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Explaining International Differences in Educational Achievements: The Role of Macroeconomic and Demographic Characteristics of Countries

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Abstract

This study assesses the determinants of international differences in student performance and provides a systematic examination of the effect of macroeconomic and demographic factors and their combined effect with socioeconomic status on student performance in mathematics, science and reading. Using the Programme for International Student Assessment (PISA) database and utilizing the HLM technique, this study revealed substantial country effects on student grades. Thus, students may better achieve in countries which have more favorable national conditions for the operation of the education system. Moreover, as the socioeconomic status of students increases, these conditions further support students in their academic endeavors and can reduce educational inequality.

Keywords: educational inequality, PISA, International Differences in Educational Achievements, macroeconomic and demographic characteristics.

Introduction

International achievement tests from the last two decades have consistently shown differences between countries in the performance of young students. A great deal of attention has been paid to this topic, as most explanations of the variation in student performance have referred to individual and school factors, such as student background, schooling resources and schooling institutions (Dossey & Funke 2016; Fuchs & Woessmann 2004), and to structural features of countries as well as norms and values (Gu 2006; Ram 2006). International comparative research has studied country factors mainly through the lens of the school system (Borgna & Contini 2014; Le Donne 2014; Riederer & Verwiebe 2015), pointing to the potential role played by policies and institutions in shaping countries' relative positions (Causa & Chapuis 2011). However, less attention has been paid to macroeconomic and demographic factors that influence student performance. While an emerging economic literature has already made use of international tests of educational achievement to analyze the determinants and impacts of cognitive skills – showing, for example, that cognitive skills of the population are powerfully related to economic growth – the incorporation of a large set of individual and school factors along with country-level factors into a model expressing individual student achievement is not as common (see in Hanushek & Woessmann 2010). Furthermore, few studies have investigated the impact of these factors on educational inequalities across countries.

I attempt to fill this void by introducing these factors in a multidimensional framework, which combines micro- and macro-level data. I argue that variation in students' grades can not only be explained by personal attributes or the structure of the local or national educational systems, but is also mediated by the economic and demographic characteristics of countries. National educational policies, partly reflected in indicators such as the ratio of students to teaching staff or class size, may also affect student performance and the achievements of students from different socioeconomic backgrounds.

Consequently, the research model examines the ways in which different structures, policies and practices lead to different educational outcomes, taking into consideration the national contexts in which students operate. For this purpose, I use the Programme for International Student Assessment (PISA) database to assess the determinants of international differences in student performance in general, and the link between socioeconomic background and student performance across countries in particular. Using a framework of comparative research, this study can help develop the understanding of the conditions that lead to educational inequality and illuminate how educational policies either ameliorate or exacerbate group differences in student academic outcomes.

I proceed as follows: First, I review the literature that studies the explanations for the variation in students' performance. Second, I develop a hypothesis on the link between macroeconomic factors and achievements. Third, the data, the analysis, and the findings are described, and finally some implications of the study are discussed.

1.1 Explanations for the variation in students' performance

Generally, the literature offers two basic explanations for the variation in students' performance; one focuses on the role of individual sociodemographic and family background characteristics, and the other emphasizes school-related contextual factors. I contend that study of the variation in student performance should take into account not only the role of family background and student characteristics in affecting school grades, but also the effect of demographic and macroeconomic factors. Accordingly, the major critique I have leveled against individual-level and school-level approaches concerns their inability to explain the relative standing in academic achievements of countries with similar student and school-related characteristics, and the variation across some countries in the association of family background and school inputs with student academic achievement. Prior studies have compared different aspects of countries' school systems, but analyses of macro-level educational factors which also incorporate individual and school-related characteristics remain quite scarce. In what follows, I discuss comprehensively the research which has incorporated individual, school and country factors, identify which country factors have been overlooked, and clarify the theoretical mechanisms through which these factors could impact educational outcomes, focusing on the interaction effect of country characteristics and socioeconomic status of students.

Individual-level explanations for the variation in achievements have mainly focused on two factors: gender and socioeconomic status of individuals and families. As regards gender, the pattern of its effect is not at all clear. Studies on the topic have shown that while it is commonly believed, and indeed frequently found, that boys have better grades in mathematics than girls (Manger & Eikeland 1998), some studies find gender similarities in their achievements (Else-Quest, Hyde & Linn 2010; Hedges & Nowell 1995; Hyde, Lindberg, Linn, Ellis & Williams 2008), whereas others even show an advantage for girls (Hyde, Fennema & Lamon 1990). Explanations for boys' advantage over girls have typically referred to biological and social influences (e.g., Baron-Cohen 2003) and school characteristics (Xie and Shauman 2003), but also to country-level factors, such as degree of economic development and level of women's participation in various spheres of life (Guiso, Monte, Sapienza & Zingales 2008; Penner 2008; Riegle-Crumb 2005). As regards family traits and family background, the evidence is straightforward. By passing on certain features, such as socioeconomic status (SES) and education, families can shape the intellectual, cognitive and mental development of children, and determine children's future educational attainment and success (Fuchs and Woessmann 2004; Woessmann 2000). Studies show that the relationship between students' SES – traditionally defined as a function of parental income, education level and occupational status – and educational outcomes is strong and positive, although there is a variation in the strength of the SES-achievement correlation (Sirin 2005). Higher-SES students typically have higher scores on standardized achievement tests and are more likely to complete secondary school and university and to enter a high-status college than their peers from lower-SES backgrounds (Blossfeld & Shavit 1993; Jerrim, Chmielewski & Parker 2015). Nowadays research interest has shifted to exploring further the relations between students' performance and the university they attend, as well as their subject of study. Some scholars have recently shown that inequality in university access largely reflects differences in high school achievement (Chowdry, Crawford, Dearden, Goodman & Vignoles 2013; Ermisch and Del Bono 2012), and that factors such as parental income and education are of great importance to university access (Jerrim & Vignoles 2015). In addition, high-SES students are more likely to choose a lucrative field of study (Davies & Guppy, 1997; Goyette and Mullen 2006), even when academic achievements are controlled for.

That is because families with higher SES enable their children to access support, materials, and opportunities that put them ahead of their peers who do not have similar access (Bradley & Corwyn 2002), and family expectations are higher as regards children’s academic careers. Families are also able to help their children succeed by sending them to schools with higher mean SES, moving to better neighborhoods, and providing out-of-school support (Marks, Cresswell & Ainley 2006), exposing them to an intellectual climate in which motivations to achieve are highly valued. In contrast, children who grow up in low-SES families are more likely to experience poverty and learning and behavioral difficulties, to underachieve at school, and to have lower skills and aspirations (UNICEF 2007).

