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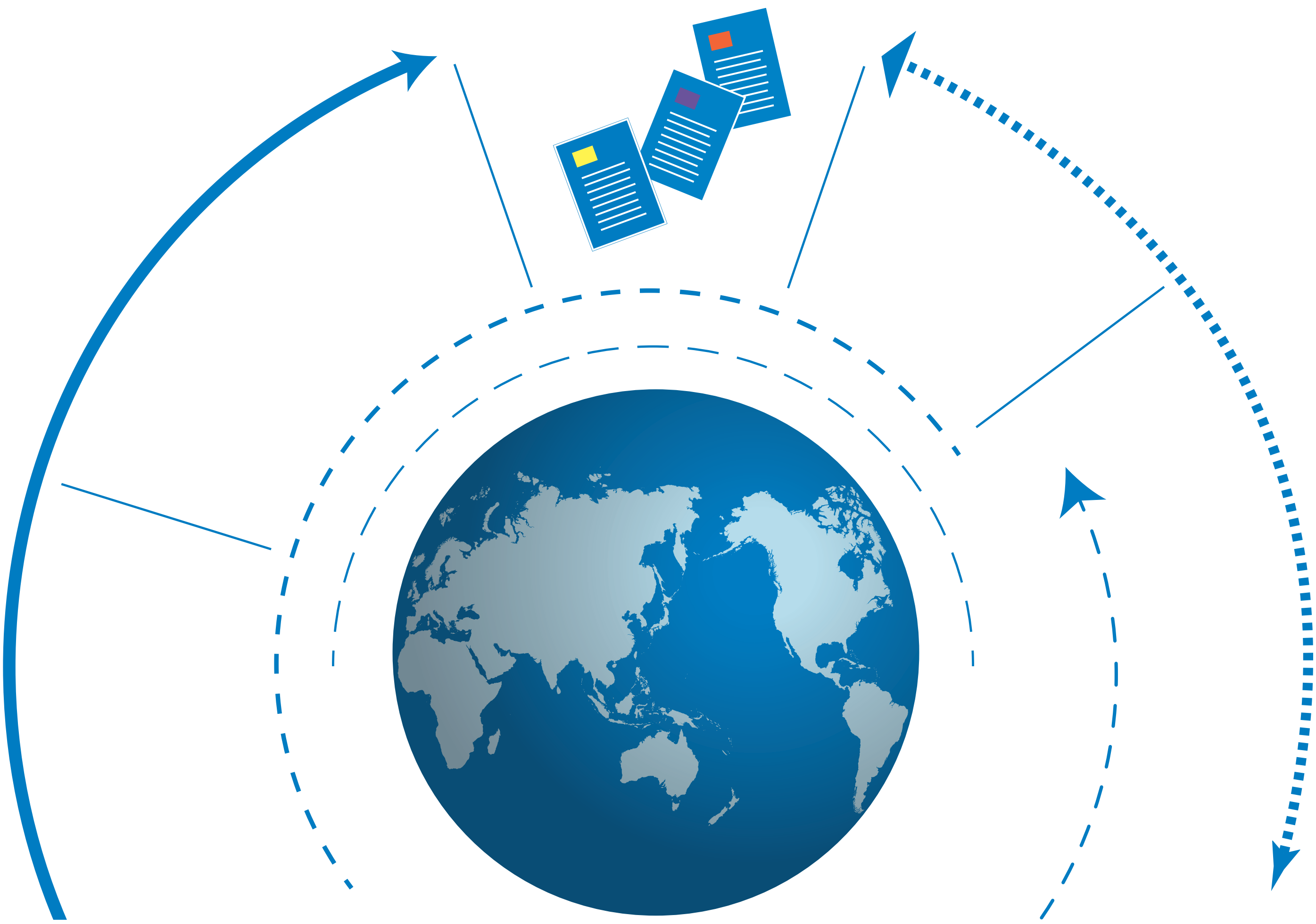
# Understanding student performance beyond traditional factors: Evidence from PISA

Rolando Avendano, Felipe Barrera-Osorio, Sebastián Nieto-Parra and Flora Vever



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# PREFACE

Education is a fundamental right for all and plays a decisive role in development by bringing about greater equality, social inclusion and by enhancing technological progress and productivity. As stressed in the *Latin American Economic Outlook 2015*, while strides have been made in some areas of education policy, such as coverage and investment, improvements in the quality of education are particularly modest. This paper aims to better understand the differences in performance among a large group of Latin American students. Using the data from PISA, a comprehensive tool for assessing secondary school students, this research analyses the linkages between schools' inputs, students' characteristics and performance in Latin America.

In both OECD and non-OECD countries, identifying which policies work for improving learning outcomes in education is not a straightforward matter. Traditional characteristics of education systems, such as teachers' qualifications, expenditure per student or physical infrastructure, have been linked to students' performance. More recently, other forms of intervention, such as the students' instructional time, teacher feedback from the principal, or intensive tutoring, have been analysed. This research aims to understand the contribution of these "pedagogical" or qualitative factors and their role in improving the quality of education systems.

The findings of this research suggest that some pedagogical actions, which are not necessarily more costly, could be introduced to improve the quality of education outcomes in secondary education. This is particularly relevant for Latin America, where the efficiency of public expenditure is critical and the fiscal space for financing new policies is limited. Less tangible elements of education, such as student motivation, perseverance or teacher effort could also improve learning outcomes.

I invite you to read this document, which makes a valuable contribution to the debate of effectiveness in education and provides an analysis of the factors which can make a difference and guide the implementation of education reforms in the future. This paper was produced within the framework of the *Latin American Economic Outlook 2015: Education and Skills for Development*, and served as an input for the Multi-dimensional Reviews of Uruguay and Peru, the OECD Skills Strategy in Latin American economies and the OECD Better Policies Series.

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Director

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May 2016

# RÉSUMÉ

Cet article étudie les liens entre les politiques en matière d'éducation et la performance des étudiants en Amérique latine. Nous exploitons la richesse de la base de données de PISA 2012 générée à partir des questionnaires soumis aux étudiants et aux écoles visant à analyser l'association entre certaines variables liées aux politiques éducatives avec la performance des élèves en mathématiques. Tout d'abord, cette recherche montre que les caractéristiques des élèves et leur environnement (sexe, âge et situation économique, sociale et culturelle des élèves et des écoles) expliquent près de 30% de la variation de la performance des étudiants en Amérique latine, un pourcentage plus élevé que dans les pays de l'OCDE et d'autres économies participant à PISA 2012. Deuxièmement, après avoir contrôlé les caractéristiques des étudiants et leur environnement, nos résultats montrent qu'en Amérique latine certaines politiques « non traditionnelles » pratiquées par certaines écoles, telles que les évaluations des enseignants réalisées par le principal, le temps d'enseignement hebdomadaire ou l'attitude et la motivation des enseignants, ont une influence sur la performance des élèves, alors que certaines politiques traditionnelles, telles que les infrastructures scolaires, la part des enseignants certifiés, les qualifications des enseignants n'en ont pas. Ces résultats suggèrent que des initiatives pédagogiques présentant un bon rapport en termes de coûts et d'efficacité peuvent être mises en œuvre en Amérique latine pour améliorer la performance des élèves dans la région.

**Classification** JEL: H41, H52, I21, I25.

**Mots-clés:** Performance en éducation, éducation secondaire, Amérique latine, PISA.

# ABSTRACT

This paper studies the linkages between schools' inputs and students' performance in Latin America. We exploit the richness of PISA 2012 questionnaires at the student and school level to study the association between a different set of inputs and students' performance in mathematics. First, this research shows that students' characteristics and their environment (i.e. sex, age and economic, social and cultural status of students and schools) explain close to 30% of the variation in education performance in Latin America, a higher percentage than in OECD and other economies which participated in PISA 2012. Second, after controlling for students' characteristics and their environment, our results show that in Latin America, some non-traditional school inputs, such as the feedback provided by the principal to the teacher, weekly instructional time or the attitude and motivation of teachers, are associated with student performance, whereas more traditional inputs (e.g. school infrastructure, share of certified teachers and teacher qualifications) are not always related to better learning outcomes. These findings suggest that some pedagogical initiatives, which are also more cost-effective, could improve students' performance in the region.

**JEL classification**: H41, H52, I21, I25.

**Keywords**: Education performance, secondary education, Latin America, PISA.

# I. INTRODUCTION

The purpose of this paper is to analyse the linkages between schools' inputs and students' performance in Latin America. We use PISA 2012, the most recent and comprehensive database for secondary education, covering close to 450 000 students in 65 economies. In particular, we exploit the richness of PISA questionnaires at the student and school level to study the association between a different set of inputs with students' performance in mathematics.

This research shows several empirical findings. First, students' characteristics coupled with their socioeconomic environment explain close to 30% of the variation in performance for Latin America, a higher percentage than in OECD and other economies. Second, after controlling for students' characteristics and environment (i.e. economic, social and cultural status of students and schools, sex and age), this paper shows that in Latin America some non-traditional school inputs, such as the feedback provided from the principal to the teacher, the quantity and quality of instructional time or the attitude and motivation of teachers, are associated with student performance, whereas some traditional interventions are not (e.g. school infrastructure, share of certified teachers, and teacher qualifications). These results provide insights in education policies which would provide gains in efficiency while not requiring large investments associated with more traditional policies such as reducing student-teacher ratios, increasing teacher qualifications or expanding school infrastructure. These results are consistent with experiences in urban charter schools in the United States where, after controlling for per-pupil expenditures, instructional time and students' and parents' behaviour, focusing on maths and reading skills affect student performance (Angrist et al., 2011). These findings suggest that there are some "pedagogical" initiatives to be implemented in Latin America, which can boost student performance in the region in a cost-effective way.

The aim of this paper is particularly relevant for Latin America, as it studies the areas in which spending money can most efficiently impact the quality of the education system. Our results show that some cost-effective pedagogical actions are associated to the quality of the educational system in Latin America, whereas some traditional inputs that generally require more spending are not necessarily linked to performance. Such findings matter particularly for Latin America. Despite increments in public spending on education in the region over the last decade, levels remain low and far from OECD countries (OECD/CAF/ECLAC, 2014). Moreover, the fiscal space to increase investment in education remains limited in the region

(OECD/ECLAC/CIAT/IADB, 2015).[2] In that context, in addition to quantity, the efficiency and adequacy with which money is spent is crucial (OECD 2013a).

While significant improvements to increase education coverage have been achieved, quality in education remains a key challenge for Latin America. The majority of countries in the region are on track to meet the MDG's by 2015. Enrolments are increasing and the gender gap has been decreasing over the last decades (OECD/CAF/ECLAC, 2014). However, the real impact of education on the life and well-being of individuals depends not only on the number of years of schooling, but also on the quality of education they receive. In particular, in mathematics, the focus of PISA 2012, Latin American countries ranked between 51 (for Chile) and 65 (for Peru) among 65 economies, demonstrating a poor performance in proficiency across all economic, social and cultural status levels. As a result, seven of the eight Latin American countries included in PISA 2012 obtained an average score in mathematics below level 2, considered by PISA to be the threshold for basic competences in mathematics.[3]

There has been a long tradition of research attempting to link test scores and school inputs since the Colleman report (Colleman et al., 1966), which have resulted in mixed results (Hanushek, 2003). The first generation of studies used available data as a proxy for school inputs (to simplify, we name these inputs as "traditional variables"). Three inputs have been extensively researched: the student-teacher ratio, teachers' qualifications (mainly, experience and diplomas) and some proxy for school infrastructure. In general, there has been a consensus that these traditional inputs have a weak correlation with students' test results. For instance, the relationship between test scores and student-teacher ratio has been difficult to determine. Also, teachers' qualifications are very poor proxies for teaching practices. Finally, the role of infrastructure in learning is unclear. In sum, during the last two decades several researchers have been attempting to establish a causal impact from these inputs – and many others – on learning (for recent reviews, see Kremer and Holla, 2009; Kremer et al 2013; Murnane and Ganimian, 2014).

Another line of research uses richer data to establish the relationship between students' performance on tests and inputs "inside" the black box of education production. The availability of new data has allowed researchers to test different inputs that theoretically are important in the production function of education (Dobbie and Fryer, 2011). These variables are related to non-traditional inputs of education such as instruction, parents' feedback and hours spent on

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[2] Fiscal revenues in Latin American economies represent less than 22% of GDP, well below OECD average (34% of GDP).

[3] Depending on the level of performance reached by the student, PISA defines 6 levels of competences. According to PISA, at level 2, students can interpret and recognise situations in contexts that require no more than direct inference. They can extract relevant information from a single source and make use of a single representational mode. Students at this level can employ basic algorithms, formulae, procedures, or conventions to solve problems involving whole numbers. They are capable of making literal interpretations of the results (OECD, 2013b).

 

mathematics and sciences, and are key to explaining pupils' performance (to simplify, we call these inputs "pedagogical variables").

The distinction between "traditional" and "pedagogical" inputs used throughout this paper follows a sequence of different factors studied in the literature. Traditional inputs refer to those factors studied in the early reviews of school performance, whereas "pedagogical" inputs are derived from the more recent collection of school and student-level data. The traditional/pedagogical perspective studied here concerns only measurable inputs. However, this analysis indirectly alludes to the debate in education policy about the effect of "tangible" and "intangible" factors. Whereas tangible inputs refer to measurable and observable aspects for improving education, intangible factors refer to unobservable elements that, despite their difficulty being captured, can have a strong effect on the quality of education. The classic example of an intangible factor is teacher quality, which, although oftentimes imperceptible through certification or experience, has a large impact on promoting active learning and engaging students.

This article provides a simple exercise to test whether – after controlling for students' characteristics and environment (socioeconomic status of students and schools, age and sex)[4] – typically traditional inputs, on one side, and pedagogical factors, on the other, are correlated with the results of PISA 2012. Although this paper follows Dobbie and Fryer's (2011) analytical approach, some important differences remain between their sample and PISA's sample. First, the 35 schools they study are based in the New York area, which considerably decreases the national and regional heterogeneities, by contrast with the PISA sample (65 countries). Second, their sample covers only charter schools, this is, institutions that receive public funding but operate independently from the public school system. Therefore, the ability to generalise and compare results is more limited. Third, part of their sample implements very specific education programmes, such as the "No excuses" initiative, which include more disciplined and accountable policies. Despite these differences, our results draw some interesting conclusions.

After showing that most of these traditional inputs have almost zero correlation with student performance in Latin America, findings show that non-traditional inputs which induce changes in incentives and experiences of students could be particularly attractive for developing countries. Such pedagogical actions are relatively more effective than traditional policies and represent feasible options in decision making for educational policies in regions where fiscal constraints are substantial, as is the case for Latin America.

The remainder of this article is organised as follows. Section II provides a review of the literature. Section III presents the dataset used in this paper. In particular we highlight some descriptive statistics from PISA 2012. Section IV specifies the model to be tested and the main hypothesis of this research. Section V presents the main econometric results and discusses some robustness checks. Finally, Section VI concludes and provides policy recommendations.

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[4] In this paper we use indistinctly economic, social and cultural status and socioeconomic status.

# II. LITERATURE REVIEW

This section highlights the main results obtained from previous datasets of PISA and presents research studying the linkages between traditional and non-traditional variables with students' performance.

The literature on PISA datasets for analysing associated factors of inputs on test scores is extensive. In addition to traditional models that determine students' performance, research has analysed measures of equality of opportunity among students, the predictive power of PISA results and the policy impact of PISA studies on national education policies.

In one of the first studies on PISA data, Fuchs and Wößmann (2007) study the main determinants of student performance, finding that student characteristics, family backgrounds, home inputs, resources, teachers and institutions are all significantly associated with student achievement. Student performance is higher with external exams, budget formulation, school autonomy in textbook choice, hiring teachers and within-school budget allocations. They also find that students perform better in privately operated schools, but private funding is not decisive. More recently, the effect of national, sub-national and school-based variables related to school management have been studied in relation to their link to PISA performance. Hanushek, Link and Woessmann (2011) study the effect of decentralisation policies among students' achievement, under the hypothesis that autonomy can be conductive to student achievement in well-developed systems, but detrimental for low-performing systems. Using PISA data from 2000 to 2009, the authors find that autonomy affects negatively student achievement in developing and low-performing countries, but it tends to be positively linked to performance in institutionally-highly-developed and high-performing countries. This finding highlights the differential effects that certain policies can have across different educational systems.

More recently, other studies have focused on the effect of other policies on performance and students' well-being. Borgonovi and Montt (2012) study parental involvement in a group of 14 countries where the PISA 2009 parental questionnaire was implemented. They evaluate the level of parental involvement across countries and sub-groups within countries, so as the link between involvement and cognitive (reading performance) and non-cognitive outcome. Their findings suggest that some forms of parental involvement (reading to children when they are young, engaging in discussions that promote critical thinking and setting a good example) are strongly related to cognitive and non-cognitive outcomes.

Another branch of studies has focused on the impact of socio-economic status on students' outcomes and performance. Gamboa and Waltenberg (2012) explore the link between equality of opportunity and educational achievement for a group of 6 Latin American countries, using data from PISA 2006 and 2009. Looking at different types (gender, school type, parental education), they find that the magnitudes of inequality of opportunity for educational achievement in Latin America (between 1% and 25%) are substantially larger than for other regions in the world. Parental education and school type prove to be important sources of inequality of opportunity, contrary to gender.

Martins and Veiga (2010) measure a socioeconomic-related inequality in mathematics performance for a group of 15 European Union countries. Using data from PISA 2003, they find socioeconomic related inequality in mathematics achievement, favouring the higher socioeconomic groups in each country. The inequality is higher in countries like Germany, Greece, Great Britain, Belgium, and Portugal. Socioeconomic factors represent between 14.9% and 34.6% of the overall inequality in education for these countries. The decomposition exercises suggest the existence of two main groups: the first includes the Nordic countries plus Great Britain, Ireland, Portugal, Spain and Greece, where socioeconomic-related inequality is explained mainly by the students' background characteristics. The second group includes Austria, Belgium, Germany, Italy, Luxembourg, Netherlands and France. In these countries, the high impact of schools' composition on individual achievement is the main driver of the studied inequality.

