi_{ist} - 1)/25] + 1}. \tag{1}$$

In the above equation Φ_{ist} is the V grade enrolment at school s in town t where the pupil i studied in 2008/09, $int(\bullet)$ is the function that takes the greatest integer less than the given argument.

Figure 4 plots the relation between average class size, its predicted level and V grade enrolment at school level. We can observe a strong and discontinuous relation between the two variables: average class size exhibits discontinous jumps around cut-off values of enrolment (multiples of 25) as it is predicted by the rule.

Figure 4: Grade Enrolment and Average Class Size, 2008/09



Note: The circles scatter plots mean class size for each enrolment cell. The x plot represents the predicted class size that describes the relationship between enrolment and class size that would exist if the maximum class-size rule were applied perfectly.

Since we know the rule explaining class organization in primary schools in 2008/09, and since in our data class size exhibits jumps at the cut-off values of enrolment, we may use regression discontinuity design to estimate causal relation between class size and pupils performance. In RD approach, if schools and parents have imperfect control over the forcing variable (enrolment), the

pupils, starting in the schooling year 2009/2010. In 2009 the reform was approved.

"treatment" effect on pupils performance through class size can be estimated by confronting test results of pupils in large and small classes on left and right sides of cut-offs respectively.

As opposed to the *sharp* RD design (the treatment assignment is a result of a *deterministic* function of the forcing variable), in a *fuzzy* RD design the probability of receiving the treatment need not change from 0 to 1 at the cut-off, *i.e.* a case of imperfect compliance (Trochim, 1984; Hahn *et al.*, 2001). As seen in Figure 4, findings suggest that the actual class size does not obey the predicted class size perfectly. It follows that enrolment does not perfectly explain class size in our data, given the Italian institutional setting. On the other hand, we still observe that the probability of reducing class size contains jumps at cut-offs points.

A standard model of fuzzy RD can be described as follows (van der Klaauw, 2002):

$$P_{ist} = \delta E(CS_{ist}|\Phi_{ist}) + \alpha(\Phi_{ist}) + \epsilon_i \tag{2}$$

$$E(CS_{ist}|\Phi_{ist}) = \lambda 1(\Phi_{ist} \geq \bar{\Phi}) + \beta(\Phi_{ist}) \tag{3}$$

In the above equations, we assume, for the sake of simplicity, one class-size cut-off and homogenous treatment effects on pupil's test score; P_{its} is the test score of pupil's i in school s in town t, CS_{ist} is average class size in V grade at school level, Φ_{ist} is the V grade enrolment at school level, $\bar{\Phi}$ indicates the cut-off values of enrolment, $\alpha(\bullet)$ and $\beta(\bullet)$ are functions of enrolment. Since enrolment is a discrete variable, class-size effect can be estimated only parametrically (Lee and Card, 2008). Given this, for $\alpha(\bullet)$ and $\beta(\bullet)$ we choose as specifications the piecewise linear splines whose *kinks* correspond to the values of cut-offs (Urquiola and Verhoogen, 2009, Zada *et al.*, 2009; see also McEwan and Urquiola, 2005).

4.1 Results (Full sample)

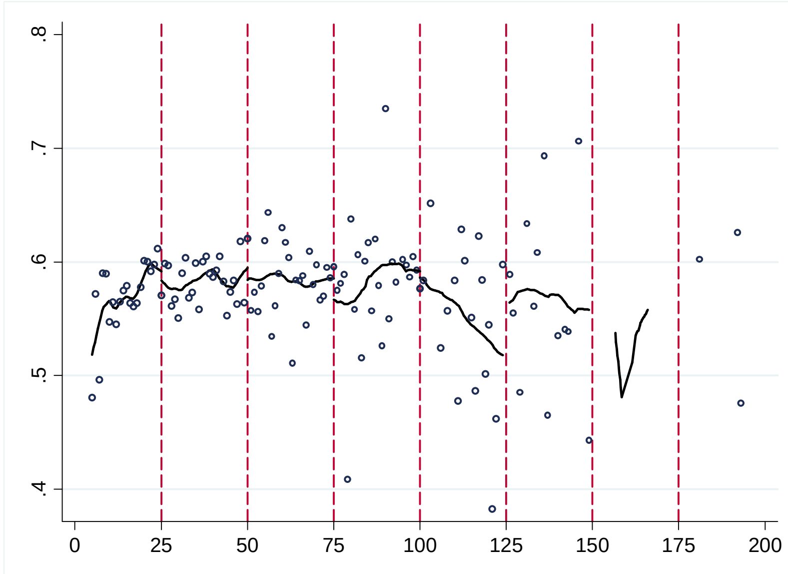
We start by looking at the distribution of pupils and schools characteristics along cut-off values of enrolment. The RD design requires that forcing variable has to be related smoothly to pupils and schools characteristics, otherwise it would be impossible to attribute differences in test score to class size differences. Table 4 reports the results of the regressions of pupil's characteristics on the cut-offs values and, as in $\alpha(\bullet)$ in (2), on the linear splines of enrolment. The coefficients on the dummies for cut-off indicators $1\Phi \geq 26$; $1\Phi \geq 51$; $1\Phi \geq 76$; $1\Phi \geq 101$; $1\Phi \geq 125$; $1\Phi \geq 150$; $1\Phi \geq 175$ are the estimates of the average variations in ISEI indexes of pupils' mothers and fathers, mothers' education and in the average number of pupils with special educational needs at those breaks. As we see, at the first cut-off ($\Phi \geq 26$), all of the above variables decrease, in particular the average decline of ISEI index of pupils' mother is equal to 4.3 (this variable varies between the minimum of 0 and the maximum of 68). All above variables are positively related to grade enrolment, which is, basically, a measure of school dimension. This does not necessarily mean that families with "better" educational and economic status prefer bigger schools, but can be a result of geografical aggregation effect whereas in bigger cities with bigger schools economical and educations status of people generally gets better. Surprisingly, we do not find that the number of pupils with special educationa needs increases in smaller classes, though it is explicitly provided by the Ministerial rules.[12]

Smoothness assumptions of regression discontinuity inference requires also that the number of observations nearly to cut-offs on left and right sides are approximately equal. [13] Figure 5 presents an histogram of V grade enrolment among schools, and such stucking is not evident for all thresholds. Only for the first and the second cut-off results show a stacking behaviour. Though we consider public primary schools where non-subscribing of pupils seems to be difficult to realize, yet, if we see Figure 5, the number of schools, whose enrolment $25 \leq \Phi < 30$ and whereas an additional class should be added for few additional pupils, declines. The same pattern can be observed for enrolment $50 \leq \Phi < 55$.

[12] Figures 15 16 and 17 (see Appendix) illustrate the results of local regressions of selected characteristics as ISEI index of pupils' father and mother and mother's eduction, which clearly illustrate the selection pattern of families on enrolment cut-offs. Specifically, ISEI index of father declines at 50, 75 and 100 pupils thresholds; ISEI index of mother declines at 25, 50, 75 and 100; and mother's education declines at 50 and 100 pupils thresholds.