Since parental education is amongst the indicators of family socioeconomic background, the same explanations offered for educational inequalities between high- and low-SES families hold true for families with well-educated and less-educated parents (Martins & Veiga 2010). Highly educated parents give their children cultural capital to better contend with the dominant culture they live in, and they are more likely than others to invest in human capital and to perceive it as an important resource for their children's future advancement (Becker 1964). Accordingly, the majority of the literature on parents’ education pertains to the direct, positive influence on children's achievement (e.g., Jimerson, Egeland & Teo 1999), and the indirect influence of the beliefs and behaviors of parents and the climate at home, leading to positive outcomes for children and youth. As a result, researchers have begun studying the influence of attitudes and self- perception of children about themselves as related to school achievements (Stevens et al 2004) and found that more positive self-beliefs are associated with better performance.

Another important set of determinants of educational performance are the institutions of the education system. School-related characteristics that have been found to affect educational output are school socioeconomic composition (e.g., Perry & McConney 2010), public versus private schools (Chen & West 2000), as well as school admission criteria and selectivity (West & Hind, 2006). Also, the quality of schooling resources, but not their amount (Gundlach, Woessmann & Gmelin 2001), leads to an increase in educational performance (Brunello & Checchi 2005). However, the cross-country association of student achievement with school resources and school characteristics tends to be much weaker than its association with socioeconomic backgrounds Hanushek and Woessmann 2010).

School socioeconomic composition, defined as the aggregated measure of the social backgrounds of the students (SES), has been shown to be independently associated with student outcomes beyond their correlation with individual student backgrounds (Rumberger & Palardy 2005; Sirin 2005; Perry & McConney 2010). In other words, the grouping of high-SES students into a school leads to even higher educational outcomes than would be expected from individual students’ SES alone. Lower-SES schools often have fewer material and financial resources and less qualified teachers than higher-SES schools (Berliner 2001; Chiu & Khoo 2005; Darling-Hammond 2007); they have less positive relationships between teachers and students, leading to disciplinary issues, whereas higher mean SES schools are often demanding of high achievements and academic success (Kahlenberg 2001; OECD 2005).

Some schools tend to select certain students over others based on academic ability or the recommendations of feeder schools, or alternatively by charging high fees (Jenkins, Micklewright & Schnepf, 2008). Ultimately, selectivity of schools is positively related to student achievement (OECD 2005), and may play a significant role in reproducing social segregation and socioeconomic group-based educational inequality. It was found, for example, that schools in London with responsibility for their own admissions had lower proportions of pupils with special educational needs and obtained higher scores in public examinations than schools whose admissions were controlled by the local authority (West & Hind 2006). Furthermore, selectivity is more salient in private than in public schools. Private schools typically have admission criteria based on academic ability and economic ability of parents, who need to be able to afford the tuition fees. Since the private operation of schools may lead to selectivity of better-achieving students and the provision of services and facilities of a high standard in comparison to public operation (Bishop & Woessmann 2004), this may affect student achievements and educational inequalities. Indeed, students are found to perform better in privately managed schools than in publicly operated ones, while private funding of schools may not always have detrimental effects on educational achievements (Fuchs & Woessmann 2004).

1.2 Country-level Effects

For long, scholarly explanations for differences in student's achievements referred to individual and school factors, not paying enough attention to the role of country characteristics. Usually, studies on this topic conduct separate analyses for groups by country (Hyde et al. 2008; Penner 2008) or resort to two-level modeling using student- and school-level correlates for each participating country (Gu 2006; Hsu 2007; Milford & Andersson 2009). Other studies rest upon bilateral comparisons between two countries, e.g., comparing a commentator's home country to the top performer (Itkonen & Jahnukainen 2007), or presenting the simple correlation between student performance and a single potential country-level determinant, such as economic development (Guiso et al. 2008). Part of the existing work is descriptive in nature, estimating the association of student achievement with certain factors after controlling for the rich set of possible inputs into educational production available in the international background data. However, this body of research hardly refers to macroeconomic and demographic characteristics of countries along with student and family background and school inputs, as factors that may explain variations in achievements.

National comparative research, which has considered country-level factors in its analysis, has typically focused on different aspects of countries' school systems, including degree of stratification and preschool attendance rates (Borga & Contini 2014), selection with tracks of study (Chmielewski 2014; Le Donne 2014), school quality (Vogtennuber 2015) and school type (Jerrim, Parker, Chmielewski & Anders 2015), vocational orientation, standardization (see Shavit & Muller 1998) and educational expenditures (Riederer & Verwiebe 2015). These studies have evaluated how country-level characteristics affect various dimensions of students' educational experience, academic performance, the income achievement gap and school outcomes. Other country-level studies have tried to explain the gender gap in mathematics, suggesting that structural factors, such as degree of economic development and level of women's participation in education, in the labor market and in politics, play a role in the formation of this gap (Ayalon & Livneh 2013; Charles & Bradley 2009; Guiso et al. 2008). Nonetheless, not only do these country characteristics offer limited and sometimes contradictory explanations of the gender gap, but only a few studies have incorporated these characteristics into a model explaining country variations in student achievements in general.

These studies have shown the importance of country-level effects on achievements, but they have failed to acknowledge other country effects, which are not distinctively related to educational systems. I argue that even after family background and student and school characteristics are accounted for, along with the country characteristics of school systems, nontrivial differences in educational achievements remain. This article aims to contribute to this area, in particular by introducing macroeconomic and demographic characteristics of countries into a theoretical model explaining between-country variations in students' grades, using the Programme for International Student Assessment (PISA) exams in mathematics, reading and science, with the intention of revealing the underlying conditions of countries that either reduce or enhance educational disparities. Moreover, this research provides additional insight into persistent gaps between students with different socioeconomic backgrounds by assessing an interaction effect between country factors and the socioeconomic characteristics of students, defined in PISA as the index of educational, social and cultural status (ESCS).

Scholars in the fields of comparative and international education have criticized, among other things, the fact that the comparison of educational systems using large-scale student learning metrics reduces complex information to simplified causal relations, leading to standardization and normative assumptions (Cowen 2014; Stromquist 2005; Rappleye 2010). A cross-national international assessment such as PISA cannot identify clear-cut cause-and-effect relationships (Schleicher 2009), which may lead to analytical rather than empirical 'best practice' claims (Auld & Morris 2016). Nonetheless, although PISA cannot identify cause-and-effect relationships between policies or practices and student outcomes, it can show educators, policymakers and the interested public how education systems are similar to and differ from each other (OECD 2013).

While the vast literature of cross-country comparison has focused on the factors that contribute to the growth of nations, employing measures related to school attainment or years of schooling to test the predictions of growth models (see in Hanushek and Woessmann 2010), few studies have investigated the impact of growth on cross-country differences in student achievements. These studies have found that varying academic achievements across countries are closely correlated with the level of economic development and economic growth (measured by GDP), and that this variable along with the relative size of the school-age population predicts approximately 80 percent of the variance in average scores across countries (Yogev, Livneh & Feniger 2009).

