Economics Letters 120 (2013) 583–587

Contents lists available at SciVerse ScienceDirect

Economics Letters

journal homepage: www.elsevier.com/locate/ecolet

Class-size effects in Japanese schools: A spline regression approach

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HIGHLIGHTS

- Effects of class size on student achievement are estimated using Japanese data.
- A piecewise-linear relationship between class size and student achievement show a better fit to the data.
- Class-size effects are mostly driven by smaller schools in the lower part of the class-size distribution.

ARTICLE INFO

Article history:
Received 2 June 2012
Received in revised form
19 June 2013
Accepted 21 June 2013
Available online 26 June 2013

JEL classification:
I21
I28

Keywords:
Class size
Education
Japan

ABSTRACT

This study introduces a piecewise-linear relationship between student achievement and class size. Using student-level data from Japan, we find that piecewise-linear specifications clearly show a better fit to the data. We also find that a significant class-size effect is observed in the lower part of the class-size distribution.

1. Introduction

Debates have been increasing worldwide about whether a reduction in class size improves student outcomes (Bandiera et al., 2010; Dee and West, 2011; Jepsen and Rivkin, 2009; Urquiola and Verhoogen, 2009). Recent studies have focused on the identification of a causal effect between class-size reduction and student achievement by examining exogenous variation created by a class-size cap rule (Angrist and Lavy, 1999) or by population variation (Hoxby, 2000). Most studies, however, implicitly assume that the effect of class size on student achievement is constant across the class-size distribution. This study explicitly introduces a piecewise-linear relationship between student achievement and class size, and it finds that a piecewise-linear specification clearly fits well.

Theoretically, a nonlinear relationship between class size and achievement is suggested by the peer-group effect literature (Lazear, 2001). Assume that a certain proportion of students enrolled misbehave, and that an entire class suffers when one student misbehaves. A student may benefit from being in a smaller class by virtue of the lower probability of being in the same class as misbehaving (impeding) students. On the other hand, if a smaller class size makes a classroom environment comfortable but less competitive, students in a smaller class may "slack off" on their studies. Therefore, if both small and large class size inhibits student achievement, we should make a nonlinear specification into consideration. Alternatively, the effect of class size may simply vary across its distribution. In that case, a linear specification may miss a significant effect of class size. In fact, the result of this study suggests that the effect of class size is not constant across its distribution. We find a statistically significant effect of class size in the lower part of the class-size distribution. The class-size reduction policy, which is being promoted by the Japanese government, might have a slightly positive impact on academic performance of Japanese students.

2. Data and background

This empirical analysis uses a rich dataset derived from the Trends in International Mathematics and Science Study (TIMSS)

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http://dx.doi.org/10.1016/j.econlet.2013.06.027

Table 1
Descriptive statistics.

	Mathematics sample		Science sample	
	Mean	SD	Mean	SD
Score	150.023	10.002	150.000	10.001
Class size	31.626	6.269	31.655	6.269
Enrollment in the 8th grade	82.822	39.850	83.021	39.771
% of economically disadvantaged	0.038	0.192	0.038	0.192
Female students	0.488	0.500	0.489	0.500
Birth month (January–March)	0.230	0.421	0.230	0.421
Observations	4499		4535	

Notes: The sample consists of students attending public schools. Sampling weights are used.