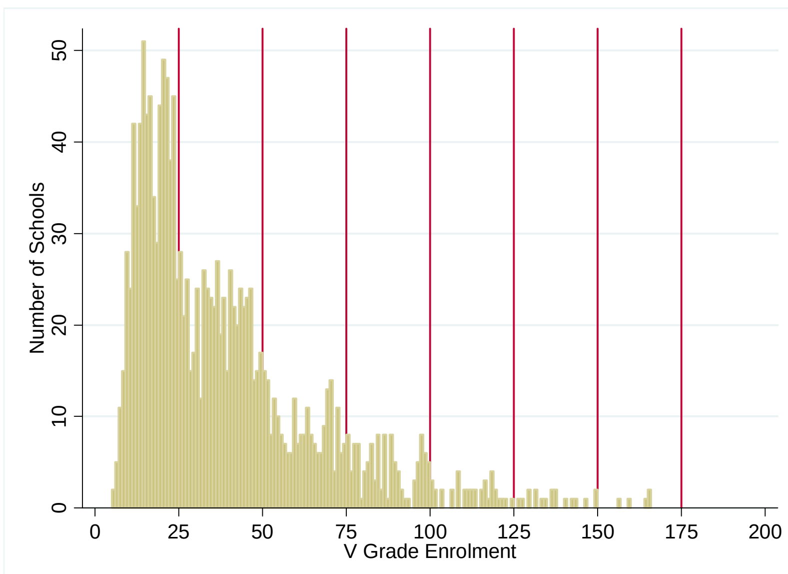
[13] Urquiola and Verhoogen (2009) constructed a theoretical model of quality differentiation and sorting where a considerable number of private schools stucks at enrolment cut-offs.

Figure 6: Distribution of Test Results in Math on Grade Enrolment (full sample), 2008/09



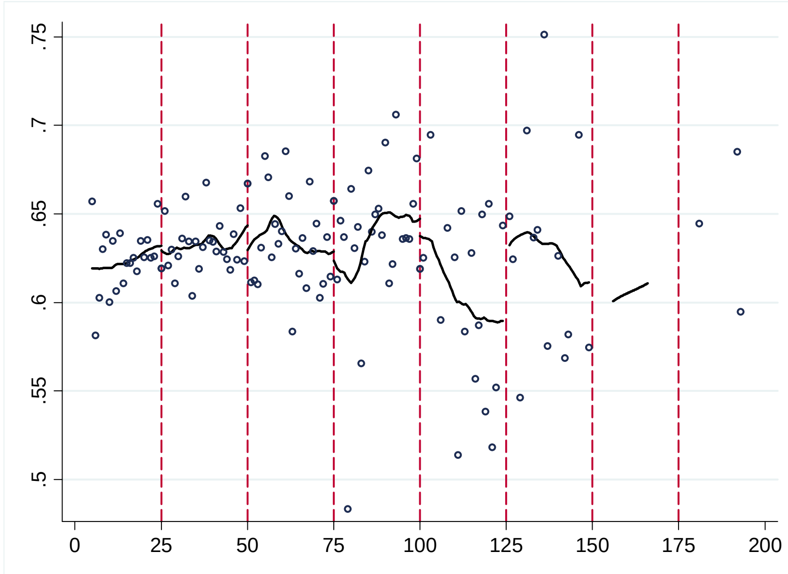
Note: Figure presents enrolment-cell means of test results in math, along with fitted values of alocally weighted regression using data aggregated by enrolment.

Figure 5: Number of Schools according V Grade Enrolment (full sample), 2008/09



Figures 6 and 7 display a graphical analysis visualizing the relationship between test scores and forcing variable. They show the findings of local regressions of test results in, respectively, math and Italian language on the grade enrolment. Despite the average class size decreases considerably in the first four cut-offs (25, 50, 75, 100), test results seem to decrease only in the fourth one. In the cut-off of 125 pupils, test results see to get better.

Figure 7: Distribution of Test Results in Italian (full sample), 2008/09



Note: Figure presents enrolment-cell means of test results in Italian, along with fitted values of locally weighted regression using data aggregated by enrolment.

Table 5 shows the results of the regression model in (2) and (3). Column (1) reports the results of first-stage regression of class size on indicators for whether enrolment exceeds the cut-off values of enrolment along with the piecewise linear splines. In this specification, standard errors are clustered by enrolment. [14] As we can see - the adjusted R-squared is about 0.66 - the rule explains a great part of variation in class size. Its average decline equals to about 9 pupils in the first cut-off decreasing in the following ones as predicted by the rule. Furthermore, the declines are statistically significant in the first four cut-offs. In column (2) and column (3), we present the results of the reduced-form regressions of test outcomes in math and Italian language, which show that test results decline on average in all cut-offs, although the declines are statistically significant only for Italian in 150 and 175 cut-offs. Columns 4-5 report IV specifications for math and Italian language, respectively. [15]

In both cases, the coefficient on class size is slightly negative and not significant.

[14] Lee and Card (2008) suggest this procedure when the forcing variable is a discrete one.

[15] In these specifications, dummy variables for the cut-offs ($1\Phi \geq 26$; $1\Phi \geq 51$; $1\Phi \geq 76$; $1\Phi \geq 101$; $1\Phi \geq 125$; $1\Phi \geq 150$; $1\Phi \geq 175$) are used as instruments for class size.

4.2 Results (Small Intervals around cut-offs)

In this section, we focus on small intervals around enrolment cuto-ffs as in van der Klaauw (2002).[16] We want to estimate class-size effect using observations in intervals of 3 and 5 pupils around the first four cut-offs (25, 50; 75 and 100).[17] Table 7 reports the results of reduced-form regression of pupils/schools characteristics on dummies for cut-off values, enrolment and piecewise linear splines.

We do not find evidence supporting a clear selection behavior of schools and families in the selected intervals. Moreover, though ISEI indexes of pupils' mother and father result significantly related to class size decline in the second cut-off, ISEI index of pupil's father increase there while ISEI index of pupil's mother decreases. Average number of pupils with special needs varies in intervals, it increases or decreases depending on the selected cut-off.

In order to fully test if observed baseline covariates are continuous at cut-off scores, we do a further control for selection pattern of schools and families. Using probit model, we regressed pupil's index of being in large (0) and small (1) classes in selected intervals on the extended list of regressors as in column (2) of Table 5 and found that the probability of being in large or small classes does not depend significantly on pupils and schools characteristics.[18]

As in the case of full sample, we control whether the number of schools on left and right sides of cut-offs does not vary considerably, otherwise it would mean that schools stuck at cut-offs by non subscribing pupils. Figure 8 presents an histogram of V grade enrolment among schools in cut-off intervals of ± 3 pupils, and such stucking is not evident.

[16]See also Hoxby (2000) and Angrist and Levy (1999, p. 540).

[17]The first four cut-offs include the majority of observations in our data. Furthermore, as predicted by the maximum class-size rule, in these cut-offs class size should decline more considerably.

[18]For space economy, we do not report the results of probit estimations for intervals of 3 and 5 pupils.