Fuchs & Woessmann (2004) and Woessmann (2000) use some country-level data on countries' GDP per capita and their average educational expenditure per student in secondary education to explain the international differences in student performance. Their findings indicate that GDP per capita is positively related to student achievement and can affect a country's ability to finance education costs and to invest in achievement-enhancing educational resources (Bishop 2004; Feniger & Shavit 2011; Woessmann 2000).[1] Hanushek and Woessmann (2009) have found similar results; after the initial level of GDP per capita and years of schooling are controlled for, the test-score measure of math and science skills features a statistically significant effect on the growth in real GDP per capita.

Among the OECD countries, however, differences in GDP per capita may play only a minor role as regards student achievement due to the relatively homogenous features of the participating countries in terms of economic development (Bishop 1997; Fuchs and Woessmann 2004). Moreover, expenditure per pupil on education is highly correlated to GDP, and thus does not generally help in understanding cross-country differences in educational performance (Woessmann 2000; Yogev, Livneh & Feniger 2009), especially when the relative size of the school-age population is also considered. This picture has been evident in many other waves of the different international achievement tests, and in most cases the lack of a significant positive cross-country association between expenditure per student and educational achievement holds up when numerous other determining factors such as family background and school features are accounted for (Fuchs and Woessmann 2007; Hanushek & Kimko 2000; Woessmann 2003).

Trying to explain country standing in international achievement tests, Feniger and Shavit (2011) further show that the influence of the size of the young population on pupil test scores is correlated to classroom crowding and class size. Since class size is determined not only by education policy, but also by the demographic burden on the education system, as the size of the young population increases, class size increases as well.

Thus, class size is another factor influencing students' grades, though the nature of its effect is dependent on the level of analysis. At the level of students within a classroom, the relationship between student achievement and class size may be negative, if students in small classes benefit from an affective learning environment (Ehrenberg, Brewer, Gamoran & Willms 2001). However, at the school level, and to some extent also at the national level, the observed relationship between class size and student achievement is often positive, suggesting that students in larger classes perform better than students in smaller classes. This counterintuitive finding is attributed to between-school sorting effects, in that low-performing children are placed in smaller classes so that they receive more individual attention (West & Woessmann 2003). The pupil-teacher ratio (PTR), a similar indicator though not the same as class size,[2] indeed shows that a lower ratio of teachers to pupils can improve students' grades (Lee and Barro 2001; Nye, Hedges & Konstantopoulos 2000). Hence, it may be that class size affects student grades positively, while PTR affects them negatively. Class size may also affect students from different socioeconomic statuses differently. In other words, the benefits of small class size may be greater for lower-SES and minority students than for their higher-SES peers (Resnick & Zurawsky 2003). Small class size may matter more for students from disadvantaged backgrounds, who do not have the same resources at home to support their education as students from rich families. For these students, smaller classes and the presence of more teachers per students can shrink the achievement gap, improve their grades, and lead to reduced grade retention and less dropping out (Krueger & Whitmore 2001).

The theoretical hypotheses follow this logic, as I assume different effects across countries of the relationship between country characteristics and socioeconomic status on students' educational achievements. My study posits that country characteristics may enhance the impact of students' socioeconomic status on their performance, so the higher their socioeconomic status and the more progressive the educational and economic systems of their countries, the more likely they are to succeed at school. This line of reasoning is based on the fact that students belonging to high-status families can use the resources available to them inside the national educational system more effectively than their low-status peers. They can utilize their positions even further to succeed academically and consequently to have better chances and opportunities later in their lives.

Method of Analysis, Data, and Variables

The Programme for International Student Assessment (PISA) is a triennial international survey which aims to evaluate education systems worldwide by testing the skills and knowledge of 15-year-old students.

Around 510,000 students in 65 economies took part in the PISA 2012 assessment of mathematics, reading and science, representing about 28 million 15-year-olds globally. PISA develops tests which are not directly linked to the school curriculum, but designed to assess the abilities that allow the knowledge and skills of students to be applied to real-life situations and challenges. The students and their school principals also answer questionnaires to provide information about the students' backgrounds, schools and learning experiences and about the broader school system and learning environment (OECD 2014).

The international PISA target population in each participating country and economy consisted of 15-year-old students attending educational institutions in grade 7 and higher. In all but one country, the Russian Federation, the sampling design used for the PISA assessment is a. two-stage stratified sample design. The first stage drew on a (usually stratified) sample of schools in which 15-year-old students were enrolled. The second stage randomly sampled 35 of the 15-year-old students in each of these schools, with an equal probability of selection for each student in a school. For schools with fewer than 35 students, all of the students were included (OECD 2014).

Given its particular features, the rich PISA database allows for a rigorous assessment of the determinants of international differences in student performance in general, and the link between country characteristics and student performance in particular. Following Fuchs and Woessmann (2004), I argue that the PISA data offers the possibility of extending the examination by including more detailed family-background and institutional data, along with macro-level data. My data on achievements, students' personal characteristics and family background, as well as on schools' resource endowments and institutional settings, are based on the PISA student and principal questionnaires. Variables representing demographic, macroeconomic and educational features of participating countries are taken from a variety of secondary sources. The most useful sources of information are the World Bank datasets, as well as the OECD datasets.[3]

The analysis is restricted to 15-year old students belonging to countries whose data on national indicators were available: 40 countries in all, of the 65 countries and economies that participated in PISA 2012, including all 34 OECD member countries, and 4 developing countries, namely Brazil, Colombia, Chile and Indonesia, as well as Latvia and the Russian Federation. The final sample contains 321,860 students distributed among the 40 countries.[4] The list of countries and some of their characteristics are presented in Table 1.

2.1 Dependent variable

The dependent variable is student test scores in mathematics, reading and science. The scores were standardized to an international average of 500 and standard deviation of 100. PISA assigns a probability distribution to the response pattern in each test. These values are called plausible values, which are values that resemble test scores and are computed to have approximately the same distribution as the latent trait being measured (Wu 2005). Because each student does not complete the entire survey, plausible values represent a sample of ability estimates from the distribution of scores that the student might have obtained had he or she completed the full test, with the measurement error associated with the test being accounted for (OECD 2014). In this study, estimation procedures involve the calculation of the required statistic once for each set of plausible values, and the replication of this procedure five times. The final estimate is the arithmetical average of the five estimates following the specific recommendations produced by the OECD for the use of PISA data.[5]

2.2 Independent variables

I relied on two types of independent variables: individual-level variables and country-level variables. Apart from their obviously important role in affecting student achievements, the individual-level and school-related variables are introduced into the model to control for differences in student characteristics and in the composition of schools.[6] The choice of variables is dictated by theoretical arguments and empirical evidence found in the economic literature on international educational achievement. Since the focus of the study is on macroeconomic factors in relation to socioeconomic status of students, the variables chosen are the ones that are both relevant and available from the data. Missing data are excluded, except for ESCS, quality of educational resources and class size for which missing values are replaced by the mean value of one's country (no more than 3% of the cases). I weighted the student variables with student weights (W_FSTUWT) provided by the data.