A more recent body of the literature focuses on the predictive power of PISA tests on students' future performance. Jakubowski (2013) analyses how students' responses to mathematics and problem-solving items in PISA 2003 are related to the students' qualifications in education in 2007 and 2010. The results show that items do differ in their predictive power, depending on some of their deep qualities. PISA mathematics and problem-solving items are grouped into various classifications according to their qualities. Among mathematics-specific item classifications, two are found to be significantly related to future student success: those that assess knowledge, understanding, and application of statistics; and those related to rates, ratios, proportions, and/or percent. These items frequently require students to apply common mathematical concepts to solve multi-step, non-routine problems, think flexibly, and understand and interpret information presented in an unfamiliar format or context.

Finally, the policy effect of PISA has drawn the attention of the general public in recent years. The impact of PISA results on national education reform and policy making has been considerable, both in OECD and non-OECD countries. Based on the results of a survey of country practices, Breakspear (2012) finds that PISA has gained prominence as a reliable instrument for benchmarking student performance worldwide, while influencing on policy reform in the majority of participating countries/economies.

Regarding the linkages between traditional and non-traditional variables with students' performance, fairly recent studies have been attempting to systematically find the causal effects of several inputs on test scores. First, regarding student-teacher ratios, the general consensus is that changes in class size will not induce substantial changes in test scores. The reason behind that is either because even after the change, class sizes remain quite large or because they did not change the experience of students (Duflo et al., 2007; Angrist and Lavy, 1999). Second, in terms of teacher qualifications, teachers are one fundamental in the production function of education. An effective teacher can increase in a substantial amount students' learning (Rivkin et al., 2005). However, teachers' certifications are not a good proxy of teacher effectiveness.

At the light of these results, new research has been focusing on the issues of increasing school accountability and teacher incentives. Regarding teacher incentives, the evidence is mixed. While some interventions shows promising results (for instance, Muralidharan and Sundararaman 2011, 2012), other showed small results emanating from teaching to the test (Kremer et al., 2010). Teachers and/or students incentive programmes might also lead to an increase of cheating practices during the tests (Behrman et al., 2012). Woessmann (2011) shows that, using PISA results and questionnaires, systems in which "teacher incentive programs are in place" perform better than others.

Accountability encompasses different programmes. For instance, school based management can induce positive results (Barrera-Osorio et al., 2009). No Child Left Behind programme is another programme condition resource to students' results. There is evidence of positive results of such programmes, but it is unclear if the results come only from "test inflation" (Koretz, 2002) or from real changes in learning.

Recently, charter schools and the so-called "No excuses" paradigm have been deeply studied in regards with school effectiveness. "No Excuses" schools are defined by their commitment to a strict discipline and behaviour norms, a long school year and day, selective teacher and principal hiring and a strong student work ethic. Carter (2000) conducts a study on 21 high poverty but high performing "No Excuses" schools in the United States. Whereas three-quarters or more of their students qualify for the federal lunch program, these schools score above the 65th percentile on national academic achievement tests. By contrast, schools with similar poverty conditions score below the 35th percentile. According to this study, "No Excuses" schools' successes rely on empowered principals, the use of interim assessments to measure student progress, frequent and effective professional development, aggressive parent outreach and a relentless focus on achievement for all students. Angrist et al. (2010) implement a quasi-experimental study on a charter school committed to the "No Excuses" approach, and find that this specific school system generates substantial score gains in mathematics and language. Similarly, Angrist, Pathak and Walters (2011) show that urban charter schools boost student achievement, whereas non-urban charter schools do not, and link this impact to some pedagogical features (length of the school day, school philosophy) embedded in the "No Excuses" approach.

# III. DATA AND METHODOLOGY

Our empirical analysis relies on the Programme for International Student Assessment (PISA) conducted by the Organisation for Economic Co-operation and Development (OECD). The PISA study, launched every three years since 2000, is designed to obtain internationally comparable, regular and reliable data on the knowledge and skills of 15 year-old students and the performance of the educational systems. PISA concentrates on three key areas: mathematics, science and reading; each PISA cycle focuses on one subject, thus gathering relatively more information on this specific area.

Data used for this paper are the PISA 2012 evaluation. The fifth PISA focused on mathematics and includes more than 485 000 students assessed in 65 economies.[5] In particular, it covers 34 OECD members plus 31 non-member countries. The eight Latin American countries included in this round of PISA are Argentina, Brazil, Chile, Colombia, Costa Rica, Mexico, Uruguay and Peru.[6] As described in the different results of this research, total number of countries could differ depending on the availability of data for some items of PISA questionnaires.

One key principle underlying the PISA assessment is the concept of "literacy", meaning the capacity of students to use what they have learnt in other contexts and novel settings. Indeed, PISA focuses on student skills and abilities more than on their "learning" and capacity to replicate what they learnt. The goal of PISA, primarily, is to evaluate how far pupils nearing the end of compulsory education have acquired some of the competencies and knowledge that are essential for their future life in society.

The PISA target population is students in their 15 years old,[7] the age at which students in most countries are nearing the end of their compulsory time in school, regardless of the grade they currently attend. A two-sampling procedure is used to ensure that a representative sample

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[5] Shanghai-China, Hong-Kong-China, Macao-China and Chinese Taipei are considered in PISA 2012 as four distinct economies.
[6] The four previous assessments have been conducted in 2000, 2003, 2006 and 2009. The first one in 2000, gathering 43 economies (29 OECD members plus 14 non-member countries) and focusing on reading, the second one in 2003 with 41 participating countries (31 OECD members plus 10 non-member countries) and a focus on mathematics, the third one in 2006 with 58 countries (34 OECD members plus 24 non-member countries) and a focus on sciences. The fourth assessment was conducted in 2009, gathered 74 participating countries (34 OECD members and 40 non-member countries) and focused on reading.
[7] From 15 years and 3 months to 16 years and 2 months at the beginning of the testing period.

of the targeted population is tested.[8] First, a random sample of schools (both public and private) is drawn (150 schools minimum per country), where the probability of each school to be selected depends on its size measured by the number of 15 year-old attending. The second stage randomly samples 35 students aged 15 in each of these schools, each student having the same sampling probability. In order to maximise the coverage of 15-year-olds enrolled in education in the national samples and ensure representativeness, the total rate of exclusion should be no more than 5% of the relevant population. Exclusions may concern schools in remote areas, students having a disability or a limited knowledge in test language. In PISA 2012, only eight OECD countries exceed this limit (Canada, Denmark, Estonia, Luxembourg, Norway, Sweden, United Kingdom and United States of America).

The tests consist in 2-hour pencil and paper tests, with questions constructed so that students should not be favoured or disfavoured according to their home country. In addition, all students receive a questionnaire about their home, learning routines, motivation and attitudes. Heads of schools are also required to complete a questionnaire about their school, its demographic characteristics, level of infrastructure and quality of learning environment. Finally, in 11 countries (eight OECD countries, including Chile and Mexico, plus Croatia, Hong-Kong-China and Macao-China), parents fulfilled a questionnaire about their opinions, attitudes and expectative on their child's education and career.

We use as dependent variable in our model the student's performance. In order to assess each student's overall level of skills and competencies, the performance in mathematics is not described through one rate but rather through a distribution of 5 plausible values of the performance in mathematics, allowing computing a global level of abilities for each student, which is the dependent variable used in this paper.

Regarding the explanatory variables, we distinguish three types of variables having a relationship with students' performance. First, we use variables describing student characteristics and socioeconomic background. The student's socio economic background is estimated by the PISA index of social, cultural and economic status (ESCS),[9] based on indicators such as parental education and occupation, the number and type of home possessions that are considered proxies for wealth and the educational resources available at home. This index is built to be internationally comparable. The social, cultural and economic status of the school (XESCS) is the average of the school students' socioeconomic statuses. In addition, we use the age of the student, in years. Finally, we include a dummy variable for sex, which takes the value of 1 if the student is a boy and of 0 if she is a girl. These variables come both from the student and the parent questionnaires.

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[8] Most PISA samples were designed as two-stage stratified samples. Where countries applied different sampling designs, these are documented in the PISA 2012 Technical Report.

[9] In order to simplify, the PISA index of social, economic and cultural status is called "socioeconomic status" in the rest of this paper.

Second, we use variables traditionally used in the literature to explain the performance of a school or an education system. These traditional variables are the size of the class: the number of students enrolled in the class, the proportion of teachers fully certified by the appropriate authority among the total number of teachers, the proportion of teachers that have an ISCED5A qualification[10] among the total number of teachers and the status of the school: a dummy variable that takes the value of 1 if the school is private and of 0 if the school is public. All these variables come from the school questionnaire, which is completed by the principal of the school.

Finally, we use variables describing pedagogical actions within the classroom and the educational system, thus called "pedagogical variables". First, a dummy variable derived from the student questionnaire that describes how many hours the student typically spends per week attending out-of-school time additional lessons in mathematics. This variable takes the value of 1 if the student spends 2 hours or more per week and the value of 0 for a lower number of hours. Second, we use a dummy variable derived from the school questionnaire, which measures the frequency of feedback given from the principal to teachers. A value of 1 indicates that the principal affirms to conduct informal observations (which should be unscheduled and last at least 5 minutes) in classroom once a month or more, and a value of 0 if this usually happens less than once a month or none. Additionally, the PISA index of use of assessment (assess) reflects to what extent students' assessments are used to monitor and inform about the child's progress, to group students according to their abilities, or to compare and assess the school's and its teachers' performance with other schools, and thus identify aspects of instruction and curriculum that could be improved. To measure tutoring, we use a dummy variable derived from the school questionnaire that takes the value of 1 if the principal affirms that the school offers mathematics lessons in addition to the lessons offered during the usual school hours, and the value of 0 if not. The time of instruction is derived from the student questionnaire and accounts for the instructional weekly time in mathematics (measured in minutes). Finally, the level of expectations from mathematics teachers on students is approximated by a dummy variable built from the school questionnaire that takes the value of 1 (the value of 0) if the principal agrees or strongly agrees (disagrees or strongly disagrees) that there is a consensus among mathematics' teachers that academic achievement must be kept as high as possible.

These pedagogical variables extend the scope of the traditionally explored areas of action in education. While the PISA score in mathematics is a measure for students' performance and competences, we include proxies for good pedagogy and human capital in the school (feedback given from the director to the teachers, use of assessment to guide school curricular and teaching practices and the weekly instructional time in mathematics). Such pedagogical actions may have an impact on student performance; for example, the feedback given to teachers from supervisors on the quality of their instruction has been shown to be an important component of the quality improvements of charter schools in the United States (Dobbie and Fryer 2011). Additionally, we

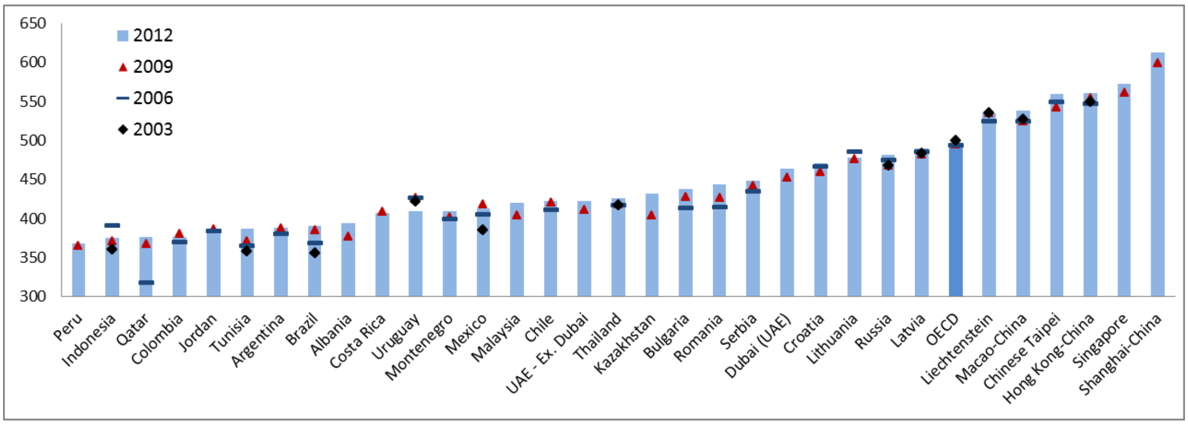
[10] According to UNESCO classification, the level 5A corresponds to the first stage of tertiary education, more precisely referring to largely theoretically based programmes, intended to provide qualifications for gaining entry into more advanced research programmes and professions with higher skills requirements.

include proxies for extra-resources to students (extra-school time tutoring classes in mathematics offered by the school), proxies for the school's atmosphere (level of expectations of mathematics' teachers on students) and finally a proxy for students' effort and motivation (extra-curricular additional classes taken by the students). These pedagogical variables are part of the bundle of best practices from top-performing charter schools that are successfully "injected" in traditional public low-performing schools in Houston to increase their performance (Fryer, 2014).

Based on these three variable groups presented above, we provide key descriptive statistics. Figure 1 summarises the mean scores in mathematics of all participating countries since PISA 2003.[11] Despite some improvements in the region over the past ten years, in particular in Brazil and Mexico, Latin American countries still have a long way to go before reaching the average performance of OECD students. When compared with Asian countries, the performance gap is even wider. Asian economies rank among the 5 top performers in mathematics and sciences (the first 4 in reading) and largely outperform the eight Latin American countries included, which rank among the 20 worse results in the three exams.

Figure 1. **Performance in PISA tests (PISA score)**

(Mathematics, 2003 to 2012)




*Note:* Countries included in the OECD average depend on which OECD members participated at PISA study each year: Chile, Estonia, Israel, Slovenia and the United Kingdom did not participate in 2003, neither did Austria in 2009.

*Source:* PISA database, 2012.

In mathematics, Latin American countries rank between position 51 (for Chile) and 65 (for Peru) among 65 countries. As a result, seven of the eight Latin American countries included in PISA 2012 obtain an average score in mathematics that is below the level 2, considered by PISA to be the threshold for basic competences in mathematics. According to PISA, students performing at the level 2 in mathematics can interpret and recognise situations in contexts that require no more than direct inference, they can extract relevant information from a single source and make use of a single representational mode. Students at this level can employ basic

[11] Due to comparison restrictions, mathematics scores from the study PISA 2000 cannot be included in this analysis.

algorithms, formulae, procedures, or conventions to solve problems involving whole numbers. Finally, they are capable of making literal interpretations of the results (OECD, 2013). As a consequence, students performing below the level 2 in mathematics may not have all the necessary skills and competencies to successfully integrate into the labour market and more generally into society.

Within the region, only Chile performs beyond this level, and to a very small margin. The variance between Latin American countries is relatively small. In 2012, the score difference between the highest and the lowest performer in the region (respectively Chile and Peru) is 55 points, the equivalent of slightly more than 1 year of schooling. For a comparison, the score difference between the highest and lowest performer in OECD countries (respectively Korea and Mexico) is 144 points, thus more than 3 years of schooling.[12]

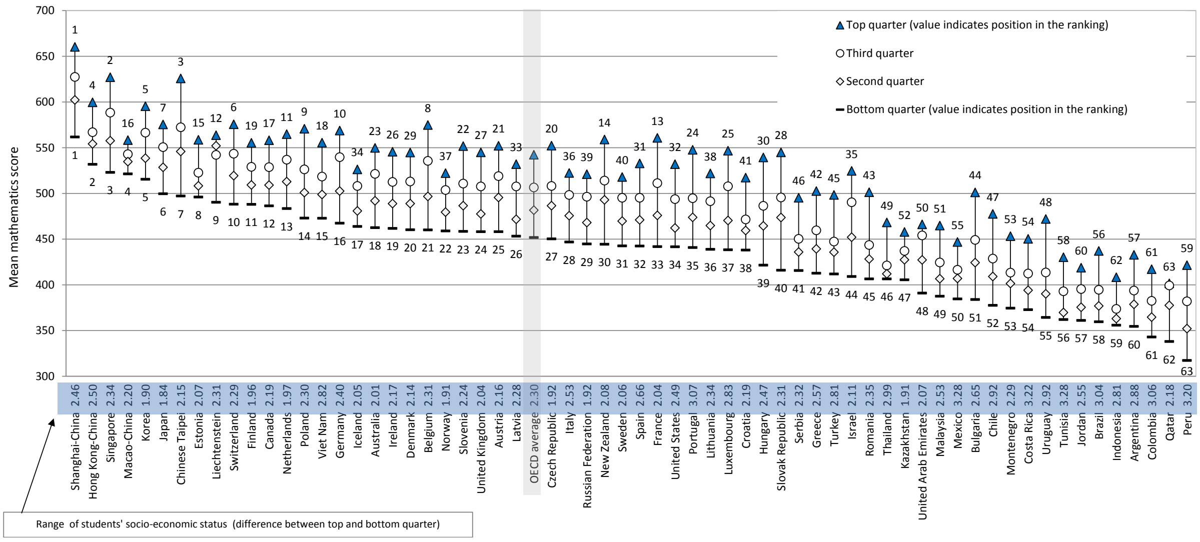
Furthermore, all students in Latin American countries, irrespective of their socio-economic status, perform poorly (Figure 2). Although there are considerable differences in performance between the socio-economically most advantaged and disadvantaged students in Latin American economies (mainly Brazil, Colombia, Costa Rica, Mexico and Peru),[13] the proficiency in mathematics of even those coming from most affluent socio-economic background in Latin America is still well below the one of their OECD peers with comparable socio-economic status. In Latin America, top quarter students in terms of socio-economic status rank in mathematics performance between position 47 (Chile) and 62 (Colombia) among 63 economies. Moreover, regarding this classification of students, five of the eight Latin American countries belong at the ten worst countries performing PISA. This poor performance, even at the top socio-economic level, makes Latin American case interesting: aspects beyond parents' background should affect students' performance. In that sense, this paper considers variables related to the school and to the education system in order to determine bad performance in PISA 2012 for Latin American countries. In that context, we use the above mentioned set of explanatory variables corresponding to the socio economic background of the student and his school, but also to traditional and pedagogical variables related to the education system that would help understanding better the main constraints to enhance mathematics performance in the region.

