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School Quality, Educational Attainment and Aggregation Bias

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Abstract

Data from 31 countries participating in the *Programme for International Student Assessment* (PISA) is used to estimate education production functions for reading literacy. The analysis suggests that the probability of finding statistically significant and correctly signed class size effects increases the higher the level of aggregation used to measure class size.

JEL-Classification: I2

Keywords: Class size, PISA data, bias

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1. Introduction

There is considerable debate (especially in the United States) surrounding the impact of "school quality" on educational attainment. School quality is often used (perhaps incorrectly) to represent expenditure on a variety of school resources. From a policy point of view, the key school quality measure is class size, since in practice reducing class size essentially means hiring more teachers and teacher salaries are usually the largest component of any school's budget (Dustmann 2003). The common sense expectation, amongst both educational researchers and parents, is that individuals taught in smaller classes, holding other factors constant, should "do better", as gauged by performance on such indicators as standardized tests.

There have been a large number of studies that have attempted to empirically evaluate the strength of the relationship between school quality and student attainment by estimating what are usually referred to as "education production functions". These functions are essentially multiple regression equations of varying degrees of technical sophistication, where some measure of attainment is related to a set of school quality variables (e.g. class size, teacher education/salaries/experience, etc.) and a set of control variables aimed at netting out the effects of family background and other factors thought to affect attainment. These functions are estimated at various level of aggregation, such as across individuals, schools, school districts (or the equivalent), geographic regions or countries. There are also studies that mix the levels at which the variables are measured. For example, attainment is measured across individuals, while school quality is measured at a higher level of aggregation such as the level of the state in the case of United States.

Hanushek in a series of papers (1986, 1989, 1996, 2003) has summarized the main findings of a large sample of those studies that have estimated education production functions. These surveys lead him to conclude that there is no systematic relationship between school quality (including class size) and educational attainment. That is, higher levels of school quality do not appear to go hand-in-hand with higher levels of attainment, since wrongly-signed, rightly-signed and statistically insignificant estimates appear with about equal frequency, and such effects are usually quite small in magnitude.

Hanushek et al. (1996) also note that studies that measure school quality at higher levels of aggregation "disproportionately" find more positive effects than studies that measure it at the individual (student) level (see also, Moffitt 1996). They show formally that the interaction of aggregation, omitted variable bias and measurement error, can bias the estimated relationship between school quality and attainment upwards and downwards (or not at all), and therefore the net effect can only be established empirically. Their analysis of US data leads them to conclude: "… [A]nalyses that use more aggregated data

… overestimate systematically the influence of school expenditure related characteristics on student attainment" (Hanushek et al. 1996: 625). The purpose of the paper is to provide a further test of this hypothesis with data from the *Programme for International Student Assessment* (*PISA*).

2. Data and Specification

PISA is a three-year survey programme, coordinated by the OECD, aimed at measuring educational attainment of 15 year old students on a cross-national basis. The first sweep was carried out in 2000 and surveyed over 250,000 students living in 32 (mainly OECD) countries. Students sat pencil and paper standardized tests that focused on their capacity to use knowledge in the areas of reading literacy, mathematical literacy and scientific literacy. Information was collected from the students about their family background as well as other aspects of their learning experience. In addition, information about the schools the students attend was collected from principals and other school administrators. Therefore, with this data it is possible to measure school quality (including class size) at different levels of aggregation: the individual or student-level; the school-level; and the country-level.

The sample used in this paper consists of 109,873 students from 31 countries (Table 1). Canada was dropped from the analysis since information was not collected from principals. The education production function is of the general form:

$$\ln R_{ijk} = \alpha + \beta \ln CS^{*} + \gamma' \boldsymbol{FB}_{ijk} + \theta_k + \varepsilon_{ilk}$$

where: "R" is the reading literacy score received by student "i" in school "j" in country "k"; "CS^*" is a measure of class size (discussed below); "***FB***" is a vector of family background factors; "θ" is a country-level fixed effect; and "ε" is a random error term. Three class size variables measured at progressively higher levels of aggregation are considered: (1) CS_{ijk} is the individual student's class size; (2) CS_{jk} is average class size in the school that the student attends; and (3) CS_k is average class size in the country that the student lives. Family background is measured by dummy variables for whether the student is female, resides with both parents, is native born, uses a home language that is not the country's national language and whether both parents are employed. Continuous variables for the number of siblings (+1) and mother's and father's schooling (measured in years of schooling completed) are also included.