The **index of educational, social and cultural status (ESCS)** is much more refined and comprehensive than the SES categories. It contains three measures: highest occupational status of parents (which corresponds to the higher score in the international socioeconomic index of occupational status (ISEI) of either parent or to the only available parent's ISEI score), highest education level of parents (in years of education according to International Standard Classification of Education (ISCED)), and home possessions. The index of home possessions comprises all items on the indices of family wealth (WEALTH), cultural possessions (CULTPOSS) and home educational resources (HEDRES), as well as books in the home recoded into a four-category variable (0-10 books, 11-25 or 26-100 books, 101-200 or 201-500 books, more than 500 books). The student ESCS scores are standardized to have a PISA mean of 0 and standard deviation of 1 (OECD 2014).

The socioeconomic composition of a school (School ESCS) is computed as the average ESCS scores of students in a given school. Each student is attached to the ESCS score of his school.

Gender: the gender of the student is coded 1 for females and 0 for males.

Public school is represented by a dummy variable, indicating whether the student attends a public school (coded 1) or private school (coded 0). In the PISA database, public schools are defined as schools managed directly or indirectly by a public education authority, government agency or governing board appointed by government or elected by public franchise. By contrast, private schools are defined as schools managed directly or indirectly by a nongovernmental organization, e.g., a church, trade union, business or other private institution (Fuchs and Woessmann 2004).

School selectivity captures the extent to which a school uses selectivity policies. This variable is considered to be continuous, since it contains 3 ordinal categories: (1) two factors are never considered; (2) at least one is sometimes considered, but neither of them always; (3) at least one is always considered.

Admission by academic record captures the extent to which a school's admission criteria are based on academic ability, scaling from (1) "never," through (2) "sometimes," to (3) "always."

Recommendation of feeder school captures the extent to which a school's admission criteria are based on the recommendation of a feeder school, scaling from (1) "never," through (2) "sometimes," to (3) "always."

Quality of educational resources was computed on the basis of six items measuring the potential factors hindering instruction at school: shortage or inadequacy of (1) science laboratory equipment, (2) instructional materials, (3) computers for instruction, (4) internet connectivity, (5) computer software for instruction, and (6) library materials. All items were reversed for scaling.

The average **Class size** (in a school) was derived from one of nine possible categories, ranging from "15 students or fewer" to "more than 50 students." The midpoint of each response category was used, resulting in a value of 13 for the lowest category, and a value of 53 for the highest (OECD, 2014).

To estimate the net effect of country characteristics on student achievements and their combined effect with student socioeconomic background, I use indicators at the country level, which are the most relevant for student socioeconomic inequality and achievements, in addition to a series of individual-level variables. Variables at the country level include the share of the young population out of a country's total population (%), GDP per capita (PPP current international dollars, year 2014),[7] [8] average class size and ratio of students to teaching staff (%) in secondary education,[9] education of the adult population (in years),[10] and the mean ESCS of students by country (computed from individual-level data on ESCS).[11] The model also includes an interaction term between the index of educational, social and cultural status (ESCS) and the above country-level variables: average class size, ratio of students to teaching staff, and education of the adult population. The rationale for using this interaction is that the country characteristics are expected to affect differently the achievements of students of low and high socioeconomic status. The descriptive statistics of all micro- and macro-level variables are presented in Appendix Table A1.

2.3 The Model

I present a two-level HLM model that estimates both the individual-level and country-level effects on student achievement. The Hierarchical Linear Model (HLM) is a procedure that estimates net effects at one level of analysis while controlling for variations at another level.

This method makes it possible to disentangle the respective influences of individual-level and country-level characteristics on behaviors and outcomes, and to directly test the extent to which country characteristics account for differences in the outcome variable, after individual-level effects have been taken into account. Using data on countries as well as on individuals within countries also makes it possible to test for macro-micro interactions. Nonetheless, the limitation of this multilevel analysis is that a small number of countries may cause unstable estimations, and only a limited number of country indicators could be included in the empirical model.[12]

I employ this procedure to estimate the impact of country-level characteristics on the students' grades in mathematics, reading and science, while controlling for variations in socioeconomic status of students and school characteristics (at the individual level). The two-level model can be represented by a set of equations. The first is a within-country equation that models student achievements as a function of the independent variables described earlier. The general form of this equation is as follows:

(1) Grades $_{ij}$ = $\beta_{0j} + \beta_{1j}$ (student's ESCS) $_{ij}$

Another set of equations models the between-country variation:

(2) $\beta 0_j = \gamma_{00} + \gamma_{01}$ (Young population) + γ_{02} (GDP) + γ_{03} (Average Class size) + γ_{04} (Ratio of students to teaching staff) + γ_{05} (Education of Adult Population) + γ_{06} (Mean ESCS) + ν_{0j}

(3) β_{1j} (student's ESCS) = $\gamma_{10} + \gamma_{11}$ (Average Class size) + γ_{12} (Ratio of students to teaching staff) + γ_{13} (Education of Adult Population) + ν_{1j}

At the individual level, Equation 1 allows for the effect of the intercept β_{0j} and the effect of β_{1j} (ESCS) to vary between countries (i.e., random effect), while all other effects are constrained to be the same across countries (i.e., fixed).[13] The dependent variable is a continuous variable indicating the grade of individual i from country j in mathematics, reading and science, and the coefficient β_{0j} is the country-specific intercept, representing the country variations in grades, the differences in individual-level variables being held constant. At the country level, macroeconomic and demographic factors of countries explain this random effect in Equations 2 and 3. Equation 2 models the effect of country-level variables on student grades, and Equation 3 models the combined effect of these variables with students' socioeconomic status on their grades.

Here, the β coefficients derived from Equation 1 constitute the dependent variables in Equations 2 and 3. The equations respectively model the variation in the student grades across different countries (i.e., effects on the intercept) and country differences in the combined effect of ESCS with average class size, ratio of students to teaching staff, and education of the adult population. A positive effect of the interaction term means that the better the conditions of educational systems of countries, the stronger the effect of students' socioeconomic status on their grades. The other variables included in the model are interpreted in a similar way.