Figure 8: Number of Schools in Enrolment Intervals: 25±3;50±3,75±3;100±3, 2008/09

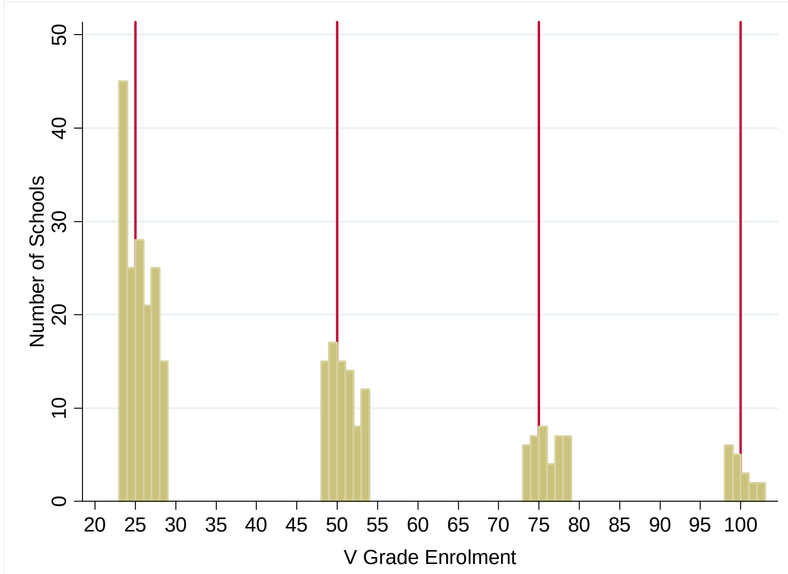


Table 8 reports the results of first stage, reduced-form for test outcomes in math and Italian language, and IV stage for math and Italian language without and with inclusion of some observables using the observations from intervals of 3 pupils: 25±3; 50±3; 75±3, 100±3. Suprisingly, we observe that class size, except in 100±3 interval, increases when enrolment exceeds cut-off values (see column (1); the average increase in class-size at first cut-off is not statiscally significant). These results agree with the visual evidence from Figures 4.2-12 which show the distribution of class size in selected intervals. Specifically, histograms show that in cut-off intervals there are many schools that deviate from the rule either by adding an additional class even if enrolment does not exceed multiples of 25, or by non-adding it when the rule provides so. The number of schools deviating from the rule by non-adding additional classes seem to prevail.

Columns 2-3 of Table 8 report the estimates of reduced form of test scores in math and Italian language. We find a negative relation between increasing class size and test performance only at the second cut-off where average class size increases and test results in math and Italian language decline. The evidence is different for the fourth cut-off where average class size decreases together with test results in math and Italian language. The estimates of IV specification of class size increasing upon pupils test outcomes are uniformly negative for both math and Italian language, but not statistically significant in both specifications without (columns 4-5) and with inclusion of selected observables (columns 6-7).[19] By adding some observables to IV specification as an

[19]Lee and Card (2008), and Urguiola and Verhoogen (2009) suggest that clustering by enrolment level lowers

additional control for possible selection problem (columns 6-7), it seems that the second stage estimation of pupils performance on class size does not change considerably the results, which suggest that RD design may be appropriate estimation strategy in this case.

Figure 9: First cut-off Interval $\Phi \in [23, 28]$*: left side [23,25]; right side [26,28]*

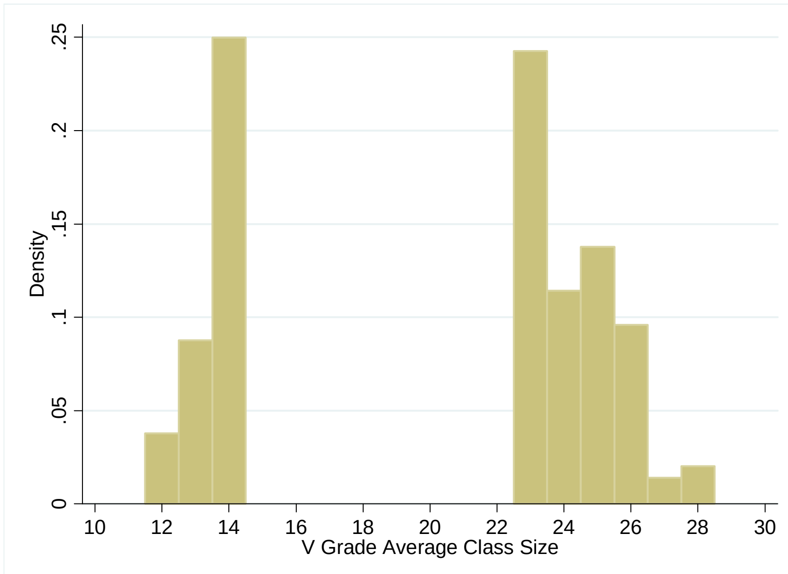
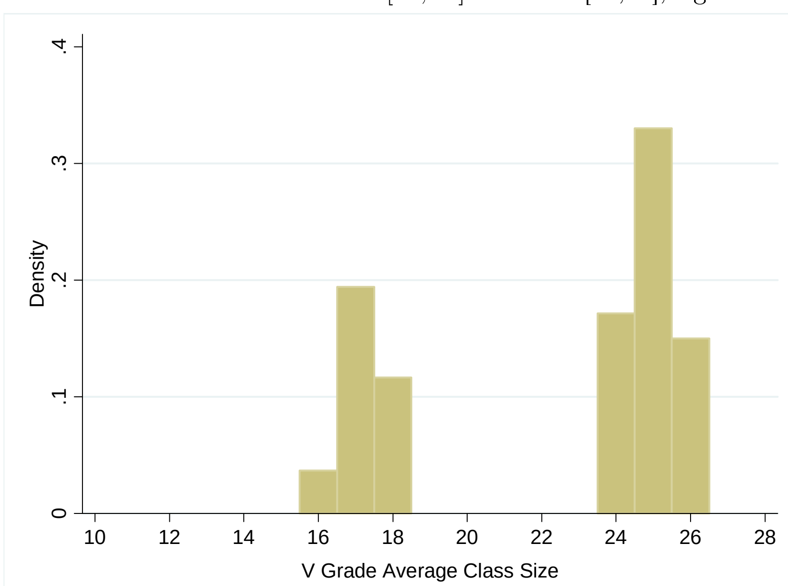


Figure 10: Second cut-off Interval $\Phi \in [48, 53]$: left side [48,50]; right side [51,53]



significance levels.

Figure 11: Third cut-off Interval$\Phi \in [73, 78]$: left side [73,75]; right side [76,78]