Table 1 summarises the mean of the three types of variables (baseline, traditional, pedagogical) between high and low performers (respectively the ones performing better the national 75th percentile and lower than the national 25th percentile). In this paper we divide countries into three groups: "OECD" represents the 34 OECD members, "LATAM" the eight Latin American countries included in PISA 2012, and "Others" the 24 non-OECD and non-Latin American economies (i.e. Shanghai-China, Hong-Kong-China, Singapore, Macao-China, Chinese Taipei, Liechtenstein, Viet Nam, Latvia, Lithuania, Russia, Croatia, Serbia, Romania, Thailand, Kazakhstan, United Arab Emirates, Malaysia, Bulgaria, Montenegro, Tunisia, Jordan, Indonesia,

12 41 points in PISA are equivalent to a one full year of schooling.
13 This aspect is analysed in more detail in Table 2 of this section.

Albania and Qatar). Due to data availability, Cyprus[14] is not included in this paper. In addition, we provide specific analysis for each Latin American country included in PISA 2012.

Figure 2. **Mean mathematics performance, by national quarter of socio-economic status**




*Note:* Countries and economies are ranked in descending order of the mean performance of students in the bottom quarter of the PISA index of economic, social and cultural status (ESCS). From 65 economies participating in PISA 2012, Albania and Cyprus are not covered for this analysis.

*Source:* OECD, PISA 2012 Database, Table II.2.4.

Table 1 illustrates significant differences between high and low performers in Latin American and OECD countries. The economic, social and cultural status of students and schools are strongly related with the performance. In Latin America and in OECD countries, high performers come from a relatively socioeconomically advantaged background. Parental education and occupation, the average family wealth and the educational resources available at home (such as books or computers) are significantly related with the student performance. In Brazil, Chile, Costa Rica, Peru and Uruguay, the socio economic gap between high and low performing students is wider than in the average of OECD countries. This lower level of social inclusion in Latin America at the student level also holds true at the school level. On average in Latin America, there is a larger gap in the school's

[14] Note by Turkey:
The information in this document with reference to "Cyprus" relates to the southern part of the Island. There is no single authority representing both Turkish and Greek Cypriot people on the Island. Turkey recognises the Turkish Republic of Northern Cyprus (TRNC). Until a lasting and equitable solution is found within the context of the United Nations, Turkey shall preserve its position concerning the "Cyprus issue".

Note by all the European Union Member States of the OECD and the European Union:
The Republic of Cyprus is recognised by all members of the United Nations with the exception of Turkey. The information in this document relates to the area under the effective control of the Government of the Republic of Cyprus.

socioeconomic status between high and low performing students than in OECD countries, highlighting the importance of peer motivation and pressure on student performance. Also, this gap underlines the importance of the levels of physical infrastructure and of educational resources, as well as the access to quality basic services (e.g. water, electricity, library), which are highly correlated with socioeconomic status of students and schools and have a strong association with performance. This last aspect is studied later in the robustness checks section.[15]

The type of the school is also highly associated with the level of performance in OECD countries and in Latin America, where the gap is even wider. In OECD countries on average, 24% of high performing students are enrolled in a private school, against 12% among their low performing peers. In Argentina, this proportion reaches 58% for high performers and 11% for low performers. The relative stronger presence of low performing students in public schools is indicative of the socioeconomic inequalities in the Latin American education system, as school status is often linked with the socioeconomic background of the enrolled students. This relation is reversed in other countries, where there is a relatively higher proportion of low performers (compared to high performers) that are enrolled in private schools.

In mathematics, boys generally outperform girls, while the results reverse in reading and are generally neutral in sciences. However, the outperformance of boys in mathematics is on average more pronounced in Latin America than in OECD and other countries ("Others" in the Table 1), a trend which should be linked with the widespread male dropout that occurs during secondary education in the region. Such dropout affects boys more severely due to the high opportunity cost of education but also to the massive presence of male-based violence in these countries (Gerardino, 2014).

Certain variables specific to the school are clearly linked with student performance. For all the countries, more time for instruction is associated with a higher performance. This additional instructional time associated with high performers is higher in Latin America than in OECD countries, but lower than in the rest of the countries included in the PISA sample. The difference is striking in Argentina, where high performers on average benefit from more than one additional hour of mathematics classes per week than their low performing peers.

The quality of faculty is weakly related with higher performance in Latin America. The proportion of certified teachers is on average higher among low performing students, and the performance difference linked with the proportion of teacher's having an ISCED5A qualification is very low, revealing that in Latin America, both certification and qualification do not guarantee an efficient learning environment. On the contrary, the certification process seems more effective in all the other countries, where it is positively associated with performance. Teachers can play a significant role on the performance of students through their expectative: in all countries, high performing students are more taught by mathematics teachers that maintain a culture of high expectations, underlining the link between motivation and perseverance.

[15] See Duarte et al (2011) for an analysis the between school infrastructure and learning in Latin America.

## Table 1. **Descriptive Statistics**

### (High performers vs. low performers, average)

| | | OECD | LATAM | Others | ARG | BRA | CHL | COL | CRI | MEX | PER | URY | Average | N |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Performance in mathematics | High | 611 | 492 | 588 | 480 | 486 | 523 | 465 | 488 | 501 | 471 | 517 | 456 | 485,490 |
| | Low | 379 | 310 | 349 | 302 | 305 | 334 | 297 | 334 | 330 | 277 | 308 | | |
| Socioeconomic status of the student | High | 0.44 | -0.44 | -0.39 | -0.11 | -0.53 | 0.18 | -0.66 | -0.23 | -0.56 | -0.41 | -0.11 | -0.61 | 473,648 |
| | Low | -0.74 | -1.65 | -1.63 | -1.25 | -1.73 | -1.20 | -1.81 | -1.62 | -1.60 | -1.94 | -1.49 | | |
| Socioeconomic status of the school | High | 0.28 | -0.55 | -0.50 | -0.26 | -0.64 | 0.10 | -0.81 | -0.41 | -0.65 | -0.56 | -0.30 | -0.60 | 480,501 |
| | Low | -0.61 | -1.55 | -1.56 | -1.14 | -1.62 | -1.09 | -1.65 | -1.42 | -1.54 | -1.82 | -1.35 | | |
| Age | High | 15.8 | 15.8 | 15.8 | 15.7 | 15.9 | 15.8 | 15.9 | 15.8 | 15.7 | 15.8 | 15.8 | 15.8 | 485,374 |
| | Low | 15.8 | 15.8 | 15.8 | 15.7 | 15.9 | 15.8 | 15.8 | 15.8 | 15.7 | 15.8 | 15.8 | | |
| Sex | High | 0.56 | 0.56 | 0.50 | 0.55 | 0.55 | 0.60 | 0.59 | 0.60 | 0.56 | 0.55 | 0.53 | 0.50 | 485,490 |
| | Low | 0.49 | 0.43 | 0.50 | 0.43 | 0.42 | 0.39 | 0.39 | 0.37 | 0.44 | 0.41 | 0.47 | | |
| Class Size | High | 29.5 | 38.2 | 35.2 | 39.9 | 36.4 | 35.3 | 42.5 | 29.1 | 41.2 | 29.4 | 28.3 | 32.20 | 462,865 |
| | Low | 31.1 | 36.1 | 33.6 | 36.5 | 37.3 | 34.3 | 40.9 | 28.8 | 37.5 | 25.5 | 27.5 | | |
| Proportion of certified teachers | High | 0.95 | 0.38 | 0.91 | 0.89 | | 0.24 | 0.11 | 0.72 | 0.24 | 0.89 | 0.62 | 0.83 | 376,980 |
| | Low | 0.79 | 0.50 | 0.71 | 0.91 | | 0.17 | 0.10 | 0.81 | 0.34 | 0.88 | 0.51 | | |
| Proportion of qualified teachers | High | 0.93 | 0.81 | 0.91 | 0.21 | 0.86 | 0.95 | 0.91 | 0.84 | 0.88 | 0.73 | 0.11 | 0.88 | 407,714 |
| | Low | 0.91 | 0.79 | 0.84 | 0.14 | 0.85 | 0.90 | 0.90 | 0.82 | 0.89 | 0.80 | 0.07 | | |
| Private status of the school | High | 0.24 | 0.39 | 0.13 | 0.58 | 0.42 | 0.84 | 0.28 | 0.36 | 0.20 | 0.47 | 0.41 | 0.19 | 471,930 |
| | Low | 0.12 | 0.07 | 0.30 | 0.11 | 0.03 | 0.44 | 0.09 | 0.02 | 0.06 | 0.09 | 0.02 | | |
| Out of school time additional classes in mathematics taken by the student | High | 0.23 | 0.29 | 0.49 | 0.12 | 0.36 | 0.14 | 0.41 | 0.18 | 0.23 | 0.47 | 0.10 | 0.28 | 308,171 |
| | Low | 0.22 | 0.36 | 0.27 | 0.17 | 0.39 | 0.34 | 0.45 | 0.27 | 0.25 | 0.53 | 0.26 | | |
| Feedback from the principal to the teacher | High | 0.54 | 0.59 | 0.66 | 0.62 | 0.59 | 0.64 | 0.70 | 0.50 | 0.52 | 0.67 | 0.65 | 0.61 | 461,667 |
| | Low | 0.62 | 0.61 | 0.61 | 0.71 | 0.59 | 0.69 | 0.72 | 0.58 | 0.59 | 0.46 | 0.62 | | |
| Use of data assessment in school monitoring | High | 4.57 | 4.85 | 4.86 | 4.27 | 4.85 | 5.12 | 5.06 | 5.08 | 5.10 | 4.99 | 4.34 | 4.74 | 264,119 |
| | Low | 4.70 | 4.77 | 5.17 | 4.19 | 5.02 | 4.58 | 4.97 | 4.64 | 4.99 | 4.62 | 4.19 | | |
| Additional mathematics lessons offered by the school | High | 0.72 | 0.64 | 0.92 | 0.44 | 0.62 | 0.80 | 0.43 | 0.43 | 0.74 | 0.55 | 0.86 | 0.70 | 466,650 |
| | Low | 0.62 | 0.45 | 0.78 | 0.65 | 0.45 | 0.64 | 0.25 | 0.53 | 0.46 | 0.37 | 0.78 | | |
| Instructional time in mathematics | High | 242 | 258 | 245 | 320 | 216 | 369 | 276 | 213 | 260 | 310 | 162 | 228 | 283,303 |
| | Low | 223 | 229 | 197 | 212 | 209 | 396 | 255 | 200 | 237 | 251 | 149 | | |
| High expectations among students in mathematics | High | 0.93 | 0.88 | 0.94 | 0.87 | 0.83 | 0.96 | 0.93 | 0.93 | 0.89 | 0.91 | 0.89 | 0.90 | 466,339 |
| | Low | 0.86 | 0.80 | 0.95 | 0.82 | 0.73 | 0.76 | 0.93 | 0.88 | 0.85 | 0.85 | 0.81 | | |

*Note:* High (Low) performers are students that perform above (below) their 75th percentile (25th percentile) of the score distribution. Depending on data availability, "OECD" includes the 34 OECD members, "LATAM" the eight Latin American countries included in PISA 2012, and "Others" are the following 24 non-OECD and non-Latin American economies: Shanghai-China, Hong-Kong-China, Singapore, Macao-China, Chinese Taipei, Liechtenstein, Viet Nam, Latvia, Lithuania, Russia, Croatia, Serbia, Romania, Thailand, Kazakhstan, United Arab Emirates, Malaysia, Bulgaria, Montenegro, Tunisia, Jordan, Indonesia, Albania and Qatar. Due to lack of data availability, Cyprus is not included in this paper. The socioeconomic status of the student is the PISA index of social, cultural and economic status of the student (ESCS) , the socioeconomic status of the school is the average of the social, cultural and economic statuses of the students enrolled in the school (XESCS), age is the age of the student in years, sex is a dummy variable that takes the value of 1 if the student is a boy and of 0 if she is a girl, class size is the number of students in the class, the proportion of certified teachers is a PISA index (propcert) representing the proportion of teachers fully certified by the adequate authority among the total number of teachers, the proportion of qualified teachers is a PISA index (propqual) showing the proportion of teachers with an ISCED5A degree among the total number of teachers, the private status of the school is a dummy variable that takes the value of 1 if the school is private and 0 if the school is public, the out of school time additional classes in mathematics taken by the student is measured by a dummy variable that takes the value of 1 if the student spends 2 hours or more per week in out of school time additional classes in mathematics and the value of 0 if she spends less than 2 hours, the feedback from the principal to the teacher is calculated from a dummy variable that takes the value of 1 if the principal affirms to conduct informal observations in classroom once a month or more, and the value of 0 if it is less frequent, the use of data assessment in school monitoring is a PISA index (assess) reflecting to what extent students' assessments are used to monitor and inform the school and its students performance, the additional mathematics lessons offered is measured by a dummy variable that takes the value 1 if the principal affirms that the school offers mathematics lessons in addition to the lessons offered during the usual school hours, and takes the value of 0 if not, the instructional time in mathematics is a PISA index (mmins) that gives the instructional weekly time in mathematics in minutes, the high expectations among students in mathematics is a dummy variable that takes the value of 1 (the value of 0) if the principal agrees or strongly agrees (disagrees or strongly disagrees) that there is a consensus among mathematics' teachers that academic achievement must be kept as high as possible.

*Source:* Authors' calculations based on PISA database, 2012.

Finally, the frequency of additional classes taken by students and of the feedback given from the principal to teachers are both negatively or very poorly linked with performance, suggesting that in many cases, low performing students have more incentives to take additional classes, but also that it is in low performing schools that principals undertake more frequent unscheduled and informal observations in classrooms.

Table 2 compares the mean of our three types of variables between Latin America, OECD and other countries in terms of socioeconomically advantaged and disadvantaged students. In each country, these advantaged and disadvantaged students are defined to have an economic, social and cultural status higher than the 75th percentile and lower than the 25th percentile, respectively. In all regions, advantaged students have a better performance in mathematics than disadvantaged students. On average, the performance gap is equivalent to more than two years of schooling. In addition, advantaged students in Latin American countries have a higher probability to attend a private school than those students in OECD countries. While in OECD countries 25% of advantaged students attend private schools (against 9% of disadvantaged students), the gap is even higher in Latin America: 45% of advantaged students attend private schools, against only 4% of disadvantaged students. On average, before controlling for the economic, social and cultural status of students, private schools perform relatively better than public ones (see Table 2). In contrast to OECD and Latin American economies, in the case of "Others", disadvantaged students seem to be more enrolled in private schools than advantaged ones. In these countries, public schools are the ones that are linked to relatively higher performance at PISA score: 26% of low performers attend private schools, against 13% of high performers (Table 1). This results in a positive relation between socioeconomic status and performance.

What teachers expect from children is strongly associated with their socioeconomic background. In the three regions included in the sample, the index of expectations is considerably lower for socioeconomically disadvantaged students. The importance of motivation for self-confidence and perseverance highlights that socioeconomically disadvantaged students suffer in the access to a good quality education, in particular from cutbacks in the quality of learning environment.

Finally, a key difference arises in Latin America with respect to the other economies. In contrast to Latin American countries, socioeconomically advantaged students in OECD and other economies have a higher proportion of highly qualified teachers than disadvantaged students (Table 2).

## Table 2. **Characteristics of students by socio-economic status**

## (Advantaged vs. disadvantaged students, average)

| | Socio economic status | OECD | LATAM | Others | ARG | BRA | CHL | COL | CRI | MEX | PER | URY | Average | N |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Performance in mathematics | Advantaged | 530 | 436 | 502 | 424 | 430 | 472 | 415 | 448 | 444 | 420 | 468 | 456 | 485,490 |
| | Disadvantaged | 438 | 360 | 405 | 354 | 355 | 377 | 344 | 373 | 385 | 317 | 364 | | |
| Socioeconomic status of the student | Advantaged | 1.17 | 0.58 | 0.70 | 0.73 | 0.37 | 0.95 | 0.25 | 0.62 | 0.62 | 0.42 | 0.69 | -0.61 | 473,648 |
| | Disadvantaged | -1.46 | -2.56 | -2.22 | -2.15 | -2.71 | -1.99 | -2.76 | -2.61 | -2.67 | -2.79 | -2.24 | | |
| Socioeconomic status of the school | Advantaged | 0.36 | -0.39 | -0.09 | -0.25 | -0.58 | 0.25 | -0.65 | -0.30 | -0.35 | -0.50 | -0.19 | -0.60 | 473,648 |
| | Disadvantaged | -0.78 | -1.74 | -1.81 | -1.20 | -1.78 | -1.27 | -1.83 | -1.60 | -1.88 | -2.02 | -1.36 | | |
| Age | Advantaged | 15.79 | 15.79 | 15.80 | 15.68 | 15.88 | 15.80 | 15.85 | 15.77 | 15.70 | 15.78 | 15.78 | 15.80 | 473,533 |
| | Disadvantaged | 15.78 | 15.80 | 15.82 | 15.68 | 15.87 | 15.80 | 15.87 | 15.78 | 15.69 | 15.79 | 15.79 | | |
| Sex | Advantaged | 0.52 | 0.51 | 0.50 | 0.52 | 0.51 | 0.49 | 0.49 | 0.50 | 0.51 | 0.49 | 0.50 | 0.50 | 473,648 |
| | Disadvantaged | 0.49 | 0.45 | 0.48 | 0.46 | 0.43 | 0.45 | 0.43 | 0.39 | 0.46 | 0.47 | 0.41 | | |
| Class Size | Advantaged | 28 | 37 | 31 | 39 | 37 | 34 | 42 | 29 | 40 | 29 | 28 | 32.20 | 451,917 |
| | Disadvantaged | 33 | 36 | 36 | 36 | 37 | 34 | 40 | 28 | 37 | 25 | 28 | | |
| Proportion of certified teachers | Advantaged | 0.91 | 0.45 | 0.92 | 0.88 | | 0.23 | 0.12 | 0.71 | 0.27 | 0.90 | 0.62 | 0.83 | 367,066 |
| | Disadvantaged | 0.79 | 0.41 | 0.71 | 0.88 | | 0.18 | 0.09 | 0.79 | 0.32 | 0.87 | 0.53 | | |
| Proportion of qualified teachers | Advantaged | 0.93 | 0.78 | 0.89 | 0.20 | 0.87 | 0.95 | 0.89 | 0.84 | 0.88 | 0.75 | 0.10 | 0.88 | 397,924 |
| | Disadvantaged | 0.91 | 0.83 | 0.85 | 0.15 | 0.86 | 0.88 | 0.90 | 0.78 | 0.89 | 0.77 | 0.07 | | |
| Private status of the school | Advantaged | 0.25 | 0.45 | 0.14 | 0.50 | 0.43 | 0.84 | 0.33 | 0.43 | 0.33 | 0.48 | 0.49 | 0.19 | 460,636 |
| | Disadvantaged | 0.09 | 0.04 | 0.27 | 0.16 | 0.02 | 0.43 | 0.05 | 0.00 | 0.01 | 0.05 | 0.01 | | |
| Out of school time additional classes in mathematics taken by the student | Advantaged | 0.21 | 0.33 | 0.41 | 0.16 | 0.42 | 0.21 | 0.42 | 0.26 | 0.26 | 0.48 | 0.20 | 0.28 | 303,774 |
| | Disadvantaged | 0.19 | 0.32 | 0.33 | 0.16 | 0.36 | 0.26 | 0.44 | 0.18 | 0.24 | 0.50 | 0.21 | | |
| Feedback from the principal to the teacher | Advantaged | 0.60 | 0.63 | 0.70 | 0.67 | 0.63 | 0.67 | 0.74 | 0.54 | 0.56 | 0.64 | 0.63 | 0.61 | 450,432 |
| | Disadvantaged | 0.59 | 0.58 | 0.62 | 0.66 | 0.57 | 0.69 | 0.73 | 0.55 | 0.55 | 0.44 | 0.65 | | |
| Use of data assessment in school monitoring | Advantaged | 4.67 | 4.79 | 4.91 | 4.17 | 4.93 | 5.07 | 5.03 | 5.03 | 5.13 | 4.95 | 4.32 | 4.74 | 258,684 |
| | Disadvantaged | 4.72 | 4.86 | 5.25 | 4.27 | 5.04 | 4.60 | 5.06 | 4.55 | 4.90 | 4.61 | 4.20 | | |
| Additional mathematics lessons offered by the school | Advantaged | 0.68 | 0.65 | 0.90 | 0.52 | 0.66 | 0.77 | 0.44 | 0.51 | 0.73 | 0.54 | 0.84 | 0.70 | 455,265 |
| | Disadvantaged | 0.62 | 0.43 | 0.81 | 0.64 | 0.41 | 0.66 | 0.25 | 0.49 | 0.48 | 0.34 | 0.80 | | |
| Instructional time in mathematics | Advantaged | 244 | 262 | 235 | 298 | 226 | 379 | 270 | 222 | 259 | 306 | 160 | 228 | 279,412 |
| | Disadvantaged | 225 | 234 | 207 | 233 | 208 | 399 | 255 | 201 | 249 | 283 | 155 | | |
| High expectations among students in mathematics | Advantaged | 0.94 | 0.88 | 0.96 | 0.88 | 0.84 | 0.92 | 0.95 | 0.93 | 0.90 | 0.91 | 0.85 | 0.90 | 455,014 |
| | Disadvantaged | 0.85 | 0.81 | 0.94 | 0.84 | 0.75 | 0.78 | 0.93 | 0.90 | 0.84 | 0.86 | 0.82 | | |

