DECENTRALIZATION, TEACHER QUALITY AND EDUCATIONAL ATTAINMENT

EVIDENCE FROM OECD COUNTRIES.[1]

(PRELIMINARY VERSION)

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Abstract: Studies that empirically analyze the effects of education decentralization have focused on the analysis of the effects on educational outcomes. This study goes deeply into this question, by analyzing the effects of decentralization on teachers' quality and to which extent these effects explain decentralization effects on educational attainment. A cross-national database for 33 OECD countries is used in the analysis, with information for 10.872 schools and 294.155 students. The results show that the effects of decentralization on teacher quality are statistically and quantitatively significant. In addition, the indirect effects through teacher quality account for a significant part of the effect of decentralization on educational attainment, which range from a 7 to a 17 percent depending on the subject.

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1. Introduction

Fiscal federalism theory identifies a number of mechanisms via which decentralization may lead to improved levels of efficiency in the provision of public goods and services (Oates, 1972; Lockwood, 2002, 2005; Besley and Coate, 2003; Hindriks and Lockwood, 2005). However, empirical literature analyzing the relationship between decentralization and efficiency has tipically estimated reduced-form equations, in which the dependent variable was an indicator of the efficiency of the government or the outcome of an specific policy[2]. In the education sector, the general conclusion of the empirical literature based on this approach is that expenditure decentralization is positively related to educational attainment (Barankay and Lockwood, 2007; Falch and Fischer, 2012), and that it is more beneficial when subnational governments have a low fiscal deficit (Barankay and Lockwood, 2007; Galiani and Schargrodsky, 2001). Autonomy of subnational governments to make decisions in education and to raise their own revenues have also been shown to have a central role at determining the effects of decentralization on educational attainment (Salinas, 2013).

None of these studies have analyzed, though, the process through which decentralization might affect educational attainment or how it might affect to educational inputs. Thus, this study pretends to go deeply into the analysis of the effects of decentralization in the education sector, by focusing on one of the most relevant determinants of educational attainment in school: teacher quality. More specifically, the role of teacher quality in a decentralization process will be analyzed, i.e how it might be affected by decentralization and to what extent this effect explains decentralization effects on educational attainment. The effect of decentralization on teacher quality is a relevant question both for education and economic policy. On the one side, teacher quality has been demonstrated to be an important determinant of differences in achievement results (Hanushek and Rivkin, 2010; Harris and Sass, 2011). On the other side, the importance of teaching quality for the long run economic growth has also been outlined in the empirical literature (Hanushek and Kimko, 2000; Woessmann, 2002; Hanushek and Woessmann, 2007a, 2007b).

Given this evidence, the development of policies seeking to improve the quality of teachers and to ensure that all students receive quality teaching is on the agenda of OECD countries (OECD, 2004). Substantial policy initiatives are under way in a range of areas, including reforming initial teacher education and professional development, reforming teacher recruitment and supply or strengthening leadership in schools. Education decentralization policies, aimed to increase the autonomy of subnational governments, are also under way in several countries. Thus, improving

[2] To our knowledge, the unique attempts to empirically analyze a particular channel of the effects of decentralization are Faguet (2004) and Solé-Ollé and Esteller-Moré (2005), who focused on empirically testing the *preference-matching argument* of the fiscal federalism theory, by analyzing investment patterns and how they were affected by decentralization.

knowledge about how a decentralization process affects educational inputs and outcomes might help to predict its effects in different countries, and to design future decentralization processes.

Decentralization is liable to affect teacher quality in different ways. On the one side, subnational governments might have better information regarding students and schools' needs in their jurisdictions, which allow them to better match their education policies with these needs. In addition, government incentives to improve educational outcomes might be enhanced under a decentralized system. A direct effect of decentralization might be therefore improving teacher labor force quality by increasing the number of teachers with the desirable characteristics, in terms of qualification, abilities and motivation and their allocation to schools. Also policies aimed to improve teachers incentives might be enhanced under a decentralized system. On the other side, decentralization might not only affect government incentives to act in the best interest of their citizens as predicted by the fiscal federalism theory, but it also might improve schools and teachers' incentives to work harder and to use educational resources to maximize students' performance, since they are made more accountable both to the government who is responsible for managing the educational system and to parents, who can more effectively demand better education for he taxes they pay (Healey and Crouch, 2012; Winkler and Yeo, 2007).

However, these positive effects could be misled if the labor market where decentralized governments can hire teachers is smaller, and that makes more difficult to find "good" teachers (Darling-Hammond and Sykes, 2003), or if the shortened distance between policy-makers and schools make school based interests groups more influential, turning to an increase in the level of corruption in the education sector (Woessman, 2001). Corruption in the education sector can take different forms, such as the deviation of resources from effective uses to uses that benefit particular purposes (such as increasing salaries, hirings…) or teachers' absenteeism. Theoretical analysis does not allow therefore predicting how decentralization might affect teacher quality, and empirical analysis is necessary. Despite of the great importance of this question for policy making, to the best of our knowledge the relationship between decentralization and teacher quality has not been empirically analyzed.

In order to capture these effects, decentralization will be measured with the *education decision-making decentralization* variable, defined as the percentage of educational decisions which are made at the subnational level of government. Defining teacher quality is a more complex task, as the criteria for doing so might vary from person to person, from one community to another and from one era to another (National Research Council, 2001; Umansky, 2005). Today's, the most accepted way to define *teacher quality* is in terms of students learning. That is, a teacher is considered to be effective when there is evidence that his or her students have acquired adequate knowledge and skills. In this

study, *teacher quality* will be therefore defined in terms of the characteristics of teachers which are conductive to educational achievement[3].