Analysis and Findings

3.1 Descriptive Overview

Table 1 presents the average PISA 2012 scores in mathematics, reading and science and five of the country-level explanatory variables: education of the adult population, ratio of students to teaching staff, share of young population, GDP per capita, and class size. The values reveal considerable country differences. On average, higher scores in all three subjects are evident for China, Korea and Japan, and lower scores for Indonesia, Brazil, Colombia and Mexico. The data further show that countries located in the top of the distribution tend to be highly-developed countries in terms of GDP per capita, whereas less-developed countries are the ones at the bottom. Even though this distinction cannot be applied to all countries,[14] the results suggest a positive and significant correlation between GDP per capita and student achievement (.353), as shown by previous studies (Bishop 2004; Woessmann, 2000). Also expected on the basis of previous findings (Feniger & Shavit 2011; Yogev, Livneh & Feniger 2009) are the relatively large size of the young population, a higher ratio of students to teaching staff, and low education of parents found in countries with poor achievements, especially Indonesia, Mexico and Colombia.

Table 1: Selected characteristics of the participating countries

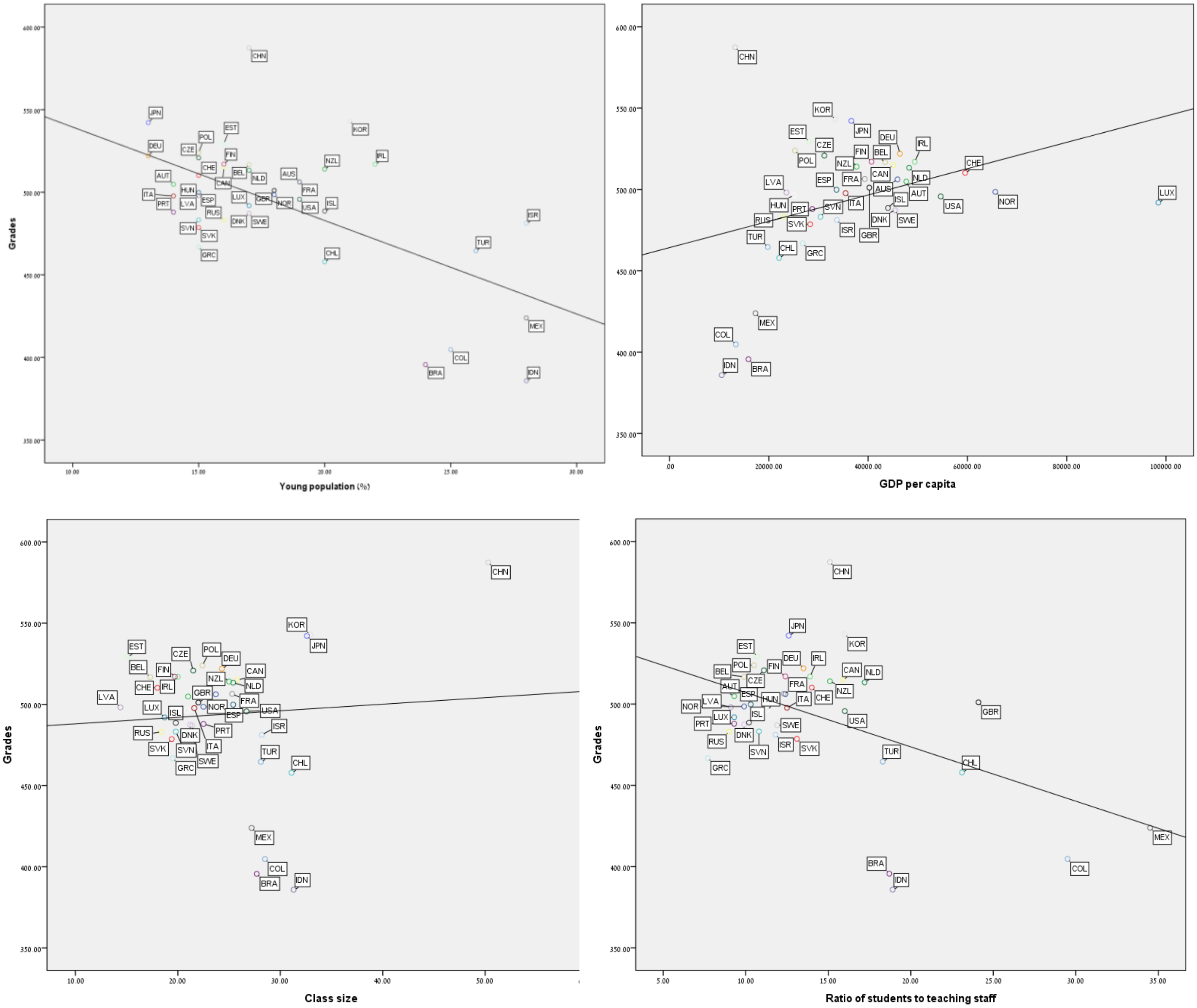
Countries	**N**	**Math**	**Reading**	**Science**	**Class size**	**GDP 2012**	**Young population (%)**	**Ratio of students to teaching staff**	**Education of adult population in years**
Australia	13381	504	512	521	23.7	45925.5	19	12.4	12.8
Austria	4628	506	490	506	21	47682.3	14	9.3	10.8
Belgium	8068	515	509	505	17.3	43434.7	17	9.9	10.9
Brazil	18175	391	410	405	27.7	15893.2	24	18.7	7.2
Canada	20515	518	523	525	25.8	45065.7	16	15.9	12.3
Switzerland	10341	531	511	522	18	59539.8	15	14	12.2
Chile	6550	423	441	445	31.1	22071.1	20	23.1	9.8
China	5039	613	570	580	50.3	13206.4	17	15.1	9.1
Colombia	8764	376	403	399	28.5	13357.1	25	29.5	7.1
Czech Republic	4333	499	493	508	21.5	31185.9	15	11.1	12.3
Germany	3469	514	508	524	24.3	46400.6	13	13.5	12.9
Denmark	6290	500	496	498	21.2	45536.5	17	9.9	12.1
Spain	24210	484	488	496	25.4	33628.9	15	10.3	9.6
Estonia	4672	521	516	541	15.1	28139.9	16	10.7	12
Finland	8569	519	524	545	19.7	40675.9	16	12.4	10.3
France	4211	495	505	499	25.3	39327.9	19	12.3	11.1
UK	11630	494	499	514	22	40233.2	18	24.1	12.3
Greece	4964	453	477	467	19.5	26850.9	15	7.7	10.2
Hungary	4650	477	488	494	20.9	25068.9	15	11.3	11.3
Indonesia	5547	375	396	382	31.3	10517.0	28	18.9	7.5
Ireland	4394	501	523	522	20	49393.2	22	13.9	11.6