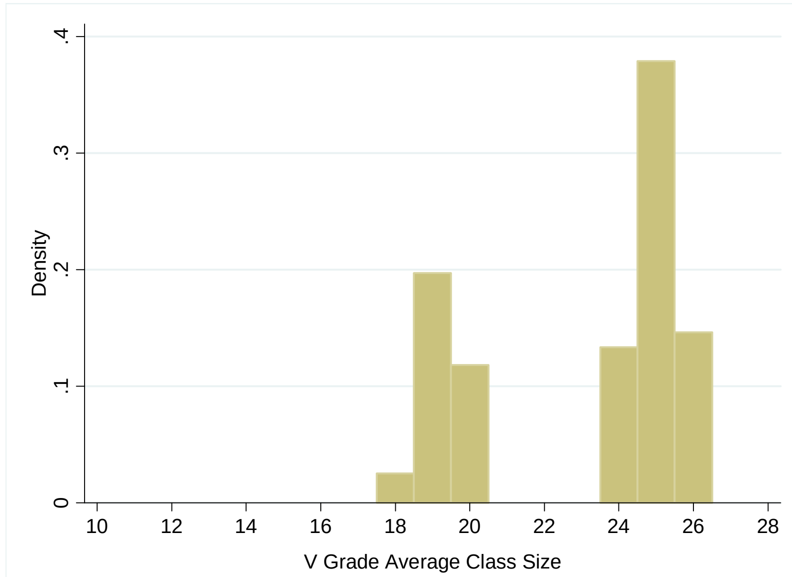
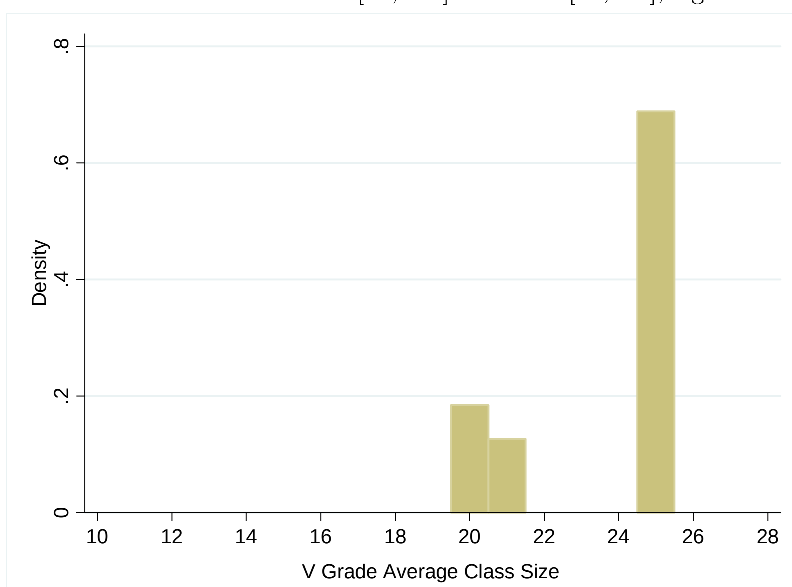


Figure 12: Fourth cut-off Interval$\Phi \in [98, 103]$: left side [98,100]; right side [101,103]



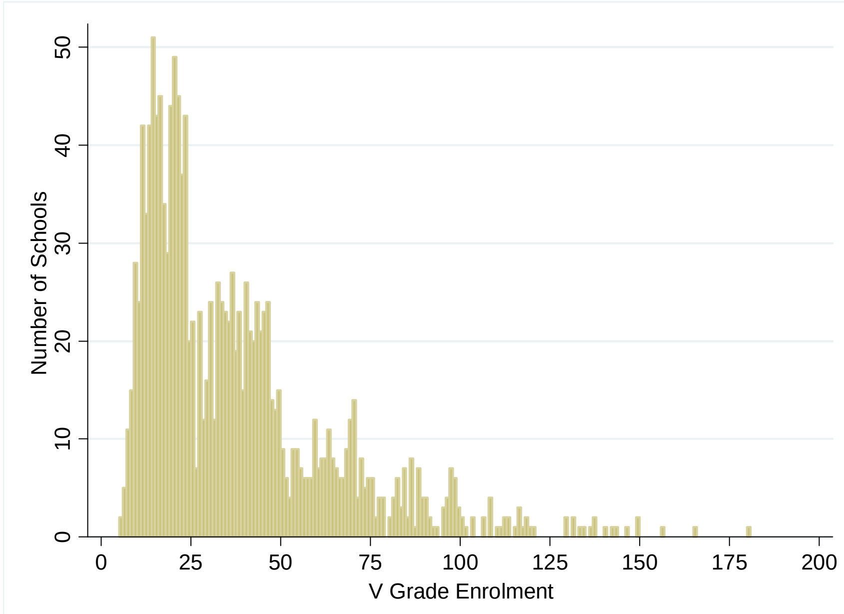
The main results, obtained focusing on observations from small intervals around first four cut-offs, are summarized in Table 9. Columns 1-4 report the results of IV stage separately for intervals of ± 3 and 5 pupils using the indicator for whether schools' grade enrolment is above the respective cut-off as an instrument. Column 5-6 show, respectively, the results of IV stage for pooled cut-off estimation without and with inclusion of observables. For each interval we report the measure of average class size on both sides of cut-off intervals. In all estimations standard errors are clustered by V grade enrolment. As we see class-size reduction has a positive and significant (*;**) effect on both test results in Math and Italian in 2 cut-off interval whereas average class-size declines from 23.078 to 20.568 in ±3 pupils interval; and from 22.983 to 20.028 in ±5 pupils interval. This is the only evidence supporting class-size reduction policy that we find in our data. In the remaining cut-offs, coefficients are statistically not significant.

4.3 Class Size Policy

In this section, we focus on schools that in 2008/09 respect the maximum class-size rule perfectly. In the previous section, looking at the observations in small intervals around enrolment cut-offs, we have found that they include a great number of schools that deviate from the rule by adding an additional class when enrolment is not sufficient, or non-adding it as predicted by rule. In this section, according to our data, we want to see whether compliant schools differ from schools that deviate from the rule in a systematic way.

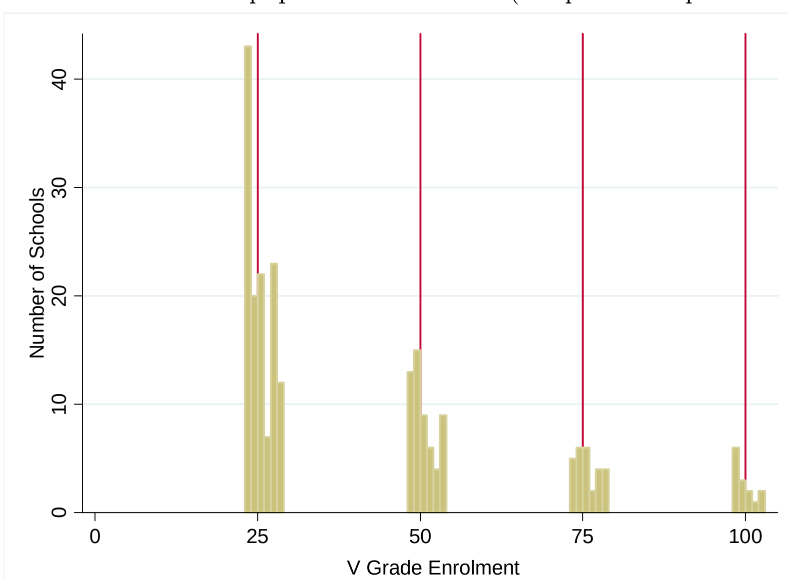
In our data there are 1,580 schools units, among them 1,467 have the average class size as predicted by the rule. Clearly, the deviating schools are concentrated in cut-off intervals (see Figure 4). Figure 13 reports the distribution of compliant schools according to enrolment. As we can see, stucking behavior is more evident in this subsample of schools compared to the full sample in Figure 5. Specifically, the number of schools applying the rule declines when enrolment exceeds multiples of 25 pupils of few pupils and grows straight afterwards. The same pattern can be observed at the cut-offs of 50, 75 and 100 pupils.

Figure 13: Number of Schools (sample of compliant schools), 2008/09



Focusing on schools in small intervals around cut-offs, we find that the number of compliant schools on their left sides is systematically larger than on the right ones (85 and 42 rispectively in the first interval; 37 and 19 in the second one; 17 and 10 in the third one; and 11 and 3 in the fourth one).