Evidence regarding the characteristics of teachers and teaching practices which are relevant to explain differences in achievement results is, however, mixed. While some studies conclude that attributes such as teachers' experience, knowledge and certification have a significant effect on students' achievement (Clotfelter et al., 2007, 2010; Fuchs and Woessmann, 2007; Woessmann et al., 2007), other studies support the hypothesis that unobservable characteristics of teachers might have a greater effect on students' achievement (Hanushek et al., 2005; Rivkin et al., 2005). For instance, the ability of teachers to create and sustain an effective learning environment, their ability to communicate effectively, their sense of caring and responsibility for helping their students to learn and become good people or their dedication to the goals of teaching have been outlined from other branches of literature as important characteristics that a high quality teacher might have (Craig et al., 1998; Darling-Hammond, 2000).

In this study, we take advantage of the detailed information provided by PISA to define three different variables that allow capturing some of these dimensions of teacher quality. The first variable is *teacher's education,* which measures if teachers hold a masters' degree. The second variable is *teacher's certification*, which measures if teachers are certified by the competent authority. And the third variable, aimed to proxy the non-observable characteristics of teachers, is *disciplinary climate*, which provides information on disciplinary climate in the classroom, and therefore it will be the result of the ability and incentives of teachers to create and sustain an effective learning environment in class. This information is available for 10.872 schools, belonging to 33 OECD countries (France is the only OECD country which was excluded from the dataset, because of missing data).

The main conclusions that come from this analysis are that decision-making decentralization has a positive and significant effect on the three variables of teacher quality. Thus, the predicted difference between a country with a low level of decentralization and a country with a high level of decentralization is around three and eight percentage points for teacher's education and certification, respectively; and 20 percent of an international standard deviation for disciplinary climate. These effects of decentralization on teacher quality might account for a significant part of the effect of decentralization on educational outcomes, which range from a 7,5% in math's to a 16,7% in reading. The proportion of the total effect of decentralization on educational outcomes explained by the indirect effect through teacher quality is even higher if decentralization is measured through the expenditure decentralization variable.

[3] Measuring teachers' quality in terms of their students learning requires very detailed datasets, with students matched to their teachers and repeated observations for each. This kind of dataset is only available for certain regions or cities in the United States, and therefore it is not possible to use this kind of measure to analyze the effects of decentralization.

Following on from this introduction, the rest of the paper is organized as follows. Section 2 provides the rationale for the analysis, describing why is teachers' quality an important factor of the education process and how it can be affected by decentralization. Section 3 describes the econometric specification that we use in the analysis, and discusses the main methodological questions of the analysis. Section 4 describes the data used in the analysis. Section 5 presents the empirical findings of the analysis. Section 6 summarizes and presents the conclusions that can be derived from the analysis.

2. Educational attainment, teacher quality and decentralization

2.1. Teacher quality and educational attainment

The objective of this study is analyzing the role of teacher quality in a decentralization process, i.e. how it might be affected by decentralization and to what extent this effect explains decentralization effects on educational attainment. In this section, the literature analyzing the importance of teacher quality for educational achievement will be reviewed, in order to determine the characteristics of teachers that might be relevant to define teacher quality. Today's, the most accepted way to define *teacher quality* is in terms of students learning, i.e. a teacher is considered to be effective when there is evidence that his or her students have acquired adequate knowledge and skills. However, the identification of teachers effects on students achievement requires very detailed datasets, which are hardly available for most countries. In this study *teacher quality* will be therefore defined in terms of the characteristics of teachers which are conductive to educational achievement[4].

Teaching quality has received considerable attention in the economics of education literature since the Coleman Report was published in 1966. This report, which concluded that differences in students' performance had little to do with differences in school resources (including teachers' characteristics), provoked lots of critiques and debate, and it was the impetus for several empirical studies about the relationship between teaching quality and educational outcomes. Nowadays, researchers agree about the great importance of teacher quality at explaining differences in achievement results, but the debate about which characteristics of teachers are relevant for teacher quality is still open. The reason for such debate is that the identification of the effect of teachers' characteristics on students' achievement presents some empirical problems which are difficult to overcome with.

The main concern comes from the fact that teachers with stronger qualifications might be matched in some systematic way with students exhibiting characteristics that are not fully controlled for in the model (Krueger, 2003; Todd and Wolpin, 2003). For example, students with family background

[4] It is important to distinguish teacher quality from teaching quality, which not only depends on teachers' quality, but also on the level of instructional resources available, staffing levels, support from administrators and parents, etc. If schools are not well organized and supportive, and they do not have the necessary educational resources, it is possible that even good teachers will not be successful.

and other factors conducive to higher achievement tend to seek out better schools with higher quality teachers. In addition, administrative decisions regarding teacher and student classroom assignments may amplify or dampen the correlations introduced by such family choices. Another source of correlation between teacher quality and student performance results from the matching of teachers with schools. Teacher preferences for schools with non-poor students or students with a higher level of achievement, potentially introduce a positive correlation between teacher quality and family contribution to learning (Hanushek et al., 2004)[5]. Early empirical evidence, which did not control for such endogeneity problems, concluded that teaching quality had little to do with differences in students' performance (Hanushek, 1986, 1989).

More recent literature tried to overcome the endogeneity problems generated by the non-random assignment of students to teachers through the value-added specification of the education production function, which controls for the lagged student achievement (Hanushek, 2003). In general terms, this literature tries to identify teacher's effectiveness, or teacher quality, on the basis of teachers' performance in obtaining gains in student achievement. Including the lagged student achievement in the education production function is supposed to control for all historical inputs and innate abilities of the student, and therefore to eliminate selection problem biases. In addition, the availability of detailed datasets for the United States during the last decade, allowed researchers to improve such value-added empirical analyses, by including also schools' fixed effects. When longitudinal data (Rivkin et al., 2005; Clotfelter et al., 2007) or data about achievement in different subjects (Clotfelter et al., 2010; Metzler and Woessmann, 2012) is available they also include students fixed effects in their regression equations, to avoid the biasing effects of the non-random sorting of students to teachers within schools[6]. Some of these studies also included teachers' fixed effects (Hanushek et al., 2005, Rockoff, 2004). Table 1 summarizes the main contributions of this branch of the literature.