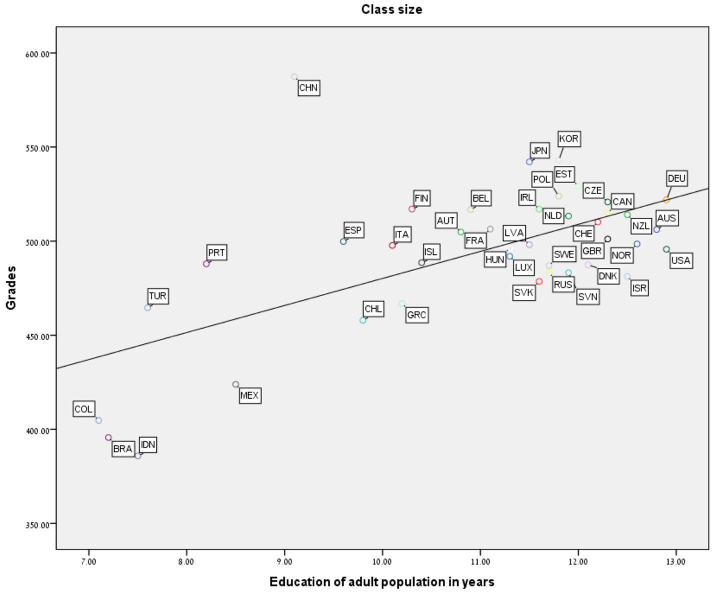
Sources: PISA 2012, World Bank (2014), OECD statistics (2013), Barro and Lee (2013).

Table 1: Selected characteristics of the participating countries- continued

Countries	N	Math	Reading	Science	Class size	GDP 2012	Young population (%)	Ratio of students to teaching staff	Education of adult population in years
Iceland	3127	493	483	478	19.8	43993.3	20	10.2	10.4
Israel	4725	466	486	470	28.2	33703.4	28	11.8	12.5
Italy	28168	485	490	494	21.6	35462.8	14	12.5	10.1
Japan	6250	536	538	547	32.6	36619.4	13	12.6	11.5
Korea	5007	554	536	538	32.9	33394.8	21	16	11.8
Luxembourg	5143	490	488	491	18.7	98459.5	17	9.3	11.3
Latvia	3951	491	489	502	14.4	23547.9	15	9.1	11.5
Mexico	32764	413	424	415	27.2	17314.7	28	34.5	8.5
Netherlands	3939	523	511	522	25.4	48253.3	17	17.2	11.9
Norway	4156	489	504	495	22.5	65614.5	18	9.9	12.6
New Zealand	3667	500	512	516	25	37679.0	20	15.1	12.5
Poland	4443	518	518	526	22.4	25261.6	15	10.5	11.8
Portugal	5269	487	488	489	22.5	28760.0	14	9.3	8.2
Russian Fed	5115	482	475	486	18.4	22989.6	16	9	11.7
Slovak Republic	4462	482	463	471	19.4	28326.5	15	13.1	11.6
Slovenia	5483	501	481	514	19.8	30402.7	15	10.8	11.9
Sweden	4498	478	483	485	21.4	45297.0	17	11.9	11.7
Turkey	4703	448	475	463	28.1	19787.7	26	18.3	7.6
USA	4590	481	498	497	26.7	54629.5	19	16	12.9
Total	321860	488.15	490.6	494.93	23.91	36315.8	18.10	14.03	10.94

Sources: PISA 2012, World Bank (2014), OECD statistics (To examine whether these country disparities are related to student grades, in Figures 1A-1E I plot the above country-level indicators with the mean grades of students in mathematics, reading and science. Overall, the data support the expectation that the educational and macroeconomic characteristics of countries are associated with student performance. Positive correlations are found when student grades are associated with GDP per capita (r=.353) and education of the adult population (r=.617), and negative correlations are found in the association with ratio of students to teaching staff (r=-.484) and the share of young population out of the total population (r=-.614). These findings are not surprising given the link between education and labor market outcomes noted in the literature, but are still interesting due to the variability in student achievement across countries and its relation to macro-economic characteristics. For example, although most countries are located closer together, China is an exception with regard to all indicators, with students obtaining good scores despite the country's 'bad' conditions in terms of class size and education of its adult population. Cultural explanations were offered for the strong performance in East Asian education systems, which focus on the disciplined study habits, including private tuition, and educational commitment, competitiveness and ambition associated with Confucian values (Cheng 2011; Jerrim 2015; Tan 2012). Also exceptional, to some extent, are Colombia, Indonesia, Mexico and Brazil, which are characterized, as expected of developing countries, by exceptionally low student achievements, lower education of the adult population and low GDP, and by higher values of the students-teacher ratio and of the share of the young population. As regards class size, no clear trend is evident. While some countries, such as Indonesia, are characterized by low test scores but relatively large class size, other countries whose students are high achievers in PISA tests are also ranked relatively high with regard to average class size. A country which best exemplifies this is, once again, China, with a class size of 50 students, and to a lesser extent also Korea and Japan, with a class size of approximately 33 students each





Figures 1A-1E: Correlations between student grades and country characteristics in 40 countries.

Sources: PISA 2012, World Bank (2014), OECD statistics (2013), Barro and Lee (2013).

To complete the picture, a correlation matrix for country-level variables appears in Table 2. All correlations are in the direction expected from the extant literature, except for the correlation between the share of young population and GDP per capita. Since the latter is known to be highly correlated to national expenditures in education, the direction had to be positive. Rather, the negative and statistically insignificant correlation may suggest that countries with a low degree of economic development, i.e., developing countries, have a young population of larger size due to population growth. Furthermore, the impressive correlation between the share of the young population and ratio of students to teaching staff (r=.632) is only reasonable, since the larger the size of the potentially school-age student population, the larger the proportion of students per teacher at school.

Table 2: Correlation matrix for country-level variables

	Young population (%)	GDP per capita	Class size	Ratio of students to teaching staff	Education of adult population	Mean ESCS
Young population (%)	1.00	-.304	.358*	.632**	-.462**	-.593**
GDP per capita	-.304	1.00	-.363*	-.360*	.565*	.630**
Class size	.358*	-.363*	1.00	.421**	-.359*	-.461*
Ratio of students to teaching staff	.632**	-.360*	.421**	1.00	-.440**	-.580**
Education of adult population	-.462**	.565**	-.359*	-.440**	1.00	.612**
Mean ESCS	-.593**	.630**	-.461*	-.580**	.612**	1.00

* p<.05, **p<.01

The findings discussed thus far reveal a meaningful association between countries' characteristics and students' academic performance. In countries in which the conditions of the educational and economic systems are favorable to students, the grades are higher, and vice versa. My main interest, though, is in the effect of country characteristics on the interplay between socioeconomic status of students (ESCS) and their grades. I argue that these characteristics may strengthen the impact of ESCS on achievements, as students of high socioeconomic status can use education-supportive settings to achieve better grades. Next, I examine this argument by analyzing whether and to what extent country-level variables could be driving the relations between ESCS and academic performance.