*Note:* Advantaged and disadvantaged students by socio-economic status are students that have in their countries a social, cultural and economic status (ESCS) higher than the 75th percentile and lower than the 25th percentile, respectively. Depending on data availability, "OECD" includes the 34 OECD members, "LATAM" the eight Latin American countries included in PISA 2012, and "Others" the 24 non-OECD and non-Latin American economies (i.e. Shanghai-China, Hong-Kong-China, Singapore, Macao-China, Chinese Taipei, Liechtenstein, Viet Nam, Latvia, Lithuania, Russia, Croatia, Serbia, Romania, Thailand, Kazakhstan, United Arab Emirates, Malaysia, Bulgaria, Montenegro, Tunisia, Jordan, Indonesia, Albania and Qatar).

*Source:* Authors' calculations based on PISA database, 2012.

# IV. SPECIFICATION AND ESTIMATION

Low performance results in the eight Latin American countries included in PISA 2012 highlight that improving the education system and the quality of learning outcomes is a key challenge for the region. Massive inequalities also exist, especially in the access to a good quality education. Targeted improvements in students' performance require a clearer analysis of which factors directly impact the performance of students.

The differential effect of traditionally collected measures of performance and "pedagogical" measures is particularly interesting for Latin America. We draw on the work of Dobbie and Fryer (2011), who study school strategies in a group of 35 charter schools in New York. The authors find that traditionally collected input measures, such as class size, expenditure per student, the share of teachers with certification, and the fraction of teachers with an advanced degree are not correlated with school effectiveness. In contrast, other pedagogical policies, such as frequent teacher feedback, the use of data to guide instruction, high-dosage tutoring, instructional time and high expectations, explain nearly half of the variation in school effectiveness.

The way PISA surveys are conducted conditions the way in which data is analysed. The use of plausible values is the most common feature when working with PISA data. As PISA applies two-stage sampling instead of simple random sampling, selected students attending the same school cannot be considered as independent observations. Students from the same school tend to share common characteristics (sharing same school resources, sharing same teachers, similar socio-economic background), and therefore the uncertainty associated with any population parameter estimate (e.g. mean, standard error) is greater for a two-stage sample than for simple random sample of the same size. As reporting accurate and unbiased standard errors is crucial, PISA experts have developed replication methods that allow for unbiased estimates, based on the methodology of Plausible Values (OECD 2009). Plausible values are described as a representation of the range of abilities that a student might reasonably have. Instead of directly estimating a student's ability $\phi$, a probability distribution for a student's $\phi$ is estimated (OECD 2009). That is, instead of obtaining a point estimate for $\phi$, a range of possible values for a student's $\phi$, with an associated probability for each of these values is estimated.

Plausible values have several methodological advantages when compared with other methods as Maximum Likelihood Estimates (MLEs) or weighted Maximum Likelihood Estimates. They provide unbiased estimations of population performance parameters, such as mean, standard deviation or variance decomposition. They also provide percentages of students per proficiency level and bivariate and multivariate indices of relations between performance and background variables (OECD 2009) as this information is included in the psychometric model used to validate PISA questions.

In general, five plausible values are assigned to each student, on each of the three tests. The estimation is performed independently in each of the five plausible values, and results should be aggregated to obtain the final estimates and standard errors. The plausible value methodology requires that each parameter has to be computed 405 times (i.e. 5 plausible values by one student final weights and 80 replicates), to obtain the final estimate of the parameter and its standard error.

In general, using one plausible value or five plausible values does not make a substantial difference when using large samples. It is, however, recommended to base the reported results on five plausible values, even on large samples. This guarantees consistency between results published by OECD with results on journals or national reports. All reported estimates in our paper use the plausible values methodology, providing unbiased estimators.

Following the work of Dobbie and Fryer (2012), we propose a baseline model including a basic specification where student performance in mathematics is the dependent variable, and economic, social and cultural status of students and schools, sex and age are included as independent variables. In the following specifications, we include a number of traditional and pedagogical factors, as follows:

$$P_i = \beta_1 ESCS_i + \beta_2 XESCS_i + \beta_3 Sex_i + \beta_4 Age_i + \Pi\theta_i + \Omega\delta_i + \varepsilon_i \quad (1)$$

Where $P_i$ represents the PISA 2012 score in mathematics for student i, $ESCS_i$ is the index of economic, social and cultural status for student *i* calculated by PISA, $XESCS_i$ is the average economic, social and cultural status at the school level, $Sex_i$ is a dummy variable for sex taking the value 1 for boys, $Age_i$ is the age of student I, $\Pi$ is a matrix containing the identified "traditional" variables (e.g. class size, share of certified teachers, school status), $\Omega$ is a matrix for "pedagogical" factors (e.g. additional hours, feedback from principal to teachers, tutoring), and $e_i$ is an error term. Standard errors are estimated using the Plausible Values (PV) methodology described above.[16]

[16] To correct for non-independence of errors, a Balanced Repeated Replication (BRR) approach is followed, using Fay's method. This method considers the full sample for estimating sampling variability in stratified samplings (such as PISA), being more efficient than other estimators (e.g. Huber-White).

# V. RESULTS AND ROBUSTNESS CHECKS

## Results

Table 3 summarises the results of the baseline model, including only variables based on individual characteristics and the environment (socioeconomic and cultural status of the school), for the three regions as well as for each of the eight Latin American countries. Results show a positive and statistically significant relationship between the socioeconomic status of the student and the performance in mathematics for all the countries. Similar results are found for the average socioeconomic status of the school.

An increase in one standard deviation of the socioeconomic status of the student[17] is associated with performance improvements of about 3% with respect to each region's average PISA performance (397 points for Latin America, 494 and 466 points for OECD and other countries, respectively). The gains are 17 points for OECD countries, 10 points for Latin America and 12 points for other countries.

When it comes to the average socioeconomic status of the school, an increase of one standard deviation is linked with some significant improvements in performance (nearly 15% in the three regions with respect to each region's average), highlighting the importance of the students' environment in their performance. Such performance gains correspond to an increase in 51 points in Latin America, 65 points in OECD countries and 64 points in other countries.

Regarding differences on performance by gender, the fact of being a boy has a positive and statistically significant association with performance in all countries, with a relatively higher effect in Latin America. The age of the student is also positively linked with performance, although it is not significant for all countries (e.g. Argentina, Chile).

Absolute results should be analysed with care, as the gap in average performance between Latin America and OECD countries is considerable. Indeed, the difference between the average performance in OECD and Latin America reaches 97 points, the equivalent of more than two years of schooling. Since absolute values of the coefficients are not directly comparable we compare the performance variation for the different models analysed. Thus, for a deeper understanding of the relationship between students' characteristics and socioeconomic environment with performance (these are the four explanatory variables of the baseline model), we use the coefficient of determination (R-squared) from simple regressions of the performance on these students' specific variables.

[17] The PISA index ESCS is built to have a mean of 0 and a standard deviation of 1 in OECD countries.

### Table 3. **Baseline model: The effect of students' characteristics and their environment on mathematics performance (PISA 2012)**

| Explanatory variables | Others | OECD | LatAm | ARG | BRA | CHL | COL | CRI | MEX | PER | URY |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Socioeconomic status of the student | **12.55 ***** | **18.53 ***** | **8.81 ***** | **8.37 ***** | **7.21 ***** | **8.41 ***** | **9.47 ***** | **8.99 ***** | **4.59 ***** | **9.01 ***** | **14.47 ***** |
| | (0.41) | (0.28) | (0.37) | (1.12) | (0.66) | (1.19) | (1.25) | (0.85) | (0.52) | (1.26) | (1.20) |
| Socioeconomic status of the school | **67.80 ***** | **72.39 ***** | **43.31 ***** | **49.80 ***** | **46.10 ***** | **47.24 ***** | **36.35 ***** | **34.54 ***** | **29.52 ***** | **49.63 ***** | **53.30 ***** |
| | (1.36) | (1.01) | (1.14) | (5.59) | (2.98) | (2.32) | (3.30) | (2.97) | (1.30) | (2.58) | (3.00) |
| Sex | **4.39 ***** | **13.64 ***** | **18.95 ***** | **15.43 ***** | **15.95 ***** | **24.74 ***** | **25.07 ***** | **21.14 ***** | **14.49 ***** | **22.17 ***** | **12.59 ***** |
| | (0.74) | (0.51) | (0.78) | (2.32) | (1.59) | (2.85) | (2.41) | (2.17) | (1.15) | (2.31) | (2.45) |
| Age | **11.07 ***** | **12.42 ***** | **10.45 ***** | 4.36 | **11.44 ***** | 2.97 | **14.07 ***** | **15.34 ***** | **10.27 ***** | **12.59 ***** | **12.60 ***** |
| | (1.22) | (0.78) | (1.22) | (4.07) | (2.48) | (3.50) | (3.53) | (3.70) | (2.70) | (3.80) | (3.63) |
| R squared | 23% | 26% | 30% | 28% | 29% | 36% | 26% | 31% | 18% | 38% | 34% |
| No. Countries | 23 | 34 | 8 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| No. Observations | 133,696 | 290,218 | 89,895 | 5,819 | 18,951 | 6,794 | 8,997 | 4,571 | 33,512 | 6,005 | 5,276 |

*Note:* * Statistically significant at the 10% level; ** statistically significant at the 5% level; *** statistically significant at the 1% level. Dependent variable is the performance in mathematics. Standard Errors shown in parentheses. Regressions are run for each country individually. Standard errors estimated with Balanced Repeated Replication (BRR), following Fay's method, to correct for non-independence of errors. The socioeconomic status of the student is the PISA index of social, cultural and economic status of the student (ESCS), the socioeconomic status of the school is the average of the social, cultural and economic statuses of the students enrolled in the school (XESCS), age is the age of the student in years, sex is a dummy variable that takes the value of 1 if the student is a boy and of 0 if she is a girl.

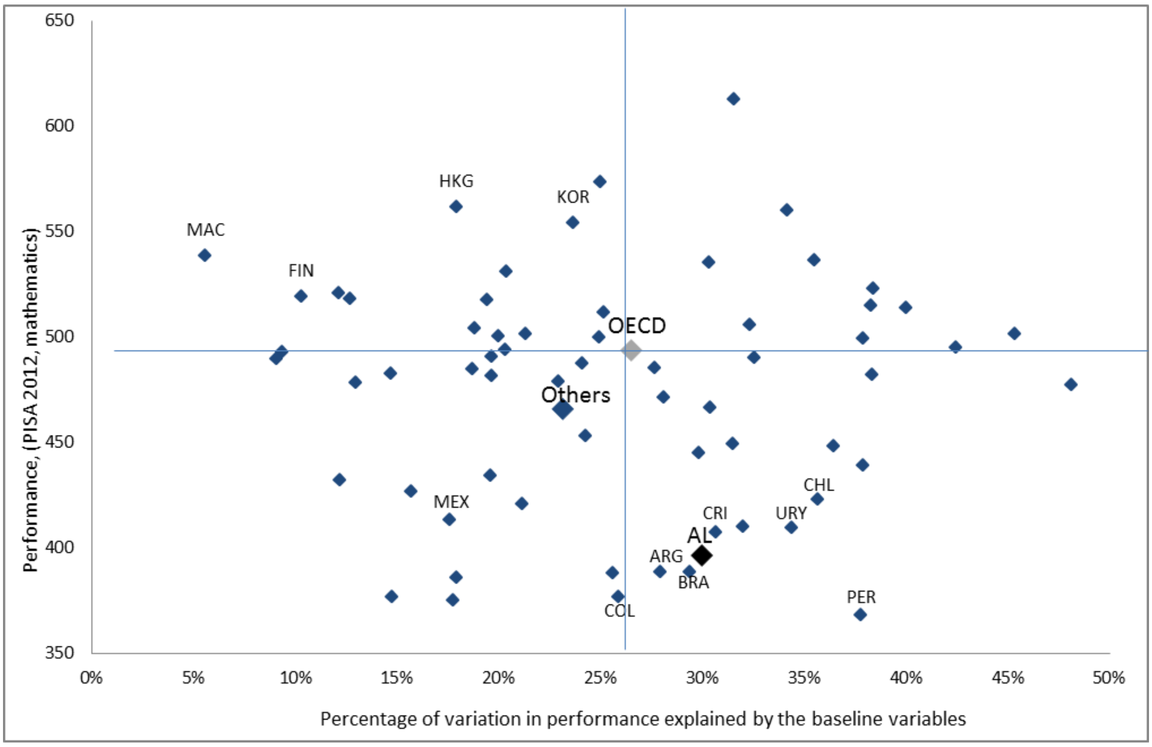
*Source:* Authors' calculations based on PISA database.

In PISA studies, the notion of equity in education is key to analyse to what extent students' socioeconomic backgrounds and environments are linked with performance. This concept of equity is approached through two main definitions: first, the score differential between students socioeconomically favoured and disfavoured, second, the percentage of variation in performance explained by the PISA index of social, economic and cultural status (ESCS). This second definition is based on the value of the R-squared resulting from a simple regression of the performance in mathematics on the socioeconomic status.

We analyse the variation in performance explained by our four variables that capture individual and households' characteristics (i.e. socioeconomic status of students and schools, age and gender) through the value of the R-squared obtained from the results of the regression shown in Table 3. Figure 3 puts students' performance in relation with the percentage of variation in performance explained by the four baseline variables.

Results show that the 4 student-level variables in the baseline specification have a relationship with performance. In Latin America, the percentage of variation in performance explained by the socioeconomic characteristics of the students (30%) is higher than in OECD countries (26%) and in other countries (23%). Only in Mexico this percentage is statistically significant lower than the average for OECD.

Figure 3. **Students' performance and variation in performance explained by students' characteristics and their environment**




*Note:* See Table 3 for the explanatory variables included in the baseline model.

*Source:* Authors' calculations.

Similar results are obtained when looking at the percentage of variation in performance explained by the economic, social and cultural status of students and schools. In OECD countries, the socioeconomic status of the student explains 15% of the variation in performance, against 18% for Latin America countries and 12% for other countries.[18] Similar results are found for the socioeconomic status of the school: once again, the variation in performance explained is higher in Latin America (27%) than in OECD (23%) and in other countries (21%).[19]

Such results suggest that, in Latin America, students' specific variables, and especially those related to socioeconomic background and socioeconomic environment of the school, explain a higher percentage of the performance variation than in the rest of the countries. In Chile, Peru and Uruguay, this link is particularly high, as social and economic characteristics explain 36%, 38% and 34% of the variation of the performance, respectively.

[18] In Chile, Uruguay and Peru, this percentage of the performance variation explained reaches 23%, higher than the region's average.

[19] Peru, Chile and Uruguay have again the highest rates (35% for Peru and 32% for Chile and Uruguay).

The presence of disrupting behaviours in school may also significantly affect the learning environment and process. For example, arriving late or skipping classes or days of school disrupt the learning environment for all other students and the teaching staff, and could contribute to a climate where academic proficiency is not valued. Teachers and school principals might found it particularly hard to ensure that students keep high levels of engagement, motivation and self-beliefs into their studies and value learning when many of the students' peers do not (OECD 2013, PISA Volume III). Such disturbing behaviours might be relevant for Latin America, where the percentages of students that arrived late in the two weeks prior to the PISA test (59% in Uruguay, 57% in Costa Rica, 53% in Peru and Chile) exceed the OECD average (35%). A similar pattern exists for skipping classes: whereas 25% of OECD students report having skipped classes or days at school, 66% of their Argentinian peers report so, 57% in Costa Rica. In order to control for this, we include a variable of skipping classes in our baseline model, based on students' answers on how many times they skipped some classes in the last two full weeks of school. Results show that skipping classes is statistically significant and negatively linked with performance, even after controlling for the socioeconomic characteristics of the students and his school. This is the case in the three regions, as well as in every Latin American country individually, except Costa Rica.