[5] Teachers' and students assignment to school practices in each country will determine this relationship. Evidence for the United States suggest that teachers with stronger qualifications are matched to students who are educationally more advantaged along dimensions that are hard to control for, and that most of this positive matching occurs at the school rather that the classroom level (Clotfelter et al., 2006). Thus, the coefficients of the teacher variables when non-random selection is not had into account would be upward biased.

[6] School fixed effects allow estimating teacher quality on the basis of within-school heterogeneity, and therefore estimated coefficients are not affected by how teachers or students are distributed across schools. However, they do not avoid the biasing effect of non-random sorting of students and teachers within schools. Instead, students' fixed effects do so. This approach, which requires the availability of longitudinal data or information about achievement in different subjects, eliminates many of the statistical problems that arise with the non-random matching of teachers and students.

Table 1. Evidence on teacher quality effects on students' achievement. Value added analyses.

Reference	Methodology	Teacher quality measures	Subjects	Level	Data	Conclusions
Rockoff, 2004	Value-added with student, teacher and school-year FE (1 step procedure)	Teaching experience	Maths, Reading	Grades 1 to 6	New Jersey	Teaching experience significantly raises student test scores, particularly in reading subject areas.
Hanushek et al., 2005	Value-added with student and teacher fixed effects (1 step procedure)	Teaching experience, master's degree, certification	Maths	Grades 4 to 8	Texas	Teacher quality appears to be unrelated to advanced degrees or certification, but experience does matter in the first year of teaching.
Rivkin et al., 2005	Value-added with student, school-grade and school-year FE (1 step procedure)	Teaching experience, advanced degrees	Maths, Reading	Grades 3 to 7	Texas	Experience is not significantly related to avhievement following the initial years in the profession, and there is no evidence that a master's degree raises teacher effectiveness.
Aaronson et al., 2007	Value-added with teacher and school FE (2-steps procedure)	Advanced degrees, certification	Maths	Grade 9	Chicago	These human capital measures are not related to teacher quality.
Clotfelter et al., 2007	Value-added with student or school FE (1 step procedure)	Teaching experience, test scores, advanced degrees, licensure, certification	Maths, Reading	Grades 3 to 5	North Carolina, 1995-2004	Teaching experience, test scores, licensure and certification all have positive effects on student achievement, with larger effects for math than for reading. Holding a master's degree is negative or non significant.
Kane et al., 2008	Value-added with covariates (1 step procedure)	Certification	Maths, Reading	Grades 4 to 8	New York city	The certification status of a teacher has at most small impacts on students performance.
Clotfelter et al., 2010	Value-added with student or school FE (1 step procedure)	Teaching experience, type of licensure, licensure test score	Several subjects	Grade 9 or 10	North Carolina, 1999-2003	Teacher credentials affect student achievement in systematic ways and the magnitudes are large enough to be policy relevant.
Harris and Sass, 2011	Value-added with student, teacher and school FE (1 step procedure)	Teaching experience, professional training	Maths, Reading	Grades 3 to 10	Florida, 1999-2003	Experience enhances the productivity of both elementary and middle school teachers, but not high school teachers. The bulk of the experience effects occur over the first few years of job, but there are still marginal effects even after 10 years. Professional training is associated with no change or a reduction in teacher productivity.
Metzler and Woessmann, 2012	Value-added with student FE	Test scores	Maths, Reading	Grade 6	Perú, 2004	Teacher subject knowledge exerts a statistically and quantitatively significant impact on student achievement.
Wiswall, 2013	Non-parametric specification (2-steps procedure)	Teaching experience	Maths, Reading	Grades 3 to 5	North Carolina, 1996-2005	Experience has a substantial and statistically significant impact on maths students achievement, even beyond the first years of teaching. For reading a small positive return to teacher experience is found for the first few years.

Source: own made

The general conclusion of these studies is that differences among teachers' effectiveness are quite significant (Hanushek and Rivkin, 2010), although they disagree about how much of this variation is explained by the observable characteristics of teachers. The characteristics of teachers which have received more attention in this literature, because of their importance for teacher policy, are teaching experience, education and certification, the results being mixed. While some studies conclude that experience is not significantly related to achievement following the initial years in the profession (Hanushek et al., 2005; Rivkin et al., 2005), others conclude that the returns to experience are quantitatively significant, even after the first few years of teaching (Clotfelter et al., 2007, 2010; Harris and Sass, 2011; Wiswall, 2013). Conclusions about how teachers' qualification is related to students' achievement vary widely depending on the specific used measure. For example, teacher subject knowledge measured thought test scores have been found to exert a statistically and quantitatively significant impact on student achievement (Metzler and Woessmann, 2012). Instead,

attainment of advanced degrees is found not significant to improve teacher productivity (Rivkin et al., 2005; Hanushek et al., 2005; Aaranson et al., 2007), or even to have negative effects (Clotfelter et al., 2007). In-service professional development is found to have mixed effects on educational attainment, depending on the grade level and the subject (Harris and Sass, 2011). Finally, the results are also mixed for having a certification (Hanushek et al., 2005; Clotfelter et al., 2007; Kane et al., 2008).

The disadvantage of these studies is that they are based on the empirical evidence of certain states, districts or cities in the United States, with the only exception of Metzler and Woessmann (2012), which is based on the empirical evidence of Perú. To the extent that teachers' quality effect on educational attainment depend on the region's characteristics or their institutional settings, their results might not be extrapolable to other contexts. In addition, value-added models are subject to various statistical concerns that could lead to upward or downward estimates of teachers' quality effects (Todd and Wolpin, 2003; Rothstein, 2010; Koedel and Betts, 2011), and which would be exacerbated when longitudinal data is not available.

Table 2. Evidence on teacher quality effects on students' achievement. Contemporaneous specification analyses.