3.2 Model Estimation

The analyses in the second stage of the analysis are based on Hierarchical Linear Models estimating student scores in mathematics, reading and science as a function of individual-level and country-level determinants. The focus of the study is on the socioeconomic effects on students' grades, therefore the individual-level characteristics incorporated in the models include sociodemographic attributes, as well as school policies and resources. Since I was limited in the number of country-level variables that could be included in the analysis, and because of a very high correlation between some of the control country-level variables (e.g., GDP and expenditure on education), I introduced into the second-level equations only variables of theoretical interest.

Hence, at the country level, the models include characteristics of educational systems (i.e., average class size, ratio of students to teaching staff), an indicator for economic development (i.e., GDP per capita), and demographic factors (i.e., percentage of the young population, education of the adult population). I allow a random effect of the individual-level variable of the index of educational, social and cultural status (ESCS) and explain the variation in the effect of ESCS by class size, ratio of students to teaching staff, and education of the adult population.[15]The results are presented in Table 3. Turning first to the individual-level variables, the findings support many of the expectations put forward at the outset. Other things being equal, being of higher socioeconomic status, studying in a private school, or in a school with a high quality of educational resources and with a high socioeconomic composition, raises students' achievements in all three subjects. Higher grades are also evident in schools where more admission criteria based on academic record and more selectivity practices are used.

Also consistent with previous studies is the tendency of males to get higher grades than females in mathematics (b=-13.075) and science (b=-3.624), and the tendency of females to better succeed in reading (b=33.945). Finally, recommendation of feeder schools is associated with lower rather than higher grades, probably because these schools give more recommendations to pupils who need help getting into better schools, than to excellent ones.

Table 3: Individual- and country-level effects on students' grades in mathematics, reading and science among 15-year old students: Results from Linear HLM Regression Equations (std. err.)

	Mathematics	Reading	Science
Country-level effects			
On the intercept			
Young population (%)	-3.640** (.975)	-1.622* (.888)	-3.660** (.916)
GDP per capita	-.0001 (.0002)	-.00009 (.0001)	-.0002 (.0001)
Average class size	3.007** (1.057)	2.148** (.579)	2.126** (.729)
Ratio of students to teaching staff	-1.532* (.833)	-1.491** (.667)	-.913 (.659)
Education of adult population	4.362 (2.805)	4.412* (2.640)	6.312** (2.955)
Mean ESCS	40.308** (11.965)	35.693** (12.247)	32.788** (13.471)
On the ESCS slope			
Average class size	.395** (.126)	.080 (.135)	.066 (.165)
Ratio of students to teaching staff	-.533** (.186)	-.383** (.174)	-.390* (.200)
Education of adult population	3.018** (.631)	2.735** (.595)	3.361** (.612)
Individual-level effects			
Intercept	508.085** (4.302)	487.197** (3.872)	508.240** (3.903)
ESCS	35.312** (.915)	33.870** (.929)	34.541** (1.004)
School ESCS	19.067** (5.354)	19.868** (5.817)	17.423** (5.496)
Gender	-13.075** (1.073)	33.945** (1.535)	-3.624** (.952)
Public	-14.261** (3.659)	-14.510** (3.268)	-12.345** (3.283)
School selectivity	4.024* (2.262)	4.131** (2.187)	2.840 (2.097)
Admission - Academic record	7.003** (1.273)	6.586** (1.328)	6.608** (1.210)
Recommendation of feeder school	-7.812** (1.792)	-7.335** (1.567)	-7.175** (1.629)
Quality of educational resources	5.107** (.858)	4.966** (.735)	4.952** (.681)
Class size	.738** (.173)	.869** (.183)	.733** (.165)
χ^2	23304.971**	13754.078**	14658.231**
N (individual)	321860	321860	321860
N (country)	40	40	40

*p<.10 **p<.05

The results lend support to my claim that country characteristics are of great importance for student performance, over and above demographic, human capital and school-related effects. The significance of the country-level variables in explaining the variance of the ESCS slope is clear. Introducing country-level variables reduces the variance by 11% in the equation as regards mathematics, 17% in the equation as regards science, and 20% in the equation as regards reading. In all study subjects, students better achieve the smaller the size of the young population in their countries, the lower the ratio of teachers per students, and the more educated their parents are. Moreover, while the GDP per capita variable has no effect on student grades, probably due to homogeneity between the countries in the level of economic development (see also Bishop, 1997; Fuchs & Woessmann, 2004), the level of socioeconomic status of countries, measured by mean ESCS of students by country, is associated with higher achievements of students. The class size (in lower secondary education) variable exerts a positive effect on student grades at both the country and individual levels (the latter derive from school-level data). This means that students in larger classes and students from countries with larger classes perform better than others. Looking at the position of countries in regard to class size reveals little variance, as classes contain 22 to 28 pupils and PISA scores range from 480 to 580 (see Figure 1C). China in particular but also Japan and Korea are exceptional, exhibiting higher grades and a lower ratio of students to teaching staff, but larger class size, probably leading to the above positive effect.[16] This effect may also be attributable to students often being intentionally grouped by educational ability, as weaker or disadvantaged students are placed in smaller classes, enabling them to receive more individual attention (Fuchs & Woessmann 2004; West & Woessmann 2003).

The main focus of this study is on the interaction term between the educational, social and cultural status (ESCS) of students and educational and demographic features of countries. The results follow theoretical expectations and show that students with high socioeconomic status utilize their country characteristics to better succeed in school than their low-status counterparts. More specifically, a lower ratio of students to teaching staff, higher education of the adult population, and larger classes (only in mathematics) in one's country increase the academic achievements of students as their socioeconomic status increases. Here, the same argument as regards the opposed effect of class size and the ratio of students to teaching staff is applicable. Furthermore, when the predicted grades in mathematics, reading and science are calculated for an average student, in each country by ESCS, on the basis of the equations presented in Table 3 (not shown), high-ESCS students consistently achieve higher grades than low-ESCS students in all subjects and in all countries. A substantial gap between low and high ESCS is found among low-achieving countries, namely Brazil, Colombia, Indonesia and Mexico, meaning that countries with relatively poor educational and economic conditions intensify the effect of student socioeconomic status on academic outcomes and that may lead to greater educational inequality.

Discussion

The objective of the present research has been to provide a systematic examination of between-country variation in student performance in mathematics, science and reading. Unlike most studies, which focus almost exclusively on student characteristics, family backgrounds, school resources and institutions, and country characteristics of the school system, the current study focuses on the impact of other country-level characteristics and their combined effect with socioeconomic status. I argue that demographic and macroeconomic features of countries can directly and indirectly affect the achievements of students from different socioeconomic backgrounds, above and beyond the effect of personal attributes or conditions of the educational system. In this sense, countries can contribute to improving students' educational achievements and reducing educational inequality.