In order to include in this baseline model variables related to the education system and the management at the school, we differentiate between traditional and pedagogical variables related to the school.

Table 4 summarises the results of the traditional model – e.g. a model that includes, in addition to variables based on individual characteristics, traditional school inputs. Among these, we include both the size of the class and the square root of the size of the class, in order to analyse a possible non-linear relationship between class size and performance. Results for the 4 baseline variables do not change considerably, with the exception of age that becomes non-significant for Mexico.

On average, the size of the class is non-significant in Latin America (in Chile, Colombia, Costa Rica, Peru and the regional average). Conversely, in Argentina, Mexico, and in OECD and "Other" economies, the size of the class if positively associated with performance, with a downward slope. In these countries, bigger classes are linked with positive but decreasing marginal gains in performance. Finally, in Uruguay bigger classes are related to lower performance, with an increasing loss in the score. Class size can affect performance in various ways: while large classes may reduce the time and attention per students, or may be more prone to disturbances from noisy students, they may also favour peer interactions and learning. The result obtained for Argentina and Mexico, as well as for OECD and 'Other" economies seems to be in the direction of the latter.

There is a large existing literature on the linkages between class size and achievement. If the majority of studies conclude that there is very little or no significant impact of the size of the class on student performance (Cho, Glewwe, Whitler, 2010 and Chingos, 2010), some find a positive impact of having small classes (such as the STAR project), which are linked to the increased available time of teacher per student.[20] However, other studies find the reverse result (a positive impact of large classes), that can be associated to peer effects, but also to the fact that top performer countries (Asian countries) traditionally have larger classes (Pong et al., 2001). This last case could explain our results. On average, Asian schools are at the same time good performers and have bigger classes than other countries, particularly Japan and Korea. In the case of Latin America, class size in Peru (worst performer) is lower than in Chile (best performer). Furthermore, schools in urban areas (more than 3.000 inhabitants) are at the same time bigger and better performers that schools in rural areas in all 3 regions. This is particularly evident in Argentina and Mexico, where classes in urban zones are on average bigger (41 against 33 students in rural areas) and outperform rural schools by 0.7 years and 1.1 years of schooling respectively.

The relationship of student performance with teachers' national certification (proportion of certified teachers in Table 4) and with the proportion of teachers that have a high qualification (proportion of qualified teachers in Table 4) are not statistically significant in Latin America, once we control for the four explanatory variables of the baseline model. In Mexico, the coefficient of the proportion of certified teachers is even negative and statistically significant, suggesting that a higher proportion of fully certified teachers would be detrimental to performance. Such result could underline the low effectiveness of certification to guarantee a quality of education and teachers in Latin America. The same analysis can be made for the level of qualification in Peru, highlighting the fact that a higher share of certified or highly qualified teachers is not necessarily associated with higher quality. This result contrasts with the case of OECD countries, where certification has a positive relationship (significant at 10%) with performance;[21] on average, an increase of one standard deviation in the proportion of certified teachers (87% on average) results in a gain of 28 points, more than half a year of schooling.

In OECD and Latin America on average, the teachers' level of qualification does not seem to be associated with a better performance after controlling for the baseline variables. In "Other" economies, the relationship between qualification and performance is positive and statistically significant at 1%: an increase of one standard deviation in the proportion of highly qualified teachers (on average 80%) leads to an increase of 35 points (the equivalent of almost one year of schooling), after controlling for the student's specific variables and socioeconomic characteristics. Improving teachers' quality can be more effective on students' outcomes than trying to reduce the size of the class. The examples of Japan and Korea, which are among the top performers, are compelling. Both countries have relatively high levels of spending by educational institutions, which tend to prioritise teachers' salaries over class size (36 and 33 students, respectively) (OECD, 2012).

[20] The Student Teacher Achievement Ratio (STAR), conducted in the late 1980s, is considered as one of the most influential and credible study of class size reductions initiatives.

[21] In Latin America, only in Uruguay the certification process seems more efficient in providing quality and effective teachers, as the coefficient is positive and statistically significant at 10%.

## Table 4. **Traditional model: the effect of traditional variables on mathematics performance (PISA 2012)**

| Explanatory variables | Others | OECD | Latam | ARG | BRA | CHL | COL | CRI | MEX | PER | URY |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Socioeconomic status of the student | **12.46 ***** | **18.79 ***** | **8.93 ***** | **8.96 ***** | **8.25 ***** | **8.87 ***** | **8.48 ***** | **9.50 ***** | **4.56 ***** | **8.04 ***** | **14.12 ***** |
| | (0.41) | (0.33) | (0.49) | (1.35) | (0.83) | (1.23) | (1.42) | (1.18) | (0.72) | (1.73) | (1.25) |
| Socioeconomic status of the school | **65.69 ***** | **67.46 ***** | **40.11 ***** | **44.46 ***** | **35.63 ***** | **43.74 ***** | **32.93 ***** | **30.13 ***** | **31.85 ***** | **40.44 ***** | **57.24 ***** |
| | (1.80) | (1.40) | (1.86) | (4.61) | (4.57) | (3.40) | (4.76) | (7.51) | (2.43) | (5.28) | (4.92) |
| Sex | **4.80 ***** | **14.66 ***** | **19.77 ***** | **14.58 ***** | **17.80 ***** | **25.34 ***** | **23.44 ***** | **21.91 ***** | **16.04 ***** | **22.73 ***** | **14.38 ***** |
| | (0.76) | (0.57) | (1.06) | (3.00) | (1.71) | (3.01) | (2.85) | (2.85) | (1.46) | (3.55) | (2.42) |
| Age | **11.95 ***** | **10.46 ***** | **9.55 ***** | -0.31 | **10.26 ***** | 3.85 | **13.65 ***** | **15.22 ***** | 4.91 | **17.26 ***** | **12.28 ***** |
| | (1.28) | (0.90) | (1.61) | (4.43) | (2.48) | (3.62) | (4.29) | (5.29) | (3.68) | (4.62) | (3.63) |
| Class Size | **10.10 ***** | **3.90 **** | 0.16 | **5.36 **** | -3.44 | 0.64 | -3.22 | 4.68 | **3.07 **** | 1.70 | **-11.12 ***** |
| | (2.49) | (1.56) | (1.59) | (2.68) | (4.50) | (6.35) | (2.38) | (5.38) | (1.36) | (4.84) | (3.96) |
| Class Size ^(1/2) | **-72.85 ***** | **-29.41 *** | 1.91 | **-64.37 **** | 39.97 | -1.94 | 42.08 | -45.30 | **-31.37 *** | -5.93 | **120.21 ****** |
| | (22.66) | (15.12) | (17.48) | (32.12) | (53.46) | (72.91) | (28.47) | (56.88) | (16.06) | (49.96) | (42.79) |
| Proportion of certified teachers | 10.09 | **28.00 *** | -2.13 | -6.92 | | 3.62 | 8.13 | -27.78 | **-11.14 **** | -1.20 | **20.37 *** |
| | (8.54) | (15.22) | (4.71) | (10.34) | | (5.88) | (16.42) | (18.98) | (4.64) | (12.00) | (12.16) |
| Proportion of qualified teachers | **34.71 ***** | 19.20 | 8.28 | 10.85 | -5.43 | 4.29 | 5.80 | -5.22 | 4.59 | **-14.17 *** | 51.85 |
| | (7.66) | (22.51) | (7.64) | (12.18) | (11.16) | (10.33) | (16.45) | (17.81) | (6.24) | (7.82) | (43.80) |
| Private status of the school | -4.79 | **-4.99 ***** | 4.46 | **18.71 **** | **24.60 **** | 10.03 | **19.15 **** | 1.10 | -9.35 | 15.49 | **-23.92 ***** |
| | (3.34) | (1.70) | (3.54) | (7.50) | (7.66) | (6.58) | (8.18) | (15.48) | (5.99) | (9.65) | (8.90) |
| R squared | 27% | 28% | 31% | 29% | 29% | 37% | 28% | 32% | 19% | 37% | 36% |
| No. Countries | 21 | 30 | 7 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| No. Observations | 99,476 | 222,684 | 47,538 | 3,470 | 13,772 | 3,156 | 6,142 | 6,234 | 4,962 | 2,784 | 20,790 |

*Note:* * Statistically significant at the 10% level; ** statistically significant at the 5% level; *** statistically significant at the 1% level. Dependent variable is the performance in mathematics. Standard Errors shown in parentheses. Standard errors estimated with Balanced Repeated Replication (BRR), following Fay's method. As the variable proportion of certified teachers is missing for Brazil, the regression is run adding the 3 other variables to the baseline model; the values of the coefficients are thus not comparable with the other countries. Class size is the number of students enrolled in the class, the proportion of certified teachers is the proportion of teachers fully certified by the appropriate authority among the total number of teachers, the proportion of qualified teachers is the proportion of teachers that have an ISCED5A qualification among the total number of teachers, the private status of the school is a dummy variable that takes the value of 1 if the school is private and of 0 if the school is public.

*Source:* Authors' calculations based on PISA database.

In order to enrich the analysis of class size and quality of teachers, we included in the traditional model a variable measuring potential shortages in qualified mathematics teachers. Although results are not reported here, they seem to confirm our first conclusions. This variable comes from the directors' views on the extent to which a lack of qualified mathematics teachers hinders the capacity of the school to provide instruction. When included to the traditional model, this variable is statistically significant and negative in OECD countries on average and in Chile: higher levels of shortages in qualified mathematics teachers are linked with lower levels of performance. However, in "Other" economies and in the seven other Latin American countries included (as well as in the regional average), the relation is not significant. This reveals that in most Latin American countries, the number of teachers available and their qualifications do not explain performance variations when we control for students' characteristics.

Finally, private schools are negative and statistically significant at 1% linked with performance in OECD countries (the performance decreases by 5points), once we control for the explanatory variables of the baseline model. This suggests that the better performance of private schools (as seen in Table 2) is mainly due to a higher socioeconomic background and environment of students. In Latin America, the type of the school (private or public) is not statistically significant after controlling for the baseline variables. This is the case for Chile, Costa Rica, Mexico and Peru. Private schools in Uruguay are associated with lower performance after controlling for the baseline variables (private schools perform 25 points lower than public ones). In Argentina, Brazil and Colombia, private schools are still linked with better score results after controlling for the baseline variables (increases in 19, 25 and 19 points, respectively). However, these performance gaps are substantially higher before controlling for the baseline variables (62, 87 and 51 points, respectively).

How much more do traditional variables help explaining students' variation performance? The traditional model explains 31% of the performance variation in Latin America (against 30% for the baseline model alone), 28% in OECD countries (against 26%) and 27% in other countries (against 23%). Adding traditional variables does not substantially increase the explained performance variation in OECD and Latin America countries.

Table 5. **Traditional variables added one by one to the baseline model**

| Explanatory variables | Others | OECD | Latam | ARG | BRA | CHL | COL | CRI | MEX | PER | URY |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Class Size | 1.21 *** | 1.06 *** | 0.22 ** | 0.18 | -0.18 | 0.58 | -0.07 | -0.26 * | 0.52 *** | 0.65 *** | 0.37 |
| | (0.12) | (0.10) | (0.11) | (0.23) | (0.37) | (0.33) | (0.24) | (0.40) | (0.11) | (0.24) | (0.37) |
| R squared | 25% | 27% | 30% | 28% | 27% | 36% | 26% | 30% | 18% | 38% | 35% |
| No. Countries | 23 | 34 | 8 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| No. Observations | 124,700 | 278,102 | 87,044 | 5,745 | 16,956 | 6,727 | 8,897 | 4,512 | 33,068 | 5,981 | 5,158 |
| Class Size ^(1/2) | 11.86 *** | 10.46 *** | 2.51 *** | 1.76 | -1.81 | 6.42 | -0.51 | -3.07 | 5.91 *** | 6.45 ** | 4.93 |
| | (1.18) | (1.04) | (1.21) | (2.80) | (4.40) | (3.93) | (2.94) | (4.32) | (1.23) | (2.57) | (3.87) |
| R squared | 25% | 27% | 30% | 28% | 27% | 36% | 26% | 30% | 18% | 38% | 35% |
| No. Countries | 23 | 34 | 8 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| No. Observations | 126,451 | 278,102 | 87,044 | 5,745 | 16,956 | 6,727 | 8,897 | 4,512 | 33,068 | 5,981 | 5,158 |
| Proportion of certified teachers | 23.78 *** | 41.38 *** | -3.23 | -5.09 | | 2.1 | -1.74 | -23.85 * | -13.82 *** | -2.18 | 21.94 * |
| | (7.71) | (13.10) | (3.99) | (10.26) | | (6.52) | (14.87) | (12.63) | (4.06) | (9.95) | (11.76) |
| R squared | 23% | 27% | 30% | 28% | | 36% | 27% | 32% | 18% | 37% | 34% |
| No. Countries | 21 | 32 | 7 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 |
| No. Observations | 102,468 | 241,109 | 53,012 | 3,769 | 0 | 6,290 | 6,572 | 3,094 | 23,347 | 4,842 | 5,098 |
| Proportion of qualified teachers | 39.51 *** | 19.32 * | 2.7 | 26.84 * | -2.13 | 6.3 | 8.5 | -14.50 | 1.2 | -13.76 * | 9.0 |
| | 7.6 | (11.39) | (5.05) | (14.00) | (10.07) | (9.56) | (13.69) | (12.46) | (6.10) | (7.41) | (28.41) |
| R squared | 23% | 27% | 30% | 28% | 30% | 36% | 26% | 32% | 18% | 37% | 34% |
| No. Countries | 22 | 32 | 8 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| No. Observations | 113,654 | 245,424 | 70,780 | 3,814 | 15,173 | 6,290 | 8,014 | 3,075 | 25,758 | 3,482 | 5,174 |
| Private status of the school | -7.45 ** | -8.26 *** | 2.3 | 27.57 *** | 17.37 *** | 8.1 | 6.3 | 2.2 | -20.98 *** | 6.9 | -28.78 *** |
| | (3.15) | (1.59) | (2.65) | (8.26) | (6.45) | (6.22) | (7.74) | (10.37) | (4.13) | (6.10) | (8.89) |
| R squared | 26% | 27% | 30% | 30% | 30% | 37% | 26% | 31% | 18% | 37% | 35% |
| No. Countries | 23 | 34 | 8 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| No. Observations | 127,585 | 283,358 | 89,708 | 5,819 | 18,951 | 6,618 | 8,988 | 4,571 | 33,512 | 5,973 | 5,276 |

*Note:* * Statistically significant at the 10% level; ** statistically significant at the 5% level; *** statistically significant at the 1% level. Dependent variable is the performance in mathematics. Standard Errors shown in parentheses. Standard errors estimated with Balanced Repeated Replication (BRR), following Fay's method.

*Source:* Authors' calculations based on PISA database.

In order to analyse the additional variation of the performance linked with each of the four traditional variables, we ran the same model sequentially adding each variable, instead of including them all together (Table 5). Results show that the traditional variables that most improve the performance variation (R-squared in the regressions) are the size of the class (in OECD) and the type of the school (in other countries). Additionally, in "Other" and OECD countries, the four traditional variables are statistically significant associated with mathematics performance. This result contrasts with the case of Latin America, where only the size of the class has a statistically significant relationship with the student's performance, confirming the results shown in Table 4.

When adding the variable class size to the four baseline variables, the goodness of fit of the model is reduced in Latin America, Argentina, Brazil and Costa Rica,[22] implying that the explained variation of performance decreases compared to the baseline model. These results could be the consequence of a reduction in the number of available observations for each specification due to missing values. Similar discrepancies are found in the following specification (pedagogical model). In the robustness section, we provide new specifications that test the randomness of missing values, and thus the comparability of the results between our three models.

Table 6 summarises the results for the pedagogical model. This model includes 6 pedagogical variables described above into the baseline model, based on individual characteristics. As we obtain in the traditional model, results for the baseline variables do no change considerably with this new specification, with the exception that the variable age becomes non-significant for Chile, Colombia and Mexico.

For all three regions, there is a positive and statistically significant relationship at 1% between weekly instructional time in mathematics and student performance in this subject. On average, spending more time in class leads to a better score. This suggests that teachers and classrooms' environments are effective throughout the learning process. However, the relationship is not equal among regions: increasing the weekly class time in mathematics by 100 minutes will imply a performance gain of 9 points in OECD, 4 in Latin America and 13 in other countries. Similar relations are found in Mexico, Peru and Uruguay, where 100 additional minutes of class time per week are associated with increases of 5, 3 and 9 points respectively. For these three countries coefficients are statistically significant at 1%.

In order to complete the analysis about instruction time, we include a proxy of teacher effort during class time. If the quantity of the time of instruction is essential, as indicated in our results, its quality matters even more. Frequent teacher absenteeism may negatively impact students' engagement and performance, and tough disciplinary climates can significantly lower the "effective" learning time in class. The efficiency of the instructional time might be crucial for Latin America. To the question how frequent does the teacher has to wait a long time for students to quiet down, Argentina, Uruguay and Chile rank in the four last positions (among 65 countries). To control for the potential effect of inefficient time of instruction, we included a variable of teacher absenteeism, based on directors' opinions on what extent the learning of students is hindered by teacher absenteeism. According to this variable, the eight Latin American countries rank in the 20 worse countries among 65. When added to the qualitative model, this proxy for teacher effort is negative and statistically significant in México.

[22] The same analysis can be done for the proportion of certified teachers in Peru, the proportion of qualified teachers in other countries and Uruguay and the private status of the school in Peru.