Reference	Methodology	Teacher quality measures	Subjects	Level	Data	Conclusions
Woessmann, 2003	Contemporaneous specification	Teaching experience, master's degree	Maths, Science	Grades 7 and 8	TIMSS 1995	Teaching experience and having a master's degree is positively related to student performance.
Clotfelter et al., 2006	Contemporaneous specification with school fixed effects	Teaching experience, test scores, master's degree, certification	Maths, Reading	Grade 5	North Carolina State	Statistically significantly positive effects for teaching experience (both in maths and reading), teacher test scores (most clearly in maths) and National Board Certification (for reading only). TNegative effect of a master's degree on student achievement.
Fuchs and Woessmann, 2007	Contemporaneous specification	Master's degree, certification	Maths, Science, Reading	15 years old students	PISA 2000	The master's in pedagogy yields positive effects for science and reading, and a master in the specific subject and certification yield positive effects for the three subjects.
Woessmann et al., 2007	Contemporaneous specification	Master's degree, certification	Maths, Science	15 years old students	PISA 2003	The master's in pedagogy and certification yield positive effects on student achievement.

Source: own made

Note: TIMSS administered the test to those students enrolled in the two adjacent grades that contained the largest proportion of 13 years-old students at the time of testing (grades 7 and 8 in most countries)

An alternative method to analyze the effects of teacher quality on students' achievement is based on a contemporaneous specification of the education production. This method was the most used one in early studies (Hanushek, 1986) and it is also used in recent studies which are based on international student achievement survey data (Woessmann, 2003; Fuchs and Woessmann, 2007). Studies based on international achievement survey data have the advantage that they allow to conduct cross-national analyses, controlling for a wide set of country characteristics and institutional settings. In addition, an extended set of school, teacher and student-level variables can be included in the analysis, what is supposed to ameliorate omitted variables bias (Clotfelter et al.,

2006)[7]. Although teachers' quality has not received as much attention in this branch of the literature, the general conclusion is that the effect of teacher's education on students' educational attainment is positive and significant (Table 2).

Therefore, the evidence regarding the characteristics of teachers which are relevant to explain differences in achievement results continues being mixed. While some studies conclude that attributes such as teachers' experience, knowledge and certification have a significant effect on students' achievement (Clotfelter et al., 2007, 2010; Fuchs and Woessmann, 2007; Woessmann et al., 2007), other studies support the hypothesis that unobservable characteristics of teachers might have a greater effect on students' achievement (Hanushek et al., 2005; Rivkin et al., 2005). For instance, the ability of teachers to create and sustain an effective learning environment, their ability to communicate effectively, their sense of caring and responsibility for helping their students to learn and become good people or their dedication to the goals of teaching have been outlined from other branches of literature as important characteristics that a high quality teacher might have (Craig et al., 1998; Darling-Hammond, 2000). Obviously, some of these characteristics are difficult to measure and therefore only a few studies have attempted to include them in their analyses of students learning. Instead, researchers tend to use measures that are proxies of these non-observable characteristics, such as parent-teacher conferences, assignment of homework or teacher school attendance to measure teachers' effort (Swada, 2000; Glewwe et al., 2010).

In this study, we take advantage of the detailed information provided by PISA to define three different variables for teacher quality. The first variable is *teacher's education,* which measures the percentage of teachers in school that hold a masters' degree. The second variable is *teacher's certification*, which measures the percentage of teachers in school that are certified by the competent authority. Obtaining a certificate generally means that a teacher has been prepared in an accredited teacher education programme. In some countries it might also imply that teachers have passed a national teacher examination or has acquired short teacher experience. The third variable, aimed to proxy the non-observable characteristics of teachers, is *disciplinary climate*, which provides information on disciplinary climate in the classroom, and therefore it will be the result of the ability or incentives of teachers to create and sustain an effective learning environment in class. These different dimensions of teacher quality are liable to be affected by decentralization in different ways, which are analyzed in the next section.

2.2. Decentralization and teacher quality

Fiscal federalism theory identifies a number of mechanisms via which decentralization may lead to improved levels of efficiency in the provision of public goods and services, both in terms of

[7] Clotfelter et al. (2006) also included school fixed effects to deal with the non-random sorting of students and teachers between schools The disadvantage is that adding school fixed effects to a contemporaneous specification only the effect of variables measured at the student level can be identified.

allocative and productive efficiency[8]. Thus, it has been claimed that subnational governments have a better knowledge of their population's preferences and needs than the central government (Oates, 1972) so that, in the absence of economies of scale and externalities, decentralization can ensure a better match between political decisions and local preferences (*preference-matching argument*). For instance, subnational governments will be better informed about whether schools have a teachers' shortage in specific fields, like special education, computer sciences or foreign languages, or about which schools need better-trained teachers to offset the worse conditions that low income, disabled, language minority and other vulnerable students may face. Evidence for the OECD countries suggests that students in disadvantaged areas find themselves in classes with the least experienced and least qualified teachers (OECD, 2004), because of attrition from the profession and the movement of teachers to other schools. Decentralization is supposed to help to improve this situation.

However, the better information that subnational governments might have regarding their school's needs will only mean an improvement in teacher quality and the allocation of teachers under certain circumstances. First, subnational governments need to have the responsibility to decide on the different factors that will determine the allocation of teachers to schools and their decision to enter and stay in the profession. Factors that have been outlined to be important determinants of teacher quality and the distribution of teachers among schools include *working conditions*, such as the availability of administrative support and educational resources, class sizes, teaching load or safety; *accountability methods*, since targeting schools that fail to meet performance standards can affect teachers' morale and leading to a teacher exodus in more disadvantaged communities; *teacher preparation*, since evidence suggest that more prepared teachers stay longer in the profession and in disadvantaged schools; and *location*, since areas where the supply of teachers is lower than the demand are likely to recruit less qualified teachers, unless compensatory incentives are set in place. Thus, the capacity of subnational governments to match teacher allocation with schools' needs will rely upon their decision-making power to determine such working conditions and compensatory policies; to design accountability methods that allow them to identify schools that need more help, without hindering teachers' incentives; and to reform teacher initial education and professional development, as well as to set the teacher's certification standards.