Figure 14: Number of Schools in 3-pupil cut-off Intervals (sample of compliant schools), 2008/09



As in the previous analysis (full and±3 and 5 pupils samples), we look at the data of compliant schools to control for the distribution of pupils' characteristics around cut-off values of enrolment. Table 5 reports the results of reduced-form regression of selected pupils' characteristics on cut-off dummies, enrolment and piecewise linear splines. We do not report the results of reduced-form for average number of pupils with special needs as it results irrelevant in cut-off intervals. As we can see, Table 5 presents a clear evidence of sorting of pupils' characteristics around cut-offs. Specifically, ISEI index of pupils' father is negatively related to class size decline and statistically significant at *all* cut-offs. At the first cut-off, all of the baseline covariates decrease, whereas the average declines in ISEI indexes of pupils' mother and father are particularly large and equal to 10.3 and 7.8, respectively. The coefficients for ISEI index of mother and mother's education are uniformely negative, though significant only, respectively, at the second and the third cut-offs. These results make us guess that there may exist a supplementary "rule" to the maximum class-size rule, according to which public primary schools' probability to get resources, mainly teachers, in order to add a class when grade enrolment exceeds the threshold values increases when they have pupils coming from "unfavorite" socio-economic background (*e.g.* less educated mother, lower socioeconomics status of mother and father).

5 Conclusions

In this paper we make an attempt to estimate the class-size effect on the pupils' performance using the data from Italian primary schools. We base our estimation strategy on RD design, which has been largely used in the recent economic literature on class-size issue. The application of RD design to estimate class-size effect is appropriate when increases in grade enrolment are linked with jumps in class size as predicted by the threshold rule generating a discontinuous relation between the two variables. Additionally, in order to apply RD estimation strategy, practitioners have to test if the assumptions of RD analyses are not infringed, otherwise it would invalid to infer a "treatment" effect of class size on pupils' test results. The RD main assumptions are that schools and/or parents should not be able to exactly manipulate the forcing variable (enrolment), and there should not be evidence of sorting of baseline covariates influent for scholastic performance on threshold values of enrolment. It follows then that baseline covariates should be used to test the adequacy of RD design by controling whether their distribution is continuous at cut-offs points and whether there is not a precise sorting of schools according their enrolment there, *i.e.* the number of schools with large and small classes should not vary consistently at cut-offs of enrolment.

Considering our data, we find evidence of discontinuities in the distribution of both baseline covariates and of numbers of schools along the dimension of enrolment levels. Only we focusing on intervals of ± 3 and ± 5 pupils around selected enrolment cut-offs (25, 50, 75 and 100), selection problem becomes less evident. We do not observe stucking behavior of schools at the enrolment thresholds. And pupils' characteristics result to be distributed smoothly in the majority of small cut-off intervals. These results suggest that RD design may be an appropriate estimation strategy of class-size effect using the observations from intervals of ± 3 and ± 5 pupils. Considering this sample, we do not find a sufficient evidence supporting class-size policy. Only in the 2 cut-off interval, class-size reduction has a positive and significant effect on test results in math and Italian language. For the rest of our analysis using the reduced sample, class-size is not statistically significant for test results.

We do not find a significant evidence which would support class-size policy, yet our results call for further research on this issue. As we observe in our data, class size is largely used in primary public schools as a kind of compensatory policy. In fact, when we focus on schools that in 2008/09 applied the maximum class-size rule perfectly, we find that they differ from "deviating" from the exogenous maximum-class-size rule schools in a more systematic way. First, the stucking behavior is more evident in the reduced sample of compliant schools. Second, in this sample there is a clearer evidence of sorting of pupils' characteristics around cut-offs points: right sides of cutoff intervals include more pupils with "unfavorite" socio-economic background. A possible issue of future research can be to understand whether the compensatory policy through class-size reduction is efficient. The data about Italian schools state that only primary level of schooling manages to compensate for family background of pupils while in "media" and "superiori" schools education gaps grow depending on students families' background.

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Appendix

Table 1: Distribution of V grade class size between Italian regions, 2008/09.

	Average class size (1)	Average class size (2)
Abruzzo	16.81	19.19
Basilicata	16.42	18.14
Calabria	14.9	18.25
Campania	17.19	19.47
Emilia Romagna	19.61	20.75
Friuli Venezia Giulia	17.34	19
Lazio	18.33	19.94
Liguria	17.77	18.95
Lombardia	18.86	20.49
Marche	18.78	20.23
Molise	14.42	18
Piemonte	17.49	19.27
Puglia	19.48	20.64
Sardegna	16.55	17.86
Sicilia	17.77	20.70
Toscana	18.79	19.61
Umbria	17.08	18.76
Veneto	18.12	18.46
Total	17.94	19.41

Note: In Column 1 average class size is calculated using the data of all public primary schools in 2008/2009. In column 2, average class size is calculated using the data of schools in our dataset.

Table 2: Summary Statistics, 2008/09

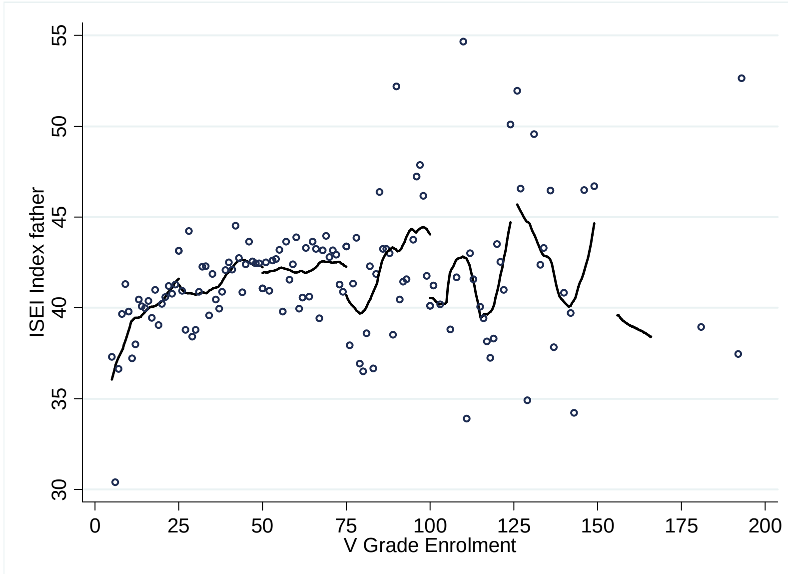
	Mean	SD	Min	Max
Girls	0.49	(0.49)	0	1
Foreign citizenship	0.053	(0.23)	0	1
Foreign country of birth of at least once parent	0.059	(0.23)	0	1
ISEI index father	41.43	(14)	0	68
ISEI index mother	26.25	(23.58)	0	68
Homemaker mother	0.38	(0.49)	0	1
Mother's education (1,2,3,4,5,6)	3.29	(1.36)	1	6
Intact family status (1,2,3,4)	1.17	(0.54)	1	4
Internet at home	0.75	(0.43)	0	1
Family language (1,2,3)	1.22	(0.53)	1	3
Homework assistance at home	0.97	(0.36)	0	1
Schooling time	32.82	(4.25)	27	40
Average V grade class size	19.45	(3.99)	2	29
Average number of pupils with special needs in V grade classes	0.56	(0.60)	0	4
School enrolment	217.3	(142.77)	6	1407
Town population	105552.07	(313209.6)	500	2547000
Mountain municipality (0,1,2)	0.48	(0.76)	0	2
N pupils		25407		
N schools		1561		