## Table 6. **Pedagogical model: the effect of pedagogical variables on mathematics performance (PISA 2012)**

| Explanatory variables | Others | OECD | LatAm | ARG | BRA | CHL | COL | CRI | MEX | PER | URY |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Socioeconomic status of the student | **11.63 ***** | **18.09 ***** | **8.71 ***** | **7.98 ***** | **7.69 ***** | **8.15 ***** | **5.73 **** | **9.90 ***** | **5.14 ***** | **11.29 ***** | **13.84 ***** |
| | (0.92) | (0.49) | (0.68) | (1.92) | (1.61) | (1.93) | (2.70) | (1.77) | (1.32) | (2.12) | (1.72) |
| Socioeconomic status of the school | **60.37 ***** | **64.05 ***** | **38.29 ***** | **37.56 ***** | **44.44 ***** | **38.96 ***** | **39.07 ***** | **31.46 ***** | **22.42 ***** | **45.48 ***** | **46.94 ***** |
| | (3.66) | (1.56) | (1.67) | (5.28) | (7.05) | (3.71) | (5.00) | (4.48) | (3.07) | (4.67) | (3.42) |
| Sex | **7.09 ***** | **13.49 ***** | **21.42 ***** | **11.53 ***** | **20.91 ***** | **24.29 ***** | **36.36 ***** | **22.61 ***** | **16.84 ***** | **21.52 ***** | **17.32 ***** |
| | (1.47) | (0.82) | (1.3) | (3.17) | (3.68) | (3.12) | (6.03) | (3.14) | (2.47) | (3.64) | (3.08) |
| Age | **12.85 ***** | **12.33 ***** | **10.88 ***** | **10.40 *** | **8.41 *** | 5.73 | 7.99 | **20.10 ***** | 5.97 | **17.50 **** | **10.94 **** |
| | (2.27) | (1.29) | (2.31) | (5.35) | (4.88) | (5.61) | (10.77) | (5.69) | (5.70) | (7.33) | (4.67) |
| Instructional time in mathematics | **0.13 ***** | **0.09 ***** | **0.04 ***** | **0.10 ***** | -0.02 | -0.01 | 0.03 | 0.02 | **0.05 ***** | **0.03 **** | **0.09 ***** |
| | (0.01) | (0.01) | (0.01) | (0.01) | (0.02) | (0.01) | (0.02) | (0.05) | (0.01) | (0.01) | (0.02) |
| High expectations among students in mathematics | **12.25 ***** | **13.79 ***** | **5.56 *** | -3.83 | 0.94 | **25.76 ***** | -12.48 | 7.61 | 6.91 | 7.87 | 11.68 |
| | (3.84) | (2.68) | (3.03) | (6.42) | (5.60) | (8.76) | (14.57) | (9.54) | (4.96) | (6.47) | (8.34) |
| Use of data assessment in school monitoring | 0.21 | 0.09 | 1.03 | 3.14 | 0.12 | 3.12 | -0.25 | 1.81 | -0.51 | -0.44 | 1.24 |
| | (1.57) | (0.58) | (0.79) | (1.94) | (2.05) | (2.26) | (3.00) | (2.37) | (1.85) | (2.18) | (1.99) |
| Additional mathematics lessons offered by the school | -0.58 | -0.52 | 0.26 | **-13.05 **** | -4.37 | 0.43 | 6.83 | -9.28 | **17.79 ***** | 6.44 | -2.72 |
| | (4.20) | (1.63) | (2.08) | (5.29) | (5.67) | (5.25) | (8.88) | (5.66) | (4.70) | (4.99) | (5.61) |
| Feedback from the principal to the teacher | -0.50 | **-3.08 *** | **-5.53 *** | **-11.57 **** | -1.92 | -10.48 | -6.92 | -5.85 | **-14.14 ***** | 0.75 | 5.9 |
| | (2.48) | (1.76) | (2.10) | (4.65) | (5.09) | (6.43) | (9.64) | (5.70) | (4.42) | (5.13) | (4.61) |
| Out of school time additional classes in mathematics taken by the student | **-8.76 ***** | **-24.39 ***** | **-16.05 ***** | **-13.60 ***** | **-8.91 ***** | **-32.62 ***** | -4.25 | **-18.71 ***** | **-4.78 *** | **-10.68 ***** | **-34.90 ***** |
| | (1.46) | (1.08) | (1.47) | (4.62) | (3.30) | (4.20) | (5.52) | (4.97) | (2.54) | (3.52) | (3.87) |
| R squared | 30% | 29% | 32% | 31% | 26% | 39% | 31% | 33% | 20% | 42% | 38% |
| No. Countries | 23 | 34 | 8 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| No. Observations | 28,558 | 102,903 | 22,678 | 1,958 | 3,603 | 2,464 | 1,337 | 1,592 | 7,567 | 1,585 | 2,572 |

*Note:* * Statistically significant at the 10% level; ** statistically significant at the 5% level; *** statistically significant at the 1% level. Dependent variable is the performance in mathematics. Standard Errors shown in parentheses. Standard errors estimated with Balanced Repeated Replication (BRR), following Fay's method. The instructional time in mathematics is a PISA index (mmins) that gives the instructional weekly time in mathematics in minutes, the high expectations among students in mathematics is given by a dummy variable that takes the value of 1 (the value of 0) if the principal agrees or strongly agrees (disagrees or strongly disagrees) that there is a consensus among mathematics' teachers that academic achievement must be kept as high as possible, the use of data assessment in school monitoring is a PISA index (assess) reflecting to what extent students' assessments are used to monitor and inform the school and its students performance, the additional mathematics lessons offered by the school is measured by a dummy variable that takes the value 1 if the principal affirms that the school offers mathematics lessons in addition to the lessons offered during the usual school hours, and takes the value of 0 if not, the feedback from the principal to the teacher is calculated from a dummy variable that takes the value of 1 if the principal affirms to conduct informal observations in classroom once a month or more, and the value of 0 if it is less frequent and the out-of-school time additional classes in mathematics taken by the student is measured by a dummy variable that takes the value of 1 if the student spends 2 hours or more per week in out-of-school time additional classes in mathematics and the value of 0 if she spends less than 2 hours.

*Source:* Authors' calculations based on PISA database.

In addition to the time spent in class, the attitude of teachers, their beliefs and motivation to attain high academic achievement, seems to have considerable repercussions on performance. Mathematics teacher's expectations on students (high expectations among students in mathematics in Table 6) are positively and significantly linked with the score results in all three regions. This relation appears to be relatively stronger in OECD and other countries, where performance rises of respectively 14 and 12 points for an increase of one standard deviation in the variable high expectations among students in mathematics, against a performance gain of 5.5 points in Latin America. In Chile, the performance gain reaches 26 points, underlining the close relation between teachers' expectations, student motivation, self-confidence and performance. However, in the rest of the Latin America countries, the relation between the level of mathematics teachers' expectations and performance is not statistically significant.

For the three regions and the eight Latin American countries individually, the extent to which students' assessments are used to monitor the school's progress and curriculum (the use of data assessment in school monitoring) is not significant. Similar results are found for the variable additional mathematics lessons offered by the school (a proxy for the presence of tutoring groups), with the exception of Mexico (where an increase of one standard deviation involves a score differential of 18 points) and Argentina, (where tutoring is negatively linked with performance). This could be explained by the fact that, in Argentina, a higher proportion of low performing students report having access to tutoring groups in their schools (65% of low performing students against 44% of high performing ones, see Table 2).

The relationship between the feedback from the principal to the teacher and performance is statistically significant in OECD and Latin American on average. In Argentina and Mexico, this relationship is negative and significant at 5% and 1%, respectively. The negative and statistically significant relationship between feedback and performance might be due to selection bias. Indeed, in both countries (as well as in OECD and Latin America on average), principals from low-performing schools report to conduct more frequent feedback than principals from high-performing schools.[23]

The results of the latest Teaching and Learning International Survey (TALIS) by OECD, which focuses on teachers' practices among lower secondary schools in OECD countries, provide some supporting evidence about the potential effect of pedagogical inputs on the teaching profession. For example, when asked about the effect of class size on job satisfaction, teachers' response reveals that it is not the number of students in the class, but the type of students, which is more related to satisfaction and feelings of self-efficacy (OECD 2014). Regarding feedback from management, the results indicate that 46% of the teachers report never receiving feedback on their teaching from their school leader. However, the effect of feedback can be significant: in nearly all countries, when teachers perceive that appraisal and feedback lead to changes in their teaching practice, they report greater job satisfaction.

As well as in the case of feedback, the negative and statistically significant link between the out-of-school time additional classes in mathematics taken by the student and performance could be explained by the bias of low-performing schools. In particular, for the case of Latin American countries, low-performing students take more out-of-school time for additional classes in mathematics than their high performing peers. This negative link is less clear in OECD and other countries, where the proportion of low and high-performing students taking additional classes is almost the same.

[23] The relation is the same in Argentina and Mexico, but is not significant for the rest of the Latin American countries and for other countries on average.

Beyond the scope of this paper, one relevant policy when assessing performance enhancers in schooling is the degree of horizontal and vertical stratification.[24] PISA results show that the degree of school systems' vertical stratification tends to be negatively related to equity outcomes and social inclusion. Across OECD countries, 32% of the variation in the impact of students' socio-economic status on their mathematics performance is explained by the degree of vertical stratification, after accounting for per capita GDP. Grade repetition, a common form of vertical stratification still applied in many countries, is in general perceived as non-beneficial for learning and performance (Manacorda, 2012). On the contrary, horizontal stratification is less related to performance, although systems that group students for all classes based on their ability tend to have lower performance. Across Latin America countries participating in PISA, score differences between schools that group students by ability or not is small (3 points on average for the region). Even if differences by ability group are not important, horizontal stratification policies have changed in the region. Between 2003 and 2012, Brazil and Uruguay reduced the share of students attending schools with no ability grouping for any mathematics class. The effects of these policies are subject for future research.

Do pedagogical variables help explaining more of the performance variation? Figure 4 shows the effect, ceteris paribus, of a one standard-deviation change of each traditional and pedagogical variable on mathematics performance. In Latin America, only one traditional variable has a significant relationship with performance: the square root of the size of the class. As previously mentioned, this positive correlation may be the consequence of peer effects, especially for small classes, or to the fact that in our database, some top performing countries (Asian countries) have large classes, and at the same time urban classes are relatively larger than rural ones and outperform them. If traditional inputs do not seem to have a strong association with performance in Latin America, the effect is bigger in OECD countries, where three out of the four traditional variables have a significant relationship with performance. Regarding the pedagogical variables, four out of six have a significant relationship with student performance in Latin America and in OECD: the weekly instructional time, the culture of high expectations on students, the feedback given from the principal to the teachers and the additional extra-school time classes taken by the students.

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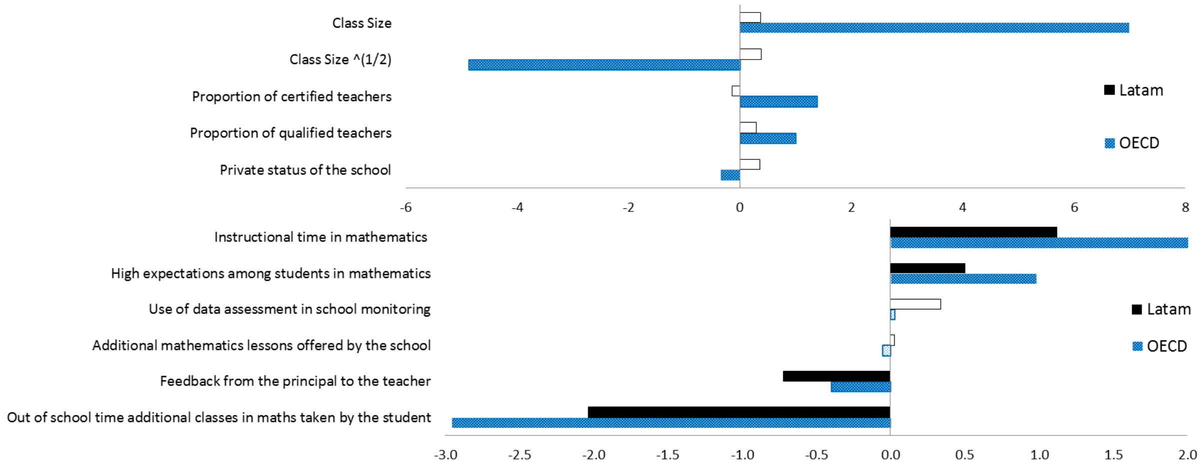
[24] Vertical stratification refers to the ways in which students' progress through school as they become older, while horizontal stratification refers to differences of programmes or instruction within a same grade.

Figure 4. **Effect on performance in mathematics: traditional and pedagogical variables (in months of schooling)**




*Note:* the bars indicate the effect in months of schooling on performance after a one standard-deviation change of each traditional and pedagogical variable. Solid bars (or striped with bold lines for OECD) show a statistically significant effect, whereas empty bars (or striped with thin lines for OECD) show a non-significant effect. See tables 4 and 6 for which countries are included in the regional averages.

*Source:* Authors' calculation based on PISA database.

Analysing the R-squared of both the traditional and pedagogical models indicates that including the six pedagogical variables to the four baseline variables moves the explained performance variation from 30% to 32% in Latin America, from 26% to 29% in OECD and from 23% to 30% in other countries. In Chile, Peru and Uruguay, the variation of the performance explained by the model is higher than the region's average, respectively at 39%, 42% and 38%.

For a better understanding of the additional performance variation driven by each pedagogical variable, we run the same model adding each pedagogical variable to the baseline model (Table 7). For all three regions, the variable that seems to explain the biggest additional variation of the performance is the out-of-school time additional classes in mathematics taken by the student, suggesting that out-of-school time additional classes taken by students is linked to performance.

## Table 7. **Pedagogical variables added one by one to the baseline model**

| Explanatory Variables | Others | OECD | Latam | ARG | BRA | CHL | COL | CRI | MEX | PER | URY |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Instructional time in mathematics | **0.14 ***** | **0.07 ***** | **0.03 ***** | **0.10 ***** | -0.01 | **-0.02 **** | **0.02 **** | -0.01 | **0.04 ***** | **0.04 ***** | **0.10 ***** |
| | (0.01) | (0.01) | (0.01) | (0.01) | (0.01) | (0.01) | (0.01) | (0.04) | (0.01) | (0.01) | (0.03) |
| R squared | 25% | 26% | 30% | 30% | 29% | 35% | 26% | 31% | 17% | 40% | 34% |
| No. Countries | 23 | 34 | 8 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| No. Observations | 78,768 | 176,026 | 48,485 | 2,329 | 9,610 | 3,727 | 4,669 | 2,713 | 20,210 | 2,288 | 2,939 |
| High expectations among students in mathematics | **9.00 ***** | **9.96 ***** | **5.62 **** | 3.52 | 3.77 | **20.12 ***** | -9.25 | 6.09 | 3.44 | 7.14 | 10.16 |
| | (2.48) | (1.84) | (2.38) | (6.92) | (3.85) | (6.60) | (9.44) | (8.54) | (3.87) | (5.26) | (7.16) |
| R squared | 23% | 27% | 30% | 27% | 29% | 37% | 26% | 31% | 18% | 38% | 35% |
| No. Countries | 23 | 34 | 8 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| No. Observations | 127,155 | 278,447 | 89,217 | 5,693 | 18,877 | 6,692 | 8,910 | 4,544 | 33,228 | 5,997 | 5,276 |
| Use of data assessment in school monitoring | 1.54 | 0.12 | **1.45 *** | 2.03 | 0.19 | **4.44 **** | 2.26 | 1.43 | -0.02 | -0.16 | 1.44 |
| | (1.51) | (0.58) | (0.78) | (2.13) | (1.69) | (2.18) | (3.35) | (2.30) | (1.68) | (1.95) | (1.92) |
| R squared | 24% | 27% | 30% | 27% | 27% | 34% | 26% | 29% | 19% | 40% | 36% |
| No. Countries | 23 | 34 | 8 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| No. Observations | 49,513 | 179,935 | 46,917 | 5,241 | 7,390 | 4,774 | 4,522 | 2,882 | 12,965 | 4,210 | 4,933 |
| Additional mathematics lessons offered by the school | -1.02 | **2.95 ***** | **3.55 **** | **-9.77 *** | -1.99 | **10.26 **** | 7.34 | **-8.70 *** | **17.47 ***** | 3.76 | 10.02 |
| | (1.88) | (1.09) | (1.68) | (5.82) | (3.42) | (4.98) | (4.61) | (4.88) | (2.89) | (4.11) | (6.27) |
| R squared | 24% | 27% | 30% | 28% | 30% | 36% | 26% | 31% | 19% | 38% | 35% |
| No. Countries | 23 | 34 | 8 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| No. Observations | 126,712 | 279,541 | 88,625 | 5,671 | 18,644 | 6,692 | 8,892 | 4,493 | 33,036 | 5,921 | 5,276 |
| Feedback from the principal to the teacher | -1.18 | **-3.84 ***** | **-4.11 **** | **-9.52 *** | -2.62 | **-9.73 *** | -5.34 | -6.52 | **-7.81 ***** | 3.21 | 5.43 |
| | (1.39) | (1.46) | (1.62) | (5.37) | (3.29) | (5.22) | (5.21) | (5.00) | (2.51) | (4.21) | (4.92) |
| R squared | 24% | 27% | 30% | 28% | 30% | 35% | 26% | 31% | 18% | 38% | 35% |
| No. Countries | 23 | 34 | 8 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| No. Observations | 126,247 | 274,992 | 88,894 | 5,646 | 18,749 | 6,612 | 8,927 | 4,504 | 33,204 | 5,976 | 5,276 |
| Out of school time additional classes in mathematics taken by the student | **-4.34 ***** | **-23.66 ***** | **-14.32 ***** | **-13.13 ***** | **-7.92 ***** | **-29.72 ***** | -3.62 | **-17.56 ***** | **-3.49 **** | **-4.84 **** | **-34.25 ***** |
| | (0.75) | (0.77) | (1.11) | (4.53) | (1.92) | (3.33) | (3.47) | (3.38) | (1.70) | (2.43) | (3.39) |
| R squared | 25% | 28% | 31% | 27% | 30% | 38% | 31% | 32% | 17% | 38% | 36% |
| No. Countries | 23 | 34 | 8 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| No. Observations | 86,314 | 188,794 | 54,790 | 3,684 | 11,790 | 4,425 | 3,404 | 2,802 | 21,772 | 3,727 | 3,186 |

*Note:* * Statistically significant at the 10% level; ** statistically significant at the 5% level; *** statistically significant at the 1% level. Dependent variable is the performance in mathematics. Standard Errors shown in parentheses. Standard errors estimated with Balanced Repeated Replication (BRR), following Fay's method.

*Source:* Authors' calculations based on PISA database.