Second, the theoretical relationship between decentralization and allocative efficiency of teachers relies on the assumption that there is an adequate supply of good quality teachers in the different fields. However, evidence for the OECD suggest that some schools are facing difficulties in recruiting teachers in computer sciences, mathematics, technology, foreign languages and sciences, fields with a high demand outside the education profession. As a consequence, the proportion of teachers teaching in areas in which they are not fully qualified is strikingly high in some key

[8] Productive efficiency is interpreted here in a broad sense to include inefficiencies such as corruption, waste and poor governance.

subjects, and attrition and turnover rates have increased in recent years in these fields (OECD, 2004). Decentralization could even worsen this problem if the labor market where decentralized governments can hire teachers is smaller, i.e if there not exists a national labor market and there are interstate barriers to mobility. However, evidence suggests that increased salaries would attract better prepared teachers, with an indirect effect on educational attainment (Darling-Hammond and Sykes, 2003). Thus, the capacity of subnational governments to set teachers' salaries, establishing incentive structures rewarding the skills and performance of teachers, or to make more flexible the pathways into teaching will also be a key determinant for decentralization to improve teacher quality.

Finally, even if subnational governments have the proper decision-making power to be able to improve teacher quality, they could see limited their capacity to do so because of the existence of budgeting restrictions, which at the same time will depend on how they are financed; and because of the existence of teacher unions, which might reduce the decision-making power of government to reform educational policies and the teacher labour market. Salaries and levels of employment are typically determined through a process of collective bargaining involving governments and teacher unions. Thus, even if subnational governments have the responsibility to determine teacher salaries and to hire and fire teachers, they will see restricted their room for maneuver in the presence of powerful teacher unions. Also, entry from outside the profession or rewarding mechanisms as a function of teaching performance or teaching fields might be restricted. Pritchett and Filmer (1997) argue that inputs directly or indirectly benefiting teachers, such as wage increases or smaller class sizes, are disproportionately favored in public education in many countries because of the lobbying power of teachers and teacher unions, despite the fact that alternative inputs are frequently found to be more cost-effective in improving student learning. However, evidence regarding the relationship between teacher unions and teacher quality and student achievement is mixed (Murillo et al., 2002; Hoxby, 1996; Zegarra and Ravina, 2003), and it might be context-specific.

The shortened distance between policy-makers and citizens implied by the decentralization of the education policy might also increase the voice of parents. Parents-citizens control and political participation might be enhanced, which in turn might ensure that subnational governments are more responsive to their demands than the central government tends to be (Shah, 1998). Closely related to this, decentralization is thought to increase the degree of political accountability of the government, which should serve as an incentive for a government to act in the best interests of its citizens (Seabright, 1996).

Again, though, these effects will depend on how subnational governments are financed, since it has been demonstrated that subnational governments incentives to act in the best interest of citizens could be misled in a situation of vertical fiscal imbalance (Rodden, 2003); and will also depend on the presence of powerful teacher unions. Some authors have argued that decentralization might

make school-based interests groups more influential, turning to an increase in the level of corruption in the education sector (Prud'homme,1995; Woessman, 2001)[9]. Despite of these theories, a number of analyses that have analyzed the relationship between decentralization and lobbying in other sectors conclude that the effects of decentralization on corruption are ambiguous and context-specific, indicating the need for empirical studies (Redoano, 2007; Bardhan and Mookherjee, 2000; Bardhan and Mookherjee, 2005).

Finally, decentralization might not only affect government incentives to act in the best interest of their citizens as predicted by the fiscal federalism theory, but it also might increase schools and teachers' incentives to work harder and to use educational resources to maximize students' performance, since they are made more accountable both to the government who is responsible for managing the educational system and to parents, who can more effectively demand better education for he taxes they pay (Healey and Crouch, 2012; Winkler and Yeo, 2007). Thus, schools and teachers' effort and commitment might also be enhanced with decentralization.

To sum up, decentralized governments might enhance policies aimed to improve teacher labor force quality, both because they have a better knowledge of their population and schools' needs and because they are more accountable, and therefore they will have more incentives to act in the best interest of their citizens than the central government. However, these effects will depend on their responsibility to make decisions and to raise their own revenues, as well as on the bargaining power of teacher unions. Theoretical analysis does not allow therefore predicting how decentralization might affect teacher quality, and empirical analysis is necessary. Despite of the great importance that these effects might have at determining the effects of decentralization on educational attainment, and the relevant policy implications that could be derived from this analysis, to the best of our knowledge the relationship between decentralization and teacher quality has not been empirically analyzed[10].

Therefore, this study will be the first attempt to analyze the role of teacher quality in a decentralization process, i.e how teacher quality might be affected by decentralization and to what extent this effect explains decentralization effects on educational attainment. The literature analyzing the effects of decentralization on educational attainment concludes that expenditure decentralization is positively related to educational attainment (Barankay and Lockwood, 2007; Falch and Fischer, 2012), and that it is more beneficial when subnational governments have a low fiscal deficit (Barankay and Lockwood, 2007; Galiani and Schargrodsky, 2001). Autonomy of subnational governments to make decisions in education and to raise their own revenues have also

[9] Corruption in the education sector can take different forms, such as the deviation of resources from effective uses to uses that benefit particular purposes (such as increasing salaries, hirings…) or teachers' absenteeism. In any case, it will have an impact on the availability and quality of educational goods and services (Hallak and Poisson, 2005; Patrines and Ruthkagia, 2007).

[10] For a review and analysis of the effects of school-based management reforms in El Salvador, Honduras and Nicaragua on teacher quality see Vegas (2005).

been shown to have a central role at determining the effects of decentralization on educational outcomes (Salinas, 2013).