Table 3: Average Class Size in V Grade on Observables, 2008/09

	(1)	(2)	(3)
Girls	-0.026958(0.0414)	-0.026707(0.0413)	-0.028921(0.0405)
Foreign Citizenship	0.141278(0.1126)	0.099019(0.1119)	-0.053408(0.1032)
ISEI Index Father	0.006494***(0.0021)	0.006290***(0.0021)	0.004784**(0.0021)
ISEI Index Mother	0.000113(0.0021)	0.000033(0.0021)	0.000497(0.0021)
Homemaker Mother	-0.388443***(0.1092)	-0.325233***(0.1077)	-0.113371(0.0986)
Mother's Education	0.033360(0.0273)	0.036768(0.0272)	0.038560(0.0265)
Cohabiting Status	0.096305**(0.0423)	0.078944*(0.0421)	0.049892(0.0401)
Siblings	0.210060*(0.1162)	0.192834*(0.1163)	0.138759(0.1146)
Average Number of Pupils with Special Needs		0.029189(0.1372)	0.000567(0.1361)
Dummy Full-time Classes		0.559463***(0.1944)	0.463471**(0.1992)
Dummy Mounting Status			-0.278924**(0.1265)
Regional Dummies	NO	NO	YES
V grade enrolment		0.269967***(0.0138)	0.260420***(0.0136)
V grade enrolment^2		-0.002184***(0.0002)	-0.002077***(0.0002)
V grade enrolment^3		0.000005***(0.0000)	0.000005***(0.0000)
Constant	11.508095***(0.3880)	11.520804***(0.3925)	11.600142***(0.4972)
Pupils	25407	25407	25407
Schools	1580	1580	1580
R-squared	0.3572	0.3604	0.3895

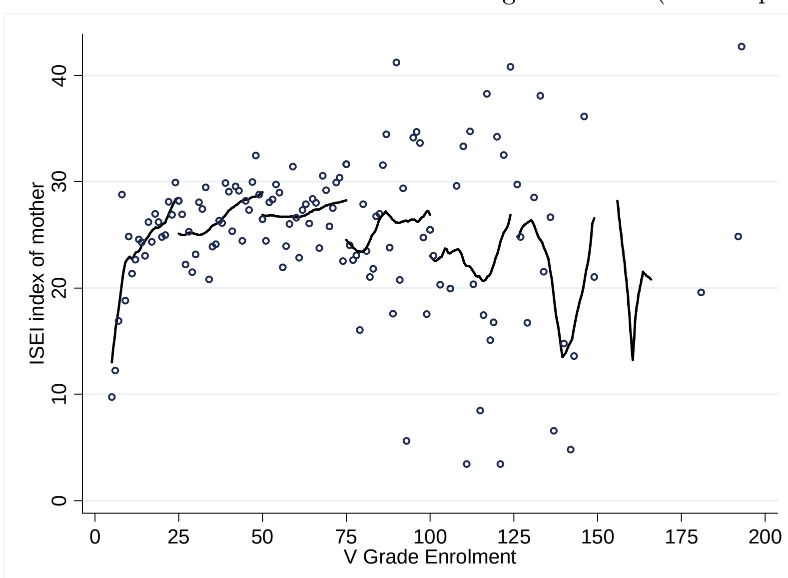
Note: Robust standard errors in parentheses.*** p<0.01, ** p<0.05, * p<0.1. The regression in column (3) include regional dummies: Abruzzo 1060 pupils, 66 schools, coef 0.76, sd 0.5123; Basilicata 1048 pupils, 59 schools, coef -0.70, sd (0.4848); Calabria 1325 pupils, 93 schools, coef -0.17, sd 0.4809; Campania 1407 pupils, 90 schools, coef -0.21, sd 0.4830; Emilia Romagna 1689 pupils, 107 schools, coef 1.31***, sd 0.4335; Friuli 2166 pupils, 126 schools, 0.69*, sd 0.4054; Liguria 1183 pupils, 82 schools, coef 0.25, sd 0.5272; Lombardia 2696 pupils, 149 schools, coef 1.00**, 0.4065; Marche 1353 pupils, 84 schools, coef 1.42***, sd 0.4765; Molise 885 pupils, 53 schools, coef -0.37, sd 0.5265; Piemonte 1763 pupils, 118 schools, coef 0.43, sd 0.4182; Puglia 1276 pupils, 64 schools, coef 0.47, sd 0.5057; Sardegna 1123 pupils, 75 schools, coef -0.17, sd 0.4782; Sicilia 1170 pupils, 68 schools, coef 0.36, sd 0.4861; Toscana 1427 pupils, 103 schools, coef 1.68***, sd 0.4417; Umbria 1014 pupils, 68 schools, coef 0.58, sd 0.5388; Veneto 1939 pupils, 119 schools, coef -0.028, 0.5072416.

Figure 15: Distribution of ISEI index of father along Enrolment (full sample), 2008/09



Note: Data are aggregated at school level. The figure presents enrolment-cell means, along with fitted values of a locally weighted regression calculated within each enrolment segment.

Figure 16: Distribution of ISEI index of mother along Enrolment (full sample), 2008/09



Note: Data are aggregated at school level. The figure presents enrolment-cell means, along with fitted values of a locally weighted regression calculated within each enrolment segment.

Table 4: Reduced Form of Selected Observables (full sample), 2008/09

	ISEI index father	ISEI index mother	Mother's education	Average number of pupils with special needs
$1\{\Phi \geq 26\}$	-1.442426*(0.7612)	-4.255093***(1.1256)	-0.153009**(0.0662)	-0.212225***(0.0628)
$1\{\Phi \geq 51\}$	-0.479656(0.7402)	-2.195675*(1.2929)	-0.096016(0.0820)	-0.053653(0.0787)
$1\{\Phi \geq 76\}$	-1.424020(1.4181)	-3.621004*(2.0253)	0.002231(0.1291)	0.134445(0.0988)
$1\{\Phi \geq 101\}$	-2.739835(2.8324)	-5.877963(4.8102)	-0.284840(0.3592)	0.238710(0.2001)
$1\{\Phi \geq 125\}$	3.002955(4.2507)	1.255818(6.6750)	0.458503(0.5402)	-0.428608**(0.1811)
$1\{\Phi \geq 150\}$	-1.284081(5.1726)	14.332224(19.4269)	0.328501(0.9411)	0.068589(0.5575)
$1\{\Phi \geq 175\}$	4.514970(6.6951)	17.190307(15.3664)	0.400489(0.7983)	0.309277(0.6437)
Φ	0.175884***(0.0468)	0.447155***(0.0765)	0.019274***(0.0042)	0.023567***(0.0050)
$(\Phi - 25)1\{\Phi \geq 26\}$	-0.058561(0.0636)	-0.263491***(0.0986)	-0.005644(0.0055)	-0.014320**(0.0060)
$(\Phi - 50)1\{\Phi \geq 51\}$	-0.126090**(0.0552)	-0.124815(0.0965)	-0.015439***(0.0058)	-0.011056**(0.0048)
$(\Phi - 75)1\{\Phi \geq 76\}$	0.172814*(0.0993)	0.105862(0.1632)	0.010930(0.0094)	-0.010986(0.0068)
$(\Phi - 100)1\{\Phi \geq 101\}$	-0.223417(0.1793)	-0.175793(0.3586)	-0.015374(0.0263)	0.015604(0.0141)
$(\Phi - 125)1\{\Phi \geq 126\}$	0.007636(0.2872)	-0.185410(0.4546)	-0.015931(0.0353)	0.015835(0.0151)
$(\Phi - 150)1\{\Phi \geq 156\}$	-0.119584(0.4337)	-0.717754(1.3031)	-0.001856(0.0674)	-0.040800(0.0445)
$(\Phi - 175)1\{\Phi \geq 176\}$	0.301190(0.3611)	0.980869(1.2663)	0.037525(0.0627)	0.023352(0.0439)
Constant	37.098596***(0.8957)	17.420455***(1.4712)	2.831901***(0.0891)	0.078356(0.0830)
Observations	25407	25407	25407	25407
R-squared	0.0078	0.0063	0.0091	0.0227