Table 7 reinforces our result: in Latin America, some pedagogical inputs seem to have a higher association with performance than traditional ones. In the region, when we include the 6 pedagogical variables individually, all of them have a statistically significant relationship with performance. In contrast, only 1 (i.e. class size) out of the 4 traditional variables is significant when adding them individually (see Tables 5 and 7). This last result differs from the OECD countries, where other traditional variables, such as teachers' certification and the private status of the school are associated with student performance. Key aspects, such as better teachers' quality of education and better accountability in the certification process in OECD comparing with Latin American countries, should be behind these findings.

## Robustness checks

### *General regressions*

To test for the robustness of our results in the previous section, we specify a general regression with all observations, in the same line as the baseline model, introducing regional dummies. In order to capture the regional effects, we introduce a dummy for OECD and for

Latin American countries in different specifications, also including the economic, social and cultural status of the student (ESCS) and the school (XESCS). The model is specified as follows:

$$P_i = \beta_1 Reg\_dummy_i + \Phi\omega_i + Reg\_dummy\,\Phi\lambda_i + \varepsilon_i \quad (2)$$

where $P_i$ represents the PISA 2012 score in mathematics for student i, $Reg\_dummy$ is a dummy variable for students in OECD or Latin American countries, $\Phi$ is a matrix of baseline factors including the index of economic, social and cultural status for student i calculated by PISA ( $ESCS$ ), the average economic, social and cultural status at the school level ( $XESCS$ ), the age and the sex (as defined in the baseline model). We include in these specifications interaction terms between the regional dummies and the variables for socio-economic characteristics. Results are presented in Table 8.

Model 1 in Table 8 illustrates the magnitude of the gap in performance between OECD and non-OECD countries. On average, OECD students perform 66 points above their non-OECD counterparts. In contrast, Latin American students have a negative gap of nearly 80 points *vis-à-vis* other regions (model 2). After controlling for the student's socio-economic status (ESCS), and introducing an interaction term between the regional dummy and the ESCS, we observe that part of this effect is explained by the socio-economic status, in the same line as our results from the previous section. In the case of Latin America (model 4), the coefficient of determination (R-squared=0.28) is higher than for OECD countries (R-squared=0.25). In addition, the aggregate effect of the socio-economic status, this is, the coefficient of the variable plus the coefficient of the interaction term, show that the gradient of socio-economic characteristics in OECD is slightly higher in OECD countries (37.4) than in Latin America (25.6). As in the previous section, we attribute this effect to the fact that the average performance for Latin American students is lower than for OECD students.

Models 7 and 8 include the specification with the regional dummy and the variables in the baseline model of the previous section (student ESCS, school ESCS, gender and age). The results highlight the importance of the average economic social and cultural status of the school for both OECD and Latin America; an increase of one standard deviation in the school's socio-economic status would be associated with an average increase of 60 and 46 points for students' performance in each region. Interestingly, both sex and age are significant linked with student performance in this configuration. While the coefficients of gender for OECD and Latin America are similar, the interaction term (4.90 for OECD and 9.45 for Latin America) reveals a larger effect of gender in Latin America, in line with the results of the previous specification. Age, on the other hand seems to have a larger effect in the performance of OECD students (aggregate coeff.=14.93). An increase of one standard deviation of age (corresponding to 1.4 years) is associated with an increase of 22 points in the math test (half a year of schooling).

## Table 8. **Gap in performance: OECD and Latin American countries (regional dummies)**

| Explanatory Variables | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 | Model 6 | Model 7 | Model 8 |
|---|---|---|---|---|---|---|---|---|
| OECD dummy | **66.25 ***** | | **37.63 ***** | | | **23.39 ***** | **-297.44 ***** | |
| | (1.69) | | (1.67) | | | (1.70) | (33.51) | |
| LATAM dummy | | **-80.48 ***** | | **-69.37 ***** | | **-60.42 ***** | | **-85.32 ***** |
| | | (1.49) | | (1.71) | | (1.71) | | (31.27) |
| Socioeconomic status of the student | | | **30.82 ***** | **37.47 ***** | **33.10 ***** | **33.10 ***** | **9.63 ***** | **15.01 ***** |
| | | | (0.79) | (0.64) | (0.99) | (0.99) | (0.36) | (0.45) |
| Socioeconomic status of the school | | | | | | | **38.74 ***** | **37.47 ***** |
| | | | | | | | (1.38) | (1.14) |
| Sex | | | | | | | **7.86 ***** | **8.01 ***** |
| | | | | | | | (1.12) | (0.90) |
| Age | | | | | | | **-5.27 ***** | **3.92 ***** |
| | | | | | | | (1.51) | (1.38) |
| Socioeconomic status of the student * OECD | | | **6.63 ***** | | 1.04 | 1.04 | **6.53 ***** | |
| | | | (0.94) | | (0.99) | (0.99) | (0.69) | |
| Socioeconomic status of the student * LATAM | | | | **-11.87 ***** | **-8.18 ***** | **-8.18 ***** | | **-7.91 ***** |
| | | | | (1.05) | (1.07) | (1.07) | | (0.53) |
| Socioeconomic status of the school * OECD | | | | | | | **5.00 ***** | |
| | | | | | | | (1.93) | |
| Socioeconomic status of the school * LATAM | | | | | | | | 2.86 |
| | | | | | | | | (1.84) |
| Sex * OECD | | | | | | | **4.90 ***** | |
| | | | | | | | (1.55) | |
| Sex * LATAM | | | | | | | | **9.45 ***** |
| | | | | | | | | (1.26) |
| Age * OECD | | | | | | | **20.01 ***** | |
| | | | | | | | (2.12) | |
| Age * LATAM | | | | | | | | 1.84 |
| | | | | | | | | (1.99) |
| R squared | 10% | 10% | 25% | 28% | 29% | 29% | 31% | 33% |
| No. Observations | 485,490 | 485,490 | 473,648 | 473,648 | 473,648 | 473,648 | 473,533 | 473,533 |

*Note:* * Statistically significant at the 10% level; ** statistically significant at the 5% level; *** statistically significant at the 1% level. Dependent variable is the performance in mathematics. Standard Errors shown in parentheses. Standard errors estimated with Balanced Repeated Replication (BRR), following Fay's method. OECD and LATAM are regional dummies for OECD and Latin American countries, respectively. Regressions include 63 countries (34 OECD members, 8 Latin American countries and 24 Non-OECD Non-Latin America). Albania is excluded when the regression includes ESCS or XESCS.

*Source:* Authors' calculations based on PISA database.

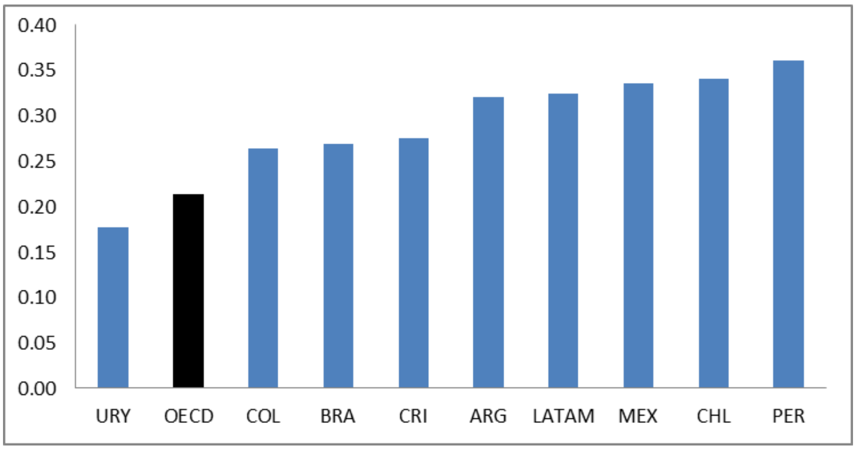
## *Other traditional inputs affecting students' performance*

The baseline model and following specifications stressed the importance of the socio-economic background (at the student and school) level for explaining differences in students' performance. Less clear is the connection between the physical endowments of the school and the performance. The existent evidence on the effect of infrastructure on educational outcomes is not conclusive. The question is important for Latin America, as disadvantaged schools in the region tend to lack resources, and therefore, before taking into account pedagogical policies as the ones studied in this paper, the effect of infrastructure and other educational resources should be addressed.

The PISA school questionnaire measure two indices of educational resources and physical infrastructure. The index of quality of school educational resources (scmatedu) is based on the self-evaluation of the school principal and provides a further measure of educational resources at school. It is based on six items: (i) the shortage or inadequacy of science laboratory equipment, (ii) shortage or inadequacy of instructional materials, (iii) shortage or inadequacy of computers for instruction, (iv) lack or inadequacy of internet connectivity, (v) shortage or inadequacy of computer software for instruction and (vi) shortage or inadequacy of library materials. The index of quality of physical infrastructure (scmatbui), also based on principal's perceptions, is constructed using three variables: school buildings and grounds, heating/cooling and lighting systems, and instructional space (e.g. classrooms). Higher values of these indexes indicate better quality of educational resources and infrastructure.

Figure 5 illustrates the relationship between the socio-economic status of students (ESCS) and the school's level of educational resources. Interestingly, for Latin American schools, the more advantaged schools tend to receive a larger share of resources, whereas OECD schools' educational resources are less correlated with socio-economic background. Figure 4 suggests that, in contrast to OECD countries, socio-economic background variables capture the effect of educational resources.

Figure 5. **Correlations between the quality of schools' educational material and students' socioeconomic status (ESCS)**




*Source:* Authors' calculations based on PISA 2012 database.

To analyse the effect of the quality of educational resources and of physical infrastructure, we modify the baseline regression and include both PISA indexes as possible explanatory factors of students' performance.

Results in Table 9 show that both indexes, educational and infrastructure are not significant in the baseline model. This goes in line with the correlation observed in Figure 5: the economic, social and cultural status index at the student and the school capture most of the effect of educational and infrastructure indices. This confirms our initial hypothesis, that socio-economic background, at least for Latin American schools, captures most of the effect in the model that school resources could have in performance.

Table 9. **Baseline Model including Educational and Infrastructure Indices**

| Explanatory variables | Others | OECD | LatAm | ARG | BRA | CHL | COL | CRI | MEX | PER | URY |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Socioeconomic status of the student | **12.97 ***** | **18.03 ***** | **9.96 ***** | **8.30 ***** | **7.15 ***** | **9.48 ***** | **8.96 ***** | **9.04 ***** | **14.49 ***** | **8.38 ***** | **4.61 ***** |
| | (0.39) | (0.29) | (0.52) | (1.10) | (0.67) | (1.24) | (0.85) | (1.27) | (1.20) | (1.21) | (0.52) |
| Socioeconomic status of the school | **64.16 ***** | **72.52 ***** | **68.92 ***** | **48.03 ***** | **43.47 ***** | **34.40 ***** | **29.91 ***** | **46.70 ***** | **49.66 ***** | **45.94 ***** | **27.12 ***** |
| | (1.39) | (1.08) | (2.18) | (6.46) | (3.12) | (3.59) | (3.34) | (2.87) | (3.53) | (2.68) | (1.58) |
| Sex | **4.55 ***** | **13.92 ***** | **18.77 ***** | **15.70 ***** | **15.83 ***** | **25.30 ***** | **21.12 ***** | **23.04 ***** | **12.22 ***** | **24.99 ***** | **14.42 ***** |
| | (0.72) | (0.53) | (0.99) | (2.36) | (1.61) | (2.43) | (2.21) | (2.36) | (2.44) | (2.87) | (1.15) |
| Age | **10.91 ***** | **11.87 ***** | **12.85 ***** | 4.69 | **11.54 ***** | 14.09 | 15.41 | 13.60 | 12.68 | **3.14 ***** | 9.51 |
| | (1.20) | (0.81) | (1.65) | (4.01) | (2.50) | (3.52) | (3.73) | (3.58) | (3.65) | (3.50) | (2.69) |
| School's quality of educational resources | 1.56 | 1.75 *** | 2.27 | -1.67 | 4.68 *** | 2.15 | 4.41 | 4.09 | -2.81 | 1.51 | 2.92 |
| | (0.90) | (0.59) | (1.25) | (2.77) | (1.95) | (2.63) | (2.55) | (2.16) | (2.32) | (2.73) | (1.53) |
| School's quality of physical infrastructures | -3.30 *** | -0.29 | 0.88 | 3.69 | -0.76 | 1.72 | 2.88 | -0.60 | **6.84 ***** | 1.44 | 0.88 |
| | (0.77) | (0.58) | (1.32) | (2.90) | (1.81) | (2.54) | (2.93) | (2.19) | (2.38) | (2.62) | (1.63) |
| R squared | 0.23 | 0.27 | 0.31 | 0.28 | 0.30 | 0.26 | 0.32 | 0.38 | 0.35 | 0.36 | 0.18 |
| No. Countries | 23 | 34 | 8 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| No. Observations | 126,722 | 274,446 | 89,240 | 5,778 | 18,793 | 6,620 | 8,934 | 4,558 | 33,339 | 5,942 | 5,276 |

*Note:* * Statistically significant at the 10% level; ** statistically significant at the 5% level; *** statistically significant at the 1% level. Dependent variable is the performance in mathematics. Standard Errors shown in parentheses. Standard errors estimated with Balanced Repeated Replication (BRR), following Fay's method. The school's quality of educational resources is a PISA index (scmatedu) based on the level of equipment, instructional materials, computers and internet connections and the school's quality of physical infrastructures is a PISA index (scmatbui) taking into account the school buildings and grounds, the heating/cooling and lighting systems, and the instructional space (e.g. classrooms).

*Source:* Authors' calculations based on PISA database.

## *A new specification without missing values*

In order to compare the results observed in the different specifications, we have assumed in our model that missing values are missing randomly. This section examines whether the results presented above are consistent in a restricted database with no missing values. To deal with the missing data across the data, we could follow a multiple-imputation approach. However, we opt for estimating the model in a restricted sample with no missing values and common to all three specifications.

Adding variables to the baseline model decreases the number of observations available in the different specifications. Table 10 shows the distribution of missing values in the PISA database. The four baseline variables are the most complete, whereas traditional and pedagogical variables have more missing values.

## Table 10. **Distribution of missing values per variable and country**

| Missing | OECD | LATAM | OTHERS | ARG | BRA | CHL | COL | CRI | MEX | PER | URY | Total | Total (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Socioeconomic status of the student | 1.0% | 0.4% | 2.1% | 0.8% | 0.5% | 1.0% | 0.4% | 0.4% | 0.3% | 0.3% | 0.7% | 12,142 | 3% |
| Socioeconomic status of the school | 0.0% | 0.0% | 1.6% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 5,012 | 1% |
| Sex | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0 | 0% |
| Age | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.1% | 0.0% | 0.0% | 202 | 0% |
| Class Size | 2.5% | 1.6% | 2.6% | 0.7% | 3.7% | 0.4% | 0.5% | 0.7% | 0.7% | 0.2% | 2.3% | 23,112 | 5% |
| Proportion of certified teachers | 10.1% | 20.2% | 10.8% | 18.8% | 35.2% | 5.2% | 13.3% | 17.3% | 15.5% | 9.9% | 3.4% | 119,205 | 25% |
| Proportion of qualified teachers | 9.3% | 10.4% | 6.9% | 18.4% | 7.0% | 5.2% | 5.4% | 17.5% | 11.8% | 21.5% | 1.9% | 86,070 | 18% |
| Private status of the school | 1.4% | 0.1% | 2.1% | 0.0% | 0.0% | 1.6% | 0.0% | 0.0% | 0.0% | 0.3% | 0.0% | 13,707 | 3% |
| Instructional time in mathematics | 23.9% | 22.8% | 19.7% | 32.1% | 17.5% | 34.4% | 23.8% | 21.8% | 20.5% | 31.9% | 44.9% | 218,821 | 45% |
| High expectations among students in mathematics | 2.5% | 0.4% | 2.2% | 1.2% | 0.1% | 0.8% | 0.5% | 0.3% | 0.4% | 0.1% | 0.0% | 19,513 | 4% |
| Use of data assessment in school monitoring | 22.6% | 23.4% | 29.9% | 5.3% | 21.5% | 22.1% | 24.4% | 19.6% | 31.3% | 15.3% | 6.6% | 244,087 | 50% |
| Additional mathematics lessons offered by the school | 2.2% | 0.7% | 2.4% | 1.4% | 0.6% | 0.8% | 0.6% | 0.9% | 0.7% | 0.7% | 0.0% | 19,395 | 4% |
| Feedback from the principal to the teacher | 3.2% | 0.6% | 2.6% | 1.6% | 0.4% | 1.7% | 0.4% | 0.8% | 0.5% | 0.2% | 0.0% | 24,291 | 5% |
| Out of school time additional classes in mathematics taken by the student | 21.2% | 19.4% | 17.0% | 19.8% | 13.5% | 26.7% | 30.7% | 20.7% | 18.1% | 19.6% | 40.2% | 191,689 | 39% |
| Total | 496,490 | 184,983 | 295,773 | 11,108 | 54,586 | 9,075 | 18,454 | 8,650 | 66,062 | 11,761 | 5,287 | | |

*Source:* Authors' calculations based on PISA database.

Tables 11, 12 and 13 present the results for the three specifications, using the exact same sample. Results for the baseline model do not change considerably when assuming no missing values. Again, the socio economic status of the student and the school are positively linked with performance, so as the fact of being a boy and the age, in all three regions. Taking each country individually, some coefficients become statistically non-significant when using the reduced sample (the socioeconomic status of the student for Colombia and the age for Colombia and Peru). In this sample, the variation of performance explained by the baseline model is slightly reduced, with the exception of Colombia, where the R-squared rises from 26% to 32%.