In this study, decentralization will be measured with the *education decision-making decentralization* variable, which measures the autonomy of subnational governments to make decisions about the main education responsibilities. More specifically, this variable measures the percentage of decisions which are made by subnational levels of government in each country in four different areas. First, decisions about *choice and teaching methods*, which include decisions about the assignment of students to schools, decisions about which textbooks, teaching methods and assessment methods are used, and decisions about the number of periods of instruction. Second, decisions about *personnel*, which include decisions about personnel hiring and firing, decisions about their duties, conditions of service and their careers, and decisions about salary levels. Third, decisions about *curriculum, certifications and infrastructures*, which include decisions about programmes of study, subjects taught and course content; decisions about the qualifying examinations for a certificate or diploma and credentialing of teachers; and decisions about the creation or closure of schools. And fourth, decisions about the *school budget*, which include both the decisions about determining the school budget and the use of resources.

3. Econometric analysis

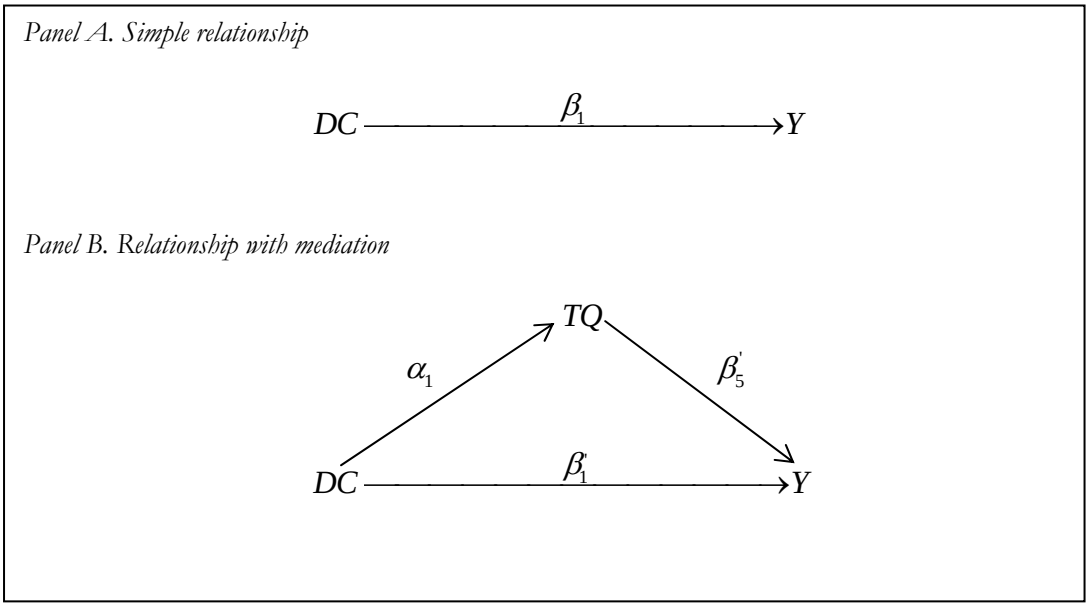
3.1. Methodology

Empirical studies that have analyzed the effects of decentralization in the education sector have focused on the analysis of its effects on educational outcomes, i.e. on analyzing whether and to what extent educational outcomes are affected by decentralization. However, the objective of this study is to go deeply into the analysis of the decentralization effects in the education sector by analyzing the process that produces these effects. More specifically, this study pretends to test the hypothesis that decentralization leads to an increase in educational outcomes by affecting teachers' quality. Thus, teacher quality is seen as a *mediator* of the relationship between decentralization and outcomes (Preacher and Hayes, 2004).

Figure 1 represents in a synthetic way the different relationships that are being analyzed. In panel A, the simple relationship between decentralization (DC) and educational outcomes (Y) is represented, i.e. when mediators are not had into account in the analysis. This relationship represents the *total effect* of decentralization on educational outcomes (β_1), which can be obtained by regressing Y on DC, without controlling for teacher quality. Panel B represents the relationship between decentralization, teacher quality and educational outcomes. In this panel, the relationship between decentralization and educational outcomes represents the *direct effect* (β_1'),

which can be obtained by regressing Y on DC, controlling for teacher quality. Thus, the *indirect effect* can be easily obtained as the difference between the *total effect* and the *direct effect* $\left(\beta_1 - \beta_1^{'}\right)$ [11].

Figure 1. Relationship between decentralization and educational outcomes



Source: own made

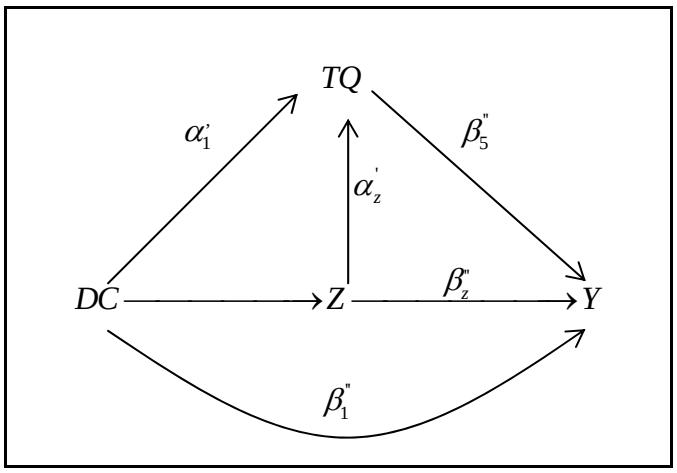
In order to conclude that teacher quality is a mediator of the relationship between decentralization and educational outcomes, quite straightforward conditions must be met (Baron and Kenny, 1986). First, decentralization must be significant at explaining educational outcomes $(\beta_1 \neq 0)$. Second, decentralization must be also significant at explaining teacher quality $(\alpha_1 \neq 0)$. Finally, teacher quality must be significant at explaining educational outcomes after controlling for decentralization $(\beta_5^{'} \neq 0)$. These conditions can be easily tested within a regression framework, which will be presented in the next sections. Additionally, the significance of the indirect effect can be tested with a Wald test of the difference between the *total effect* and the *direct effect*, which in the mediation literature is known as the *Sobel test*.