Note: In all regressions, standard errors are clustered by grade enrolment levels, see Lee and Card (2008). *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 6: First-Stage, Reduced-Form, and Base IV Specifications (full sample), 2008/09

	First Stage	Reduced Form		IV	
	(1)	Italian (2)	Math (3)	Math (4)	Italian (5)
Class size				-0.000627(2.1138e+14)	-0.001102(7.3480e+13)
$1\{\Phi \geq 26\}$	-9.143398***(1.2008)	-0.002573(0.0075)	-0.015859(0.0108)		
$1\{\Phi \geq 51\}$	-4.436271***(0.9527)	-0.001557(0.0119)	-0.011572(0.0152)		
$1\{\Phi \geq 76\}$	-2.155639***(0.6917)	-0.007726(0.0123)	-0.005951(0.0131)		
$1\{\Phi \geq 101\}$	-1.903903***(0.6224)	-0.013241(0.0278)	-0.002703(0.0297)		
$1\{\Phi \geq 125\}$	0.715847(1.2263)	0.067480(0.0461)	0.061012(0.0550)		
$1\{\Phi \geq 150\}$	1.647837(3.2977)	-0.076490**(0.0332)	-0.043703(0.0800)		
$1\{\Phi \geq 175\}$	1.649347(2.8404)	-0.044547*(0.0238)	-0.005930(0.0546)		
Φ	0.891612***(0.0433)	0.000907(0.0006)	0.002549***(0.0008)	0.001831***(0.0006)	0.000782(0.0005)
$(\Phi - 25)1\{\Phi \geq 26\}$	-0.539012***(0.0797)	-0.000677(0.0007)	-0.002319**(0.0010)	-0.002188**(0.0010)	-0.000634(0.0007)
$(\Phi - 50)1\{\Phi \geq 51\}$	-0.179272**(0.0795)	-0.000226(0.0008)	0.000243(0.0009)	0.000493(0.0008)	-0.000237(0.0006)
$(\Phi - 75)1\{\Phi \geq 76\}$	-0.091754*(0.0551)	0.001047(0.0009)	0.000111(0.0009)	0.000117(0.0008)	0.000536(0.0008)
$(\Phi - 100)1\{\Phi \geq 101\}$	-0.079961(0.0574)	-0.003576*(0.0020)	-0.003476(0.0022)	-0.002059(0.0014)	-0.002177(0.0013)
$(\Phi - 125)1\{\Phi \geq 151\}$	0.074019(0.0731)	0.001138(0.0030)	0.000953(0.0043)	0.001732(0.0030)	0.002538(0.0021)
$(\Phi - 150)1\{\Phi \geq 151\}$	-0.308677(0.2378)	0.007237***(0.0024)	0.005151(0.0050)	0.000213(0.0049)	-0.000857(0.0028)
$(\Phi - 175)1\{\Phi \geq 176\}$	0.265873(0.2310)	-0.005714***(0.0007)	-0.003161(0.0035)	0.000136(0.0031)	0.000376(0.0018)
Constant	1.552466**(0.6483)	0.612339***(0.0109)	0.535714***(0.0141)	0.558596(4.4614e+15)	0.635631(1.3896e+15)
Observations	25407	25407	25407	25407	25407
R-squared	0.6627	0.0027	0.0039	0.0029	0.0017

Note: In all regressions, standard errors are clustered by enrolment levels, see Lee and Card (2008). *** p<0.01, ** p<0.05, * p<0.1

Table 7: Reduced-Form of Observables on Enrolment (+/- 3 pupils intervals), 2008/09

Class size	ISEI Father	ISEI Mother	Mother's education	Pupils with special needs
$1\{\Phi \geq 26\}$	-3.288314(2.5079)	-2.536289(2.7587)	-0.261644(0.2209)	-0.306781***(0.0499)
$1\{\Phi \geq 51\}$	2.554171***(0.8889)	-1.949527*(1.1088)	0.050558(0.1821)	0.405290***(0.0972)
$1\{\Phi \geq 76\}$	-3.464544(2.1830)	2.825578(2.3141)	0.143400(0.3019)	0.211008(0.3235)
$1\{\Phi \geq 101\}$	-1.070654(1.1072)	-1.020663(1.6489)	0.051864(0.0946)	-0.559914***(0.0710)
Φ	0.017402(0.0177)	-0.035368(0.0240)	0.000905(0.0015)	-0.002964**(0.0013)
$(\Phi - 25)1\{\Phi \geq 26\}$	1.497996(1.1920)	-0.643432(1.3018)	0.080478(0.1049)	0.067425***(0.0065)
$(\Phi - 50)1\{\Phi \geq 51\}$	-0.828296**(0.3969)	0.470961(0.4469)	-0.039146(0.0871)	-0.168912***(0.0443)
$(\Phi - 75)1\{\Phi \geq 76\}$	2.030979**(0.8101)	-1.136631(0.7985)	0.002731(0.1157)	-0.030554(0.1253)
$(\Phi - 100)1\{\Phi \geq 101\}$	-0.621750***(0.0177)	-1.53963***(0.0240)	-0.223731***(0.0015)	0.388616***(0.0013)
Constant	41.034821***(0.7707)	29.28249***(0.9712)	3.330471***(0.0655)	0.690685***(0.0738)
Observations	5396	5396	5396	5396
R-squared	0.0077	0.0064	0.0054	0.0327

Note: In all regressions, standard errors are clustered by enrolment levels, see Lee and Card (2008). *** p<0.01, ** p<0.05, * p<0.1.

Table 8: First stage, Reduced-Form and IV stage (+/- 3 pupils intervals), 2008/09