## Table 11. **Baseline model without missing values**

| Explanatory variables (same sample) | Others | OECD | Latam | ARG | BRA | CHL | COL | CRI | MEX | PER | URY |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Socioeconomic status of the student | **11.29 ***** | **18.09 ***** | **8.69 ***** | **9.54 ***** | **6.77 ***** | **8.56 ***** | 4.09 | **9.62 ***** | **5.38 ***** | **11.89 ***** | **13.67 ***** |
| | (1.07) | (0.59) | (0.83) | (2.25) | (1.72) | (2.07) | (3.42) | (2.43) | (1.67) | (2.89) | (1.84) |
| Socioeconomic status of the school | **65.64 ***** | **70.13 ***** | **40.01 ***** | **44.75 ***** | **44.61 ***** | **43.10 ***** | **44.40 ***** | **29.37 ***** | **25.32 ***** | **41.94 ***** | **46.56 ***** |
| | (3.57) | (1.84) | (1.92) | (5.05) | (7.82) | (3.56) | (7.11) | (5.97) | (3.64) | (4.87) | (3.56) |
| Sex | **5.21 ***** | **13.18 ***** | **21.10 ***** | **11.06 **** | **21.32 ***** | **25.05 ***** | **33.06 ***** | **23.11 ***** | **15.96 ***** | **22.18 ***** | **17.03 ***** |
| | (1.73) | (1.03) | (1.58) | (4.31) | (3.85) | (3.78) | (7.00) | (4.11) | (3.20) | (5.11) | (3.27) |
| Age | **15.50 ***** | **10.18 ***** | **11.99 ***** | 2.78 | **10.04 *** | 7.39 | 7.45 | **23.71 ***** | 8.38 | **23.62 **** | **12.56 **** |
| | (2.73) | (1.53) | (2.76) | (6.33) | (5.78) | (6.03) | (12.40) | (7.01) | (7.37) | (9.82) | (4.84) |
| R squared | 22% | 25% | 30% | 26% | 28% | 34% | 32% | 30% | 16% | 38% | 34% |
| No. Countries | 21 | 30 | 8 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| No. Observations | 23,138 | 82,529 | 13,345 | 1,242 | 3,053 | 2,272 | 852 | 984 | 4,682 | 873 | 2,440 |

*Note:* * Statistically significant at the 10% level; ** statistically significant at the 5% level; *** statistically significant at the 1% level. Dependent variable is the performance in mathematics. Standard Errors shown in parentheses.

*Source:* Authors' calculations based on PISA database.

The coefficients in the traditional model present some slight changes when compared to previous results. In the OECD group, the proportion of certified teachers becomes not significant, while this same variable, as well as the private status of the school, becomes significant in Latin America. Results for countries at the individual level show that only the socioeconomic status of the school and the sex remain significant for all regions and countries presented here. The goodness of fit of the model suggests that a reduced sample does not change the explained performance variation in Latin America, Brazil and Uruguay. This variation marginally rises in Colombia, Costa Rica and Peru, while it slightly decreases in OECD, other countries, Argentina, Chile and Mexico.

### Table 12. **Traditional model without missing values**

| Explanatory Variables | Others | OECD | Latam | ARG | BRA | CHL | COL | CRI | MEX | PER | URY |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Socioeconomic status of the student | **11.53 ***** | **18.00 ***** | **8.84 ***** | **9.40 ***** | **6.71 ***** | **8.54 ***** | 3.66 | **9.39 ***** | **5.27 ***** | **11.88 ***** | **13.71 ***** |
| | (0.98) | (0.60) | (0.92) | (2.25) | (1.68) | (2.07) | (3.48) | (2.43) | (1.66) | (2.88) | (1.83) |
| Socioeconomic status of the school | **70.88 ***** | **65.55 ***** | **34.72 ***** | **35.72 ***** | **39.39 ***** | **42.10 ***** | **34.69 ***** | **13.04 **** | **25.17 ***** | **36.23 ***** | **56.08 ***** |
| | (4.75) | (1.99) | (2.49) | (5.58) | (6.94) | (4.27) | (10.57) | (6.05) | (4.79) | (6.76) | (6.16) |
| Sex | **5.37 ***** | **14.12 ***** | **21.28 ***** | **10.07 **** | **21.70 ***** | **24.89 ***** | **34.21 ***** | **23.48 ***** | **16.53 ***** | **21.96 ***** | **17.81 ***** |
| | (1.72) | (0.96) | (1.73) | (4.26) | (3.71) | (3.72) | (7.11) | (4.15) | (3.20) | (5.06) | (3.27) |
| Age | **13.65 ***** | **9.62 ***** | **11.75 ***** | 3.06 | 8.37 | 7.41 | 8.02 | **21.17 ***** | 5.83 | **25.24 **** | **11.52 **** |
| | (2.51) | (1.54) | (3.01) | (5.90) | (5.75) | (6.01) | (12.45) | (6.87) | (6.73) | (10.09) | (4.90) |
| Class Size | **18.56 ***** | 2.27 | 1.20 | 3.17 | 2.28 | 2.96 | -4.50 | **10.99 **** | **4.01 **** | -3.30 | -4.92 |
| | (4.77) | (2.48) | (2.08) | (2.87) | (7.42) | (8.89) | (5.67) | (6.22) | (2.10) | (6.24) | (3.21) |
| Class Size ^(1/2) | **-159.71 ***** | -14.81 | -7.70 | -39.2 | -21.47 | -26.11 | 58.44 | -100.93 | **-41.95 *** | 43.4 | 52.5 |
| | (46.22) | (23.85) | (23.34) | (34.14) | (86.75) | (103.18) | (68.73) | (64.20) | (24.96) | (65.20) | (34.16) |
| Proportion of certified teachers | -9.52 | 14.09 | **-16.35 *** | -3.19 | | -10.17 | -67.96 | -38.41 | -1.59 | 2.61 | 4.27 |
| | (14.34) | (19.25) | (8.71) | (14.46) | | (9.70) | (49.09) | (24.8) | (7.89) | (12.28) | (13.12) |
| Proportion of qualified teachers | **38.87 **** | 22.06 | 13.21 | 19.09 | -25.60 | **21.92 **** | 2.16 | 18.05 | -8.55 | -1.77 | 41.56 |
| | (16.29) | (27.92) | (9.14) | (20.24) | (16.25) | (8.96) | (32.67) | (22.21) | (9.61) | (8.51) | (43.35) |
| Private status of the school | -2.03 | **-4.71 *** | **10.70 **** | **21.68 **** | 12.20 | 5.91 | 34.12 | **31.48 **** | 0.55 | 8.42 | **-27.23 **** |
| | (5.32) | (2.49) | (5.11) | (8.57) | (10.30) | (7.46) | (24.35) | (15.00) | (11.07) | (9.77) | (10.60) |
| R squared | 29% | 28% | 32% | 29% | 29% | 35% | 34% | 34% | 17% | 39% | 35% |
| No. Countries | 21 | 30 | 7 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| No. Observaciones | 23,138 | 82,529 | 13,345 | 1,242 | 3,053 | 2,272 | 852 | 984 | 4,682 | 873 | 2,440 |

*Note:* * Statistically significant at the 10% level; ** statistically significant at the 5% level; *** statistically significant at the 1% level. Dependent variable is the performance in mathematics. Standard Errors shown in parentheses.

*Source:* Authors' calculations based on PISA database.

Similar results are found for the pedagogical model: using the reduced sample alters the significance of some variables: the additional mathematics lessons offered by the school become statistically significant for "Others" countries and the feedback from the principal to the teacher not significant for OECD countries. In Brazil, the instructional time in mathematics becomes significant, while the reverse happens in Peru. Finally, the out-of-school time additional classes in mathematics taken by the student become not significant in Mexico. In Latin America, the explained performance variation increases from 32% to 33%. Similar results are found for Argentina, Brazil, Chile and Colombia, where the goodness of fit of the model increases slightly. In OECD and other countries, the R-squared do not change.

The minor changes resulting from using a reduced sample for all specifications suggest that missing values are randomly distributed among our database, and R-squared values are comparable between different specifications. This robustness check allows us to confirm our original result: the socioeconomic background and environment of the student have a positive and significant relationship with student performance, and this association is larger for Latin America (30%) than for OECD countries (25%). In comparison with some traditional factors such as the size of the class or the quality of the teachers, some pedagogical actions such as tutoring classes, the level of expectations on the students and the instructional time have a statistically significant relationship with the performance of the student

### Table 13. **Pedagogical model without missing values**

| Explanatory variables (same sample) | Others | OECD | Latam | ARG | BRA | CHL | COL | CRI | MEX | PER | URY |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Socioeconomic status of the student | **11.03 *** ** | **17.96 *** ** | **8.47 *** ** | **8.32 *** ** | **7.36 *** ** | **8.38 *** ** | 3.30 | **10.00 *** ** | **5.09 *** ** | **11.61 *** ** | **13.69 *** ** |
| | (1.04) | (0.58) | (0.83) | (2.15) | (1.66) | (1.95) | (3.51) | (2.43) | (1.70) | (2.97) | (1.78) |
| Socioeconomic status of the school | **59.40 *** ** | **64.66 *** ** | **38.34 *** ** | **41.16 *** ** | **45.22 *** ** | **38.46 *** ** | **44.60 *** ** | **27.19 *** ** | **22.05 *** ** | **42.10 *** ** | **45.92 *** ** |
| | (4.20) | (1.88) | (1.93) | (4.44) | (7.71) | (3.70) | (7.01) | (6.37) | (3.44) | (5.79) | (3.33) |
| Sex | **6.38 *** ** | **13.64 *** ** | **20.83 *** ** | **9.25 ** ** | **21.71 *** ** | **24.93 *** ** | **32.91 *** ** | **22.12 *** ** | **16.54 *** ** | **21.86 *** ** | **17.36 *** ** |
| | (1.60) | (0.96) | (1.56) | (4.25) | (3.94) | (3.20) | (6.91) | (4.27) | (3.08) | (5.21) | (3.09) |
| Age | **13.53 *** ** | **10.26 *** ** | **12.20 *** ** | 5.66 | **9.73 * ** | 7.15 | 8.26 | **26.44 *** ** | 4.68 | **24.45 ** ** | **11.21 ** ** |
| | (2.54) | (1.49) | (2.70) | (6.51) | (5.89) | (5.82) | (12.18) | (6.43) | (7.12) | (9.68) | (4.62) |
| Instructional time in mathematics | **0.13 *** ** | **0.09 *** ** | **0.03 *** ** | **0.10 *** ** | **-0.03 * ** | -0.01 | 0.03 | 0.04 | **0.04 *** ** | 0.03 | **0.08 *** ** |
| | (0.02) | (0.01) | (0.01) | (0.02) | (0.02) | (0.01) | (0.02) | (0.04) | (0.01) | (0.02) | (0.03) |
| High expectations among students in mathematics | **12.49 *** ** | **14.02 *** ** | **6.92 * ** | -1.25 | -1.36 | **29.26 *** ** | 5.63 | 7.37 | 9.16 | -3.22 | 9.75 |
| | (4.23) | (2.60) | (3.90) | (7.80) | (6.39) | (9.76) | (18.70) | (13.21) | (6.64) | (11.01) | (9.12) |
| Use of data assessment in school monitoring | -0.29 | 0.23 | 0.68 | 2.99 | -0.19 | 3.44 | -0.93 | 1.86 | -0.96 | -2.24 | 1.42 |
| | (1.78) | (0.70) | (1.00) | (2.50) | (2.22) | (2.63) | (3.87) | (3.07) | (2.62) | (3.27) | (2.04) |
| Additional mathematics lessons offered by the school | **-8.76 ** ** | -1.34 | 1.36 | **-16.47 ** ** | -1.11 | 1.37 | 13.47 | -5.21 | **19.10 *** ** | 1.63 | -1.92 |
| | (4.00) | (2.23) | (2.69) | (6.56) | (6.45) | (5.63) | (13.06) | (8.08) | (5.07) | (7.13) | (5.76) |
| Feedback from the principal to the teacher | 0.15 | -2.35 | **-4.49 * ** | **-10.33 * ** | -1.83 | -8.65 | -13.63 | 0.74 | **-10.20 * ** | 0.06 | 7.91 |
| | (2.88) | (1.65) | (2.60) | (5.41) | (5.98) | (6.87) | (12.72) | (7.04) | (5.70) | (7.20) | (4.91) |
| Out of school time additional classes in maths taken by the | **-8.48 *** ** | **-21.92 *** ** | **-16.69 *** ** | **-14.24 ** ** | **-9.00 ** ** | **-33.13 *** ** | -4.16 | **-20.80 *** ** | -2.39 | **-14.39 *** ** | **-35.40 *** ** |
| | (1.68) | (1.28) | (1.73) | (6.18) | (3.52) | (4.41) | (6.82) | (5.30) | (3.52) | (4.31) | (3.99) |
| R squared | 30% | 29% | 33% | 33% | 28% | 40% | 33% | 33% | 19% | 39% | 38% |
| No. Countries | 21 | 30 | 8 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| No. Observations | 23,138 | 82,529 | 13,345 | 1,242 | 3,053 | 2,272 | 852 | 984 | 4,682 | 873 | 2,440 |

*Note:* * Statistically significant at the 10% level; ** statistically significant at the 5% level; *** statistically significant at the 1% level. Dependent variable is the performance in mathematics. Standard Errors shown in parentheses.

*Source:* Authors' calculations based on PISA database.

## *Selection bias in additional classes taken by the student and feedback*

As suggested before, the negative links between the two variables feedback from principals to teachers and out-of-school time in additional classes taken by the student and performance may be due to selection bias. Indeed, in Latin America, low performing students take more out-of-school time additional classes than their high performing peers, and principals in low-performing schools in OECD and Latin America provide more feedback than their peers in high-performing schools (Table 1).

One way to assess the magnitude of the selection bias consists in estimating separate regressions of the pedagogical model for high performers (above 75th percentile in performance within the country) and low performers (below 25th percentile). Under the assumption of selection bias, the PISA performance should be unrelated or positively correlated to extra-curricular classes in the high performers' estimation, whereas the correlation should be negative in the low performers' sample. Results are presented in Table 14. We still find either a non-significant or a negative association between performance and additional classes.

To assess if the selection is explained by the socio-economic origin of students, we do the same exercise separating the sample between rich (ESCS above 75th percentile) and poor (below

25th percentile) students. Results (also in Table 14) suggest that the negative association between extra-curricular classes and performance is not explained by self-selection socio-economic background.

## Table 14. Pedagogical model by performance and socioeconomic groups: variables of feedback and out-of-school time additional classes

| Explanatory variables for High Performers (maths > p75) | ARG | BRA | CHL | CRI |
|---|---|---|---|---|
| Out of school time additional classes in maths taken by the student | -8.01 | -7.08 | **-12.80 **** | **-16.94 **** |
| | (7.62) | (4.71) | (5.17) | (7.33) |
| Feedback from the principal to the teacher | -9.16 | 4.77 | -6.21 | -3.84 |
| | (6.39) | (4.91) | (4.77) | (5.87) |

| Explanatory variables for Low Performers( maths < p25) | ARG | BRA | CHL | COL | CRI | MEX | PER | URY |
|---|---|---|---|---|---|---|---|---|
| Out of school time additional classes in maths taken by the student | 7.48 | -3.09 | -4.37 | -10.43 | -0.35 | 0.42 | 1.55 | -8.10 |
| | (8.41) | (5.63) | (6.16) | (9.09) | (6.10) | (3.66) | (7.24) | (5.84) |
| Feedback from the principal to the teacher | -3.21 | -0.63 | -0.46 | 4.05 | 6.53 | -4.32 | -8.81 | 4.71 |
| | (6.26) | (5.25) | (5.40) | (10.76) | (5.56) | (4.22) | (8.49) | (6.14) |

| Explanatory variables for Advantaged students (ESCS > p75) | ARG | BRA | CHL | CRI |
|---|---|---|---|---|
| Out of school time additional classes in maths taken by the student | **-25.04 ***** | **-20.27 ***** | **-31.20 ***** | **-29.38 ***** |
| | (8.36) | (5.67) | (6.07) | (9.89) |
| Feedback from the principal to the teacher | **-17.34 **** | -3.10 | **-23.99 ***** | -4.68 |
| | (7.37) | (8.70) | (7.99) | (8.17) |

| Explanatory variables for Disadvantaged students (ESCS < p25) | ARG | BRA | CHL | COL | CRI | MEX | PER | URY |
|---|---|---|---|---|---|---|---|---|
| Out of school time additional classes in maths taken by the student | -6.34 | -3.88 | **-25.57 ***** | -12.5 | **-20.65 ***** | -4.22 | **-21.69 **** | **-16.02 **** |
| | (9.12) | (5.52) | (6.90) | (11.63) | (7.49) | (4.88) | (8.59) | (8.87) |
| Feedback from the principal to the teacher | -2.83 | 9.89 | -10.56 | -0.62 | 0.52 | **-13.30 **** | -6.06 | 5.91 |
| | (8.30) | (7.68) | (8.42) | (22.54) | (9.74) | (7.31) | (12.62) | (7.07) |

*Note:* * Statistically significant at the 10% level; ** statistically significant at the 5% level; *** statistically significant at the 1% level. Dependent variable is the performance in mathematics. Standard Errors shown in parentheses.

*Source:* Authors' calculations based on PISA database.

# VI. CONCLUSIONS

Low students' performance results in the eight Latin American countries included in PISA 2012 highlight that improving the quality of education system is a key challenge for the region. Improving students' performance requires a clearer analysis of which factors directly affects it, and fiscal constraints in the region highlight the necessity to invest in a more efficient way.

The differential effect of traditionally collected measures of performance and "pedagogical" measures is particularly interesting for Latin America. We draw on the work of Dobbie and Fryer (2011), who study the strategies of 35 charter schools in New York. By exploiting the richness of PISA 2012 questionnaires for close to 450 000 students in 65 countries we study the correlation between a different set of proxy inputs of Dobbie and Fryer (2011) with students' performance in mathematics. The main results of this paper are the following. First, this research shows that students' characteristics and their environment explain close to 30% of the variation in performance for Latin America, a higher percentage than in OECD and other economies. Second, after controlling for students' characteristics and their environment, this paper shows that some non-traditional school inputs, such as the feedback provided by the principal to the teacher, weekly instructional time or the attitude and motivation of teachers are associated with students' performance, whereas some traditional inputs are not (e.g. teacher certifications and qualifications). These results are also confirmed by the different robustness checks performed in this paper.

These results provide some insights into education policies that could contribute to improve learning outcomes without requiring the large investments involved in reducing student-teacher ratios, increasing teacher qualifications or building more physical infrastructure. These findings suggest that some "pedagogical" initiatives can be cost-effective to boost students' performance in the region.

The analysis of school practices and policies on student performance is large and some areas go beyond the scope of our paper. Future research in this area can focus on the effects of horizontal and vertical stratification in performance, the effect of teacher effort on motivation and other performance-related factors, the incidence of violence in the context of effectiveness of school policies and a more thorough study on cost-efficiency for educational policies.

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