My main results revealed substantial country effects on student grades. The share of the young population and the ratio of students to teaching staff are associated with lower grades, while the education of the adult population, class size and the aggregate level of student's socioeconomic status by country are associated with higher grades. Thus, students may better achieve in countries which not only invest in the education system itself, but also have more favorable national conditions for the operation of the education system. Moreover, as socioeconomic status increases, these conditions further support students in their academic endeavors and academic performance follows. In other words, students with higher socioeconomic status not only access support, materials, and opportunities that put them ahead of their low-status peers, but the countries they live in further enable them to use their relative position to enjoy better conditions for learning.

Most discussions of education policy tend to ignore this impact, often focusing on the implicitly assumed positive link between schooling resources and student background and student performance.

Prior studies (e.g., Blossfeld & Shavit 1993) have shown, albeit not without criticism (Marks & MaCmilan 2003), that education policies alone are not effective in improving access to higher education for low-status students, and public policy may be more effective in promoting social mobility and academic achievements. The current study suggests that such policy has to consider country characteristics that influence educational systems and demographic structures. Taking these country-level factors into consideration may shed light on the role of countries and policies in reducing educational inequality and help in tracing the mechanisms behind national educational processes.

Future comparative research on student performance should refer more extensively to features of educational systems, focusing on developing countries and the policies that they should implement. As I have shown here, developing countries exhibit poor educational systems which cannot meet the demands of the growing population of young pupils and uneducated adults. It is therefore plausible that students in these countries achieve badly and experience greater class disparities in grades. Future studies could use more detailed data on developing countries to compare working-class to higher-class students in order to better understand the relationship between class and achievements in unique national contexts. Although it is not my main topic, it is also important to consider the role of cultures and norms in explaining educational gaps, as exemplified by China whose students obtain good grades, despite having to contend with 'bad' national conditions.

My results, based on the analysis of the combined effect of individual, school and country characteristics on student achievements, show that focusing on macroeconomic and demographic characteristics of countries may open a new angle in the investigation of inequality in educational achievements. It follows that educational inequality can best be tackled by improving the national educational systems to provide equal opportunities to students, independently of their socioeconomic status. Improving national school systems of countries may help to reduce inequality and help students from low socioeconomic households and communities develop academic skills and better succeed in school (Glewwe, 2002). For these students, changes at the national level, such as smaller classes and the presence of more teachers per students, can shrink the achievement gap and improve their grades and their life chances. In this respect, a comparative analysis of educational systems could contribute to developing a theory about the mechanisms that mediate the relationship between student socioeconomic status and achievement across a range of national contexts, and thus put us in a better position to implement educational reforms that reduce socioeconomic inequalities.

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Appendix Table A1: Descriptive Statistics

	N	Mean	S.D	Min	Max
Mathematics	321860	481.27	97.08	78.84	903.11
Reading	321860	485.09	94.37	27.54	849.36
Science	321860	488.15	94.96	63.26	829.11
ESCS	321860	-0.19	1.12	-5.62	3.69
School ESCS	321860	-0.19	0.26	-3.40	1.34
Women	321860	0.51	0.50	0.00	1.00
Public	321860	0.81	0.39	0.00	1.00
School selectivity	321860	2.08	0.86	1.00	3.00
Academic record	321860	1.95	0.89	1.00	3.00
Feeder schools	321860	1.70	0.77	1.00	3.00
Quality of educational resources	321860	-0.08	1.07	-3.59	1.98
Class size	321860	28.67	9.70	13.00	53.00
Young population (%)	40	18.10	4.21	13.00	28.00
Average class size	40	23.91	6.25	14.40	50.30
GDP	40	36315.80	16456.0	10517.0	98499.56
Ratio of students to teaching staff	40	14.03	5.64	7.70	34.50
Education of adult population	40	10.94	1.67	7.10	12.90
Mean ESCS	40	-0.10	0.52	-1.77	0.78

Sources: PISA 2012, World Bank (2014), OECD statistics (2013), Barro and Lee (2013).

[1] All these studies are observational, so there might be a case for reverse causality, which may cause endogeneity biases. In order to rectify this confounding issue, an instrumental variables strategy is implemented in this study.

[2] Pupil-teacher ratio refers to the number of students and teachers in an educational unit, while class size refers to the number of students regularly in a single teacher's classroom, for whom that teacher is responsible.

[3] Data for average class size and ratio of students to teaching staff was obtained from OECD statistics (2013). Data for share of the young population and GDP per capita was obtained from World Bank data (2014), and for education of the adult population (in years) from Human Development Report (Barro and Lee 2013).

[4] China is represented in PISA 2012 by three cities; Shanghai, Macao and Hong Kong. Since there are minor differences between the cities and national data treat Hong Kong separately, only Shanghai has been chosen for the analysis.

[5] The standard errors of the final model were calculated based on each set of plausible values.

[6] School variables were assigned to individual students in accordance with their school id.

[7] Due to high correlation between the two, I follow previous studies and focus on GDP per capita rather than on expenditure on education.

[8] In order to address the issue of reverse causality between economic growth (GDP) and students' achievements, I use the unemployment rate as an instrument for the measure of economic growth in the achievements regression, using a two-stage least squares (2SLS) estimation (see Hanushek & Woessmann 2009). The first-stage results confirm a statistically significant association between unemployment rate and GDP, but no effect of GDP on achievements in the second stage. Thus, the results are not hampered by endogeneity biases.

[9] I use both variables of class size and ratio of students to teaching staff since they are not highly correlated (.421). There are countries with large classes that have more than one teacher per classroom (e.g., China and Japan).

[10] Education of the adult population may indicate the level of parents' education, which is known to be highly correlated with children's education (Blossfeld & Shavit 1993).

[11] The mean ESCS of students by country is included mainly because the ESCS variable at the individual level was centered on the country mean, i.e., the ESCS slope was allowed to vary among countries.

[12] This is the reason why the model does not include all country characteristics of the school system and three-level analysis.

[13] The ESCS variable was centered on the country mean. Other quantitative individual-level variables and country-level variables were centered around their grand mean. The dummy variables retained their original form.

[14] For example, see China, a country with low GDP but highest in students' grades, and at the other extreme, Luxembourg and Norway, well-developed but relatively poor-performing countries.

[15] Since the GDP per capita and share of the young population variables did not reach statistical significance, they were removed from the ESCS slope analysis.

[16] Excluding these countries from the model does not alter the positive effect of class size, but rather decreases its magnitude.