	First stage	Reduced-form		IV		IV with observables	
	(1)	Math (2)	Italian (3)	Math (4)	Italian (5)	Math (6)	Italian (7)
Class Size				-0.005190(0.0146)	-0.003018(0.0161)	-0.002389(0.0180)	-0.000656(0.0186)
$1\{\Phi \geq 26\}$	0.727449(2.8013)	0.016253(0.0119)	0.015994(0.0137)				
$1\{\Phi \geq 51\}$	1.085096***(0.3597)	-0.027010***(0.0091)	-0.027144***(0.0061)				
$1\{\Phi \geq 76\}$	0.670140**(0.2611)	-0.018062(0.0162)	-0.004612(0.0125)				
$1\{\Phi \geq 101\}$	-0.695183**(0.2975)	-0.051235***(0.0121)	-0.063188***(0.0139)				
Φ	0.024155***(0.0045)	0.000103(0.0002)	0.000270(0.0002)	0.000157(0.0004)	0.000278(0.0005)	0.000049(0.0005)	0.000189(0.0005)
$(\Phi-25)1\{\Phi \geq 26\}$	-2.875964**(1.3461)	-0.011280***(0.0039)	-0.009216(0.0059)	-0.017721(0.0393)	-0.010166(0.0430)	-0.009870(0.0475)	-0.003130(0.0487)
$(\Phi-50)1\{\Phi \geq 51\}$	-1.834880***(0.1560)	-0.007162**(0.0026)	-0.000276(0.0004)	-0.025746(0.0228)	-0.015962(0.0237)	-0.021861(0.0278)	-0.012697(0.0275)
$(\Phi-75)1\{\Phi \geq 76\}$	-0.852245***(0.0599)	0.003576(0.0053)	-0.002082(0.0032)	-0.005844(0.0107)	-0.004736(0.0111)	-0.005556(0.0121)	-0.005015(0.0126)
$(\Phi-100)1\{\Phi \geq 101\}$	-0.960405***(0.0045)	0.032427***(0.0002)	0.032789***(0.0002)	0.007624(0.0194)	0.005876(0.0216)	0.016525(0.0237)	0.013763(0.0247)
Average number of pupils with special needs						-0.003077(0.0092)	0.001518(0.0037)
Mother's education						0.015243***(0.0028)	0.016755***(0.0020)
ISEI index father						0.001056***(0.0003)	0.001029***(0.0002)
ISEI index mother						0.000284**(0.0001)	0.000270**(0.0001)
Constant	21.688432***(0.2628)	0.595040***(0.0120)	0.630779***(0.0095)	0.710567**(0.3228)	0.698901*(0.3510)	0.550023(0.3959)	0.541377(0.4024)
Observations	5396	5396	5396	5396	5396	5396	5396
R-squared	0.2756	0.0077	0.0064	0.0066	0.0048	0.0508	0.0679

Note: In all regressions, standard errors are clustered by enrolment level, see Lee and Card (2008).*** p<0.01, ** p<0.05, * p<0.1.

Table 9: Treatment Effect (+/- 3 and 5 pupils intervals), 2008/09

					Pooled	
	1 cut-off (25)	2 cut-off (50)	3 cut-off (75)	4 cut-off (100)	(5)	(6)
Dep.var: Math	0.007544	0.018233*	0.002555	-0.005858	-0.005190	-0.002389
Three-pupil interval	(0.0024)	(0.0090)	(0.0066)	(0.0122)	(0.0146)	(0.0180)
Average class-size (left side of cut-off)	22.174	23.078	23.479	23.876	NO	NO
Average class-size (right side of cut-off)	17.509	20.568	22.413	21.470	NO	NO
N obs	2703	1544	786	363	5396	5396
Dep.var: Italian	0.000021	0.012751*	-0.003949	0.000413	-0.003018	-0.000656
Three-pupil interval	(0.0021)	(0.0063)	(0.0121)	(0.0135)	(0.0161)	(0.0186)
Average class-size (left side of cut-off)	22.174	23.078	23.479	23.876	NO	NO
Average class-size (right side of cut-off)	17.509	20.568	22.413	21.470	NO	NO
N obs	2703	1544	786	363	5396	5396
Dep.var: Math	-0.002680	0.0294233*	0.004375	-.0025679	-0.006296	-0.006244
Five-pupil interval	(0.0034)	(0.015042)	(0.01564)	(0.02074)	(0.0060)	(0.0074)
Average class-size (left side of cut-off)	21.355	22.983	23.235	23.612	NO	NO
Average class-size (right side of cut-off)	16.556	20.028	22.839	21.470	NO	NO
N obs	5415	3184	1415	671	10685	10685
Dep.var: Italian	-0.000055	0.0254139**	-0.00851	0.011597	-0.004871	-0.005164
Five-pupil interval	(0.0032)	(0.01135)	(0.03094)	(0.02493)	(0.0075)	(0.0068)
Average class-size (left side of cut-off)	21.355	22.983	23.235	23.612	NO	NO
Average class-size (right side of cut-off)	16.556	20.028	22.839	21.470	NO	NO
N obs	5415	3184	1415	671	10685	10685

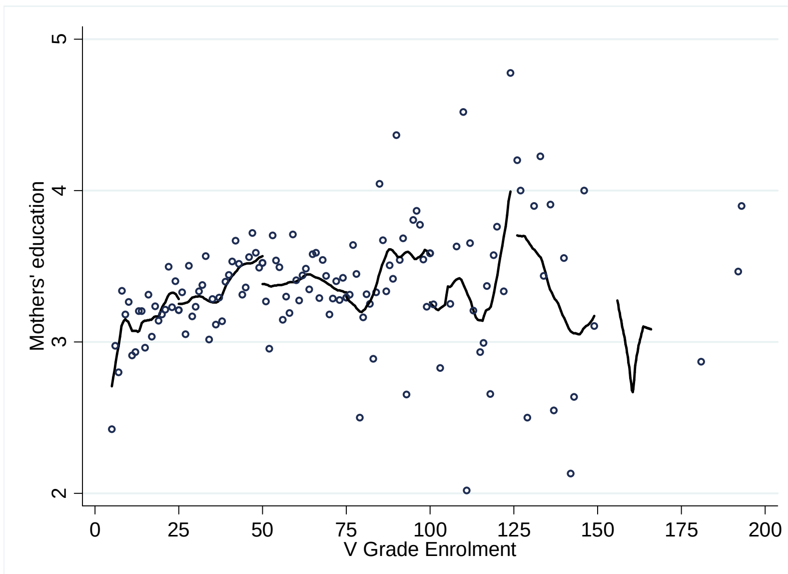
Note: In all regressions, standard errors are clustered by enrolment levels, see Lee and Card (2008). *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 10: Reduced-Form Estimates of Selected Observables (sample of compliant schools), 2008/09

	ISEI index father	ISEI index mother	Mothers' education
	(1)	(2)	(3)
$1\{\Phi \geq 26\}$	-7.773760***(2.3482)	-10.318900***(0.9757)	-0.763182***(0.1729)
$1\{\Phi \geq 51\}$	1.930775*(1.0391)	-4.608166***(0.9732)	0.021752(0.2848)
$1\{\Phi \geq 76\}$	-11.345361***(0.7926)	-6.244773(3.8475)	-0.186474*(0.1080)
$1\{\Phi \geq 101\}$	-3.084358**(1.1662)	-0.302702(1.9496)	0.072928(0.0884)
Φ	0.021136(0.0186)	-0.028598(0.0290)	0.000868(0.0014)
$(\Phi - 25)1\{\Phi \geq 26\}$	3.097997***(0.9371)	1.748179***(0.2892)	0.255036***(0.0683)
$(\Phi - 50)1\{\Phi \geq 51\}$	-0.677889*(0.3413)	0.654220**(0.2343)	-0.047910(0.1005)
$(\Phi - 75)1\{\Phi \geq 76\}$	3.965961***(0.1036)	0.570533(1.2766)	0.095906***(0.0324)
$(\Phi - 100)1\{\Phi \geq 101\}$	-0.052756***(0.0186)	-2.039584***(0.0290)	-0.235058***(0.0014)
Constant	40.956966***(0.8348)	29.367030***(1.1970)	3.347153***(0.0697)
Observations	4111	4111	4111
$R^2 - adj$	0.0102	0.0140	0.0093

Note: Estimates are done using the observations from +/- 3 pupils intervals around the first four cut-off regions. Standard errors are clustered by enrolment, see Lee and Card (2008). *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Figure 17: Distribution of Mother's education along Enrolment (full sample), 2008/09



Note: Data are aggregated at school level. The figure presents enrolment-cell means, along with fitted values of a locally weighted regression calculated within each enrolment segment.