Obviously, teacher quality might not be the only potential mediator in the relationship between decentralization and educational outcomes. According with the discussion above, decentralization might also have an effect on accountability, the incentives of the different "agents" involved in the

[11] The indirect effect can be equivalently obtained as the product between the effect of decentralization on teacher quality, α_1, and the effect of teacher quality on educational outcomes, $\beta_5^{'}$ (Mackinon et al., 1995). Although in a multilevel setting both equations for indirect effects are not algebraically equivalent, Krull and Mackinon (1999) show that the discrepancy between the two is equal to zero, and that for very large samples the two estimates would be equivalent. However, as the parameter $\beta_5^{'}$ is likely to be upward biased in this setting, the indirect effect will be estimated as the difference between the *total effect* and the *direct effect*.

educational system or educational policies. These factors might at the same time influence both teacher quality and educational attainment. Figure 2 represents this setting. In order to improve the understanding of the decentralization effects on teacher quality, the indirect effects through these factors (Z) will also be estimated.

Figure 2. Relationship between decentralization and educational outcomes



Source: own made

3.2. Decentralization effects on teacher quality

As explained above, in order to conclude that teacher quality is a mediator in the relationship between decentralization and educational outcomes, a relevant condition is decentralization to have a significant effect on teacher quality ($\alpha_1 \neq 0$). In addition, whether decentralization has an effect on teacher quality, and the magnitude of this effect, are themselves relevant outputs in this study. Also the decomposition of this effect between a direct effect (α_1') and an indirect effect $(\alpha_1 - \alpha_1')$ though factors (Z) will be analyzed. Thus, in this section the specifications that allow identifying these effects of decentralization on teacher quality are presented.

As explained above, the characteristics of the schools, such as size or location might determine both the attractiveness of the school for teachers and the possibilities of the school to find good teachers. Teachers also have into account the characteristics of the students in a school in their school choices, so that students' characteristics are also relevant to explain schools' teacher quality. Finally, the quality of educational resources, the characteristics of the school's principal and the schools' accountability might also affect teachers' quality, but they are also likely to be affected by decentralization. Thus, the effect of decentralization on teachers quality will be estimated with and without including these variables, what will allow to obtain some information regarding the process through which decentralization might affect teacher quality:

$$TQ_{jk}^{l} = \alpha_0 + \alpha_1 DC_k + \alpha_2 Sc_{jk} + \alpha_3 St_{jk} + \varepsilon_{jk} \quad (1)$$

$$TQ_{jk}^{l} = \alpha_0^{'} + \alpha_1^{'} DC_k + \alpha_2^{'} Sc_{jk} + \alpha_3^{'} St_{jk} + \alpha_5^{'} \mathrm{Re}\, s_{jk} + \alpha_6^{'} Ppal_{jk} + \alpha_4^{'} Acc_{jk} + \varepsilon_{jk}^{'} \quad (2)$$

where TQ_{jk}^{l} represents the measure *l* of teachers' quality in school *j* in country *k*; DC_k represents decentralization in country *k*; Sc_{jk} represents the school characteristics; St_{jk} represents the students' characteristics; $\mathrm{Re}\, s_{jk}$ represents educational resources; $Ppal_{jk}$ represents school *j* principal's characteristics; Acc_{jk} represents accountability of school *j* in country *k*; and ε_{jk} is the error term. All the variables included in the analysis are defined in Table A.1.

As explained above, teacher quality is measured with three different variables. The first variable is *teacher's education,* which measures if teachers hold a masters' degree. The second variable is *teacher's certification*, which measures if teachers are certified by the competent authority. And the third variable, aimed to proxy the non-observable characteristics of teachers, is *disciplinary climate*, which provides information on disciplinary climate in the classroom, and therefore it will be the result of the ability or incentives of teachers to create and sustain an effective learning environment in class. Otherwise, this variable can be also interpreted as a relevant determinant of teaching quality, which might be understood as a broader concept than teacher quality. Decentralization will be measured with the *education decision-making decentralization* variable, defined as the percentage of education decisions which are made at the subnational level of government.

Although the analysis is focused on teachers' quality, which is measured at the school level in the PISA dataset[12], the analysis has been conducted at the student level for which proper weights are available in the PISA database. Estimations are conducted by least square estimation weighted by students sampling probability, with equal weights for each country. In addition, since students are grouped in schools, and schools in countries, we need to have into account the dependence between units in the same cluster. We use a Clustering Robust Linear Regression (CRLR) to estimate standard errors that recognize this clustering of the student-level data within schools, and school-level data within countries (Deaton, 1997). Balanced Repeated Replication (BRR) with Fay's modification has been used to compute estimates of the sampling variance. In this way, we allow within school correlation of the error term, but we do not need to make any assumption about the distribution or the within-cluster dependence of the residuals[13].

[12] Disciplinary climate in PISA is measured at the student level, so that it was aggregated at the school level for the analysis.

[13] Some studies used multi-level regression methods to estimate education production functions. However, these methods do not take into account the sample design information used in PISA to reduce the sampling variance, and therefore the sampling variances estimated with multilevel models will always be greater than the sampling variances estimated with Fay replicate samples (OECD, 2009).