3. Estimates

The estimates are shown in Table 1. It is worth noting that the estimates do not change much when country-specific fixed effects are included. In the equations that include individual-level class size (Columns (1) and (2)), the class size effect is positive and statistically significant. As Hanushek has shown, such wrongly-signed significant effects are not uncommon and have been found by others who have used *PISA* data (e.g. Fertig, Schmidt, 2002). In the equations that include school-level class size (Columns (2) and (3)), the class size effect is still positive but is no longer statistically significant at the 5 per cent level, although the effect is statistically significant at the 10 per cent level in the model that includes country-specific fixed effects (Column (4)). Finally, in the equation that includes country-level class size, the effect is negative and statistically significant. As the level of aggregation at which class size is measured increases, the effect changes from being small, positive and statistically significant (elasticity = 0.04) to being small, negative and statistically significant (elasticity = –0.07).

Table 1

Education Production Functions: Reading Literacy
PISA, 2000

	(1)	(2)	(3)	(4)	(5)
Class size measure:	Individual-level (CS_{ijk})		School-level (CS_{jk})		Country-level (CS_k)
Country dummies included:	No	Yes	No	Yes	No
Female = 1	0.062 (32.1)	0.062 (36.3)	0.063 (32.4)	0.064 (31.8)	0.063 (31.5)
Native born = 1	0.039 (7.8)	0.035 (8.0)	0.041 (8.1)	0.036 (8.1)	–0.046 (9.0)
Intact family = 1	0.021 (11.4)	0.021 (12.4)	0.022 (12.0)	0.021 (12.6)	0.024 (13.0)
Other home language = 1	–0.060 (9.8)	–0.076 (14.9)	–0.064 (10.3)	–0.078 (15.2)	–0.070 (11.4)
Both parents work = 1	0.046 (10.3)	0.034 (8.5)	0.046 (10.2)	0.036 (8.9)	0.042 (9.5)
ln(number of siblings +1)	–0.034 (16.8)	–0.040 (24.1)	–0.036 (17.7)	–0.044 (24.9)	–0.036 (17.8)
ln(mother's schooling)	0.061 (28.5)	0.048 (24.0)	0.061 (28.6)	0.050 (24.6)	0.060 (27.7)
ln(father's schooling)	0.057 (25.6)	0.047 (23.0)	0.058 (25.9)	0.049 (23.4)	0.056 (25.4)
ln(class size)	0.040 (9.8)	0.040 (9.8)	0.004 (1.0)	0.009 (1.9)	–0.069 (7.8)
Constant	5.74 (440.6)	5.80 (341.1)	5.81 (416.2)	5.88 (340.4)	6.05 (195.3)
R^2 (%)	10.5	18.2	9.9	19.4	10.3

Authors' calculations. – [1]Number of individuals = 109,873. – [2]Number of countries = 31: Australia, Austria, Belgium, Brazil, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Korea, Latvia, Liechtenstein, Luxembourg, Mexico, Norway, New Zealand, Poland, Portugal, Russia, Spain, Sweden, Switzerland, United Kingdom and United States. – [3]Absolute value of t-statistics in parenthesis.

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The estimates also confirm the importance of family background. In all the equations, all the family background variables are statistically significant. The estimates suggest that reading attainment is higher for native-born females who reside with two working parents. Attainment is lower for those whose home language is not the national language and decreases the larger the number of siblings. Finally there is a positive relationship between attainment and mother's and father's schooling.

4. Concluding Comment

The analysis in this paper suggests that it does matter at what level of aggregation school quality variables are measured in the estimation of education production functions. Our findings are in agreement with those of Hanushek et al. (1996) – as the level of aggregation increases, the probability of finding statistically significant and correctly signed school quality effects also increases. However, our analysis does not cast much light on the key policy question of whether decreasing class size will lead to higher educational attainment.

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