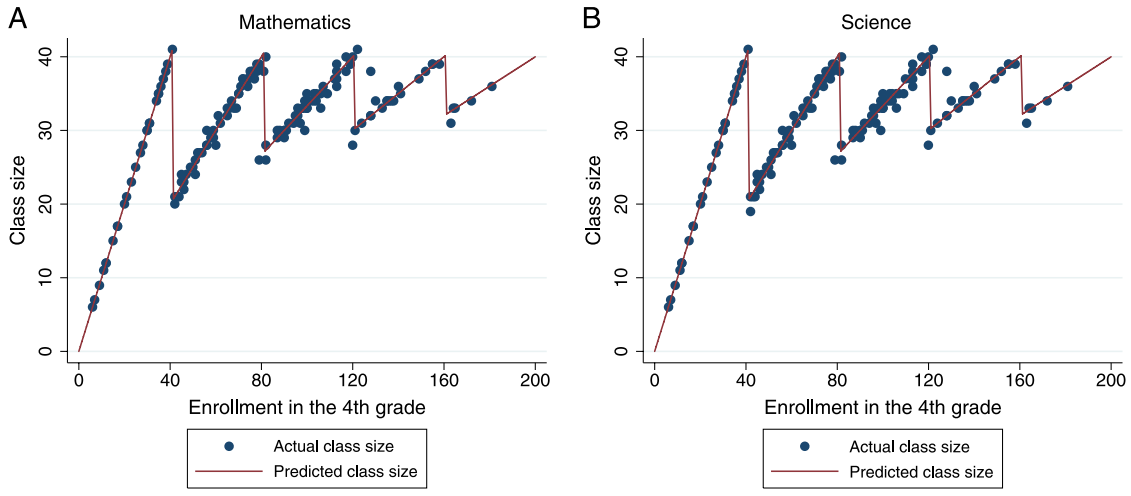

Fig. 1. Actual and predicted class size.

conducted in 2003 and focuses on Japanese students in the fourth grade. There are two reasons for using this dataset. First, in 2003, most Japanese public schools organized classes according to the class-size cap rule regulated by law.[1] Therefore, we can clearly find a discontinuous variation in class size that arises from this rule. In addition, because ability-based grouping was not widespread among public schools in 2003, we can expect less effect stemming from a school's autonomy/control in organizing classes. Second, empirical research on Japanese education is scarce, despite the fact that Japanese students have often ranked highly in international surveys on academic performance (i.e., in various rounds of TIMSS and Programme for International Student Assessment [PISA]). Therefore, this study contributes to the class-size literature by reporting new evidence from the Japanese experience.[2]

Table 1 reports the descriptive statistics of the data used in this study.[3] The sample consists of about 4500 fourth-grade students in public schools (i.e., in the fourth year of primary education).[4] Two subjects were examined: mathematics and science. Scores were measured as having a domestic mean of 150 and a domestic standard deviation of 10.

Fig. 1 shows the relationship between grade enrollment and actual class size, plotted as dots. The Japanese law regulates public schools to have a maximum class size of 40. Fig. 1 clearly shows that most public schools complied with this legal class-size regulation in 2003.

3. Empirical strategy

The empirical model frequently used in the class-size literature is specified as

$$y_{ijk} = \beta_1 C_{jk} + X\delta + \epsilon_{ijk}, \tag{1}$$

where y_{ijk} is the score of student i in class j in school k; C_{jk} is the actual class size; and X is a set of controls. X includes grade enrollment (and its squared and cubed), dummy variables for a higher percentage of economically disadvantaged students (i.e., more than 25% at school level), female students, and birth month (born from January to March).[5]

To allow the effects of class size on student achievement to vary across class-size distribution, we use the following model that

[1] Because the Japanese government started relaxing the class-size cap rule in 2002, some schools introduced class-size reductions in 2003. Kawaguchi (2011) details the compulsory-education system in Japan.

[2] Akabayashi and Nakamura (2013) estimate the effect of class size in Japanese schools and show that a reduction in class-size has positive effects on Japanese language test scores of the sixth grade students.

[3] To obtain a complete dataset for all students, we impute small amount of missing data according to the usual methodology followed in the literature (Fuchs and Wößmann, 2007). Missing data on the percentage of economically disadvantaged is imputed by median imputation. Missing data on birth month is imputed by mode imputation at the school level. Imputation dummies for missing data are included in all the regressions below.

[4] In Japan, students are selected through a multistage stratified sampling design. At the first stage, schools are stratified into three types according to their location (big city, city, and non-city). At the second stage, schools are sampled so as to represent the schools within each stratum, and one or two classes are randomly selected from sampled schools; therefore, the sample represents students in public schools nationwide.

[5] In Japan, the academic year starts on April 1, and children born between April 2 in year T and April 1 in year $T+1$ are eligible to enter primary school in year $T+7$. Almost all children start primary schooling according to this rule, and dropout rates are quite low in primary and lower secondary school. Kawaguchi (2011) shows that, in Japan, children born from January to March apparently underperform compared to older students within their cohort, possibly due to relative immaturity.