3.3. Decentralization effects on educational attainment

The analysis of the effects of decentralization on educational outcomes will be conducted within the education production function framework, which considers the education process as analogous to a firm production process (Hanushek 1986, 2003), where educational resources or inputs are transformed into educational achievement or outputs. According with the benchmark model of the contemporaneous specification, students' educational attainment, measured through individual PISA test scores, are regressed on a set of variables which will measure the inputs of the educational process. In order to identify the *total effect* of decentralization on educational outcomes, all the inputs that are not likely to be affected by decentralization will be included in the regression equation according with specification (3).

$$Y_{ijk} = \beta_0 + \beta_1 DC_k + \beta_2 S_{jk} + \beta_3 F_{ijk} + \beta_4 \xi_{ijk} + \varepsilon_{ijk} \quad (3)$$

where Y_{ijk} is the test score of student *i* in school *j* in country *k*; β_0 is the overall mean; DC_k represents decentralization, measured at the country or regional level; S_{jk} represents the school characteristics, measured at the school level; F_{ijk} represents the family inputs, which are measured at the student level and include both home resources and family background variables; ξ_{ijk} represents the student characteristics, which are also measured at the student level; ε_{ijk} is the student-specific error term; and β_1 is the *total effect* of decentralization on educational outcomes. Table A.1 defines all the variables included in the model, the data source and the expected sign of their coefficients according to theoretical background and previous empirical evidence. The total effect of decentralization on educational outcomes can be decomposed in a direct and an indirect effect through teacher quality, by adding teacher quality variables to specification (3):

$$Y_{ijk} = \beta_0^{'} + \beta_1^{'} DC_k + \beta_2^{'} S_{jk} + \beta_3^{'} F_{ijk} + \beta_4^{'} \xi_{ijk} + \beta_5^{'} TQ_{jk} + \varepsilon_{ijk}^{'} \quad (4)$$

where TQ_{jk} represents teacher quality variables, measured at the school level, and $\beta_1^{'}$ is the *direct effect* of decentralization on educational outcomes. The rest of variables are defined as above. According with the discussion above, this specification does not include other inputs which are likely to be affected by decentralization, such as accountability methods or schools' educational resources. In this way, the effect of decentralization on educational outcomes, which is interpreted here as the *direct effect*, might also include indirect effects through such kind of omitted inputs. The i*ndirect effect* of decentralization on educational outcomes through teacher quality can be estimated as the difference between total effects and direct effects:

$$\beta_1'' = \beta_1 - \beta_1' \tag{5}$$

The different specification problems that have been outlined in the literature to affect the estimation of the education production functions (Todd and Wolpin, 2003) are not likely to affect decentralization coefficients, since they are not likely to change over the student school life nor to be correlated with the students' non-observable characteristics, such as innate ability. However, these biasing effects are likely to affect teacher quality coefficients, if teachers with stronger qualifications are matched in some systematic way with students exhibiting characteristics that are not fully controlled for in the model. The matching of better students with higher quality teachers would tend to increase the positive correlations produced by family decisions, while conscious efforts to place more effective teachers with struggling students would tend to reduce them. In order to reduce such bias, we include a set of variables that allows us to control for the students' and school characteristics which could be driving the non-random sorting process of students and teachers to schools. In addition, since teacher quality variables are measured at the school level, their coefficients are not going to be affected by within school sorting processes of students and teachers.

4. Data

Equations (1) and (2) will be estimated by using a huge dataset, which contains personal and academic information of 294.155 students, grouped in 10.872 schools and belonging to 33 OECD countries. Although the database contained information for the 34 OECD countries, France had to be excluded from the analysis because school level variables were missing for this country. Table A.2 provides information about how many students and schools were sampled in each country. As it can be observed, for Belgium and the United Kingdom the information is provided at the regional level, so that the number of independent observations for country or regional data is incremented to 35 observations.

The average of the *teacher quality* variables for each country and their average test scores in Math's, Science and Reading are also included in Table A.2. In order to compute them, we had into account the complex data structure produced by the PISA survey design, which is based on a two-stage stratified sample. The first-stage sampling units consisted of individual schools having 15-year-old students. The second-stage sampling units were students within sampled schools. A sample of 35 students were selected with equal probability and, for schools with less than 35 15-year-old students, all of them were selected. Therefore, survey weights must be incorporated into the analysis in order to make valid estimates and inferences of the population (OECD, 2009).

The performance of students in PISA is denoted with 5 plausible values in each of the tested domains. That is, instead of directly estimating a point estimate of students' ability, a range of

possible values for a student's ability, with an associated probability for each of these values, is estimated. Plausible values are random draws from this estimated distribution for a student's ability. They are defined in such a way that the mean and standard deviation on reading scores are 500 and 100 respectively, for the equally weighted 27 OECD countries that participated in PISA 2000; the mean and standard deviation on math's scores are 500 and 100 respectively, for the 30 OECD countries that participated in PISA 2003; and the mean and standard deviation on science scores are 500 and 100 respectively, for the 30 OECD countries that participated in PISA 2006 (OECD, 2009).

The average teachers' qualification in OECD countries is quite high. The percentage of teachers holding a master degree is equal to 85,23%, and the percentage of certified teachers is equal to 82,10% on average. However, differences among the different countries are important, specially with regard to teacher's education. Average test scores present also a wide variation between countries. Average test scores in Math's range from 418,51 in Mexico to 546,23 in Korea, with an overall mean for OECD countries equal to 488,51. Average test scores in Science range from 415,91 in Mexico to 554,08 in Finland, with an overall mean for OECD countries equal to 496,44. Finally, average test scores in Reading range from 425,27 in Mexico to 539,27 in Korea, with an overall mean for OECD countries equal to 491,55. Therefore, there is a huge variability in average test scores among the different countries. Although an important part of this variability can be explained by student, family and school factors, the countries' institutional factors are also important at explaining it.

Finally Table A.3. provides a descriptive analysis for the whole set of explanatory variables included in the model. Although the missing rate is not high for most of the variables, deleting all the observations that have a missing value for at least one variable would have reduced the sample size considerably. Therefore, missing values of the different variables were imputed in order to include the maximum number of cases in the analysis, following the method proposed by OECD (2009). For continuous variables, missing values were replaced by the weighted school average of the variables; if all data on the respective variable were missing in one school such that the weighted school mean could not be computed, the weighted country mean was imputed. For dichotomous variables missing values were replaced by 0. It is known that this imputation method generally produces biased estimates of coefficients, and that standard errors of those variables that contain missing values are underestimated since they do not account for the uncertainty introduced through imputation. However, given that the percentage of data with missing values was very low for most variables, this bias was considered negligible. In addition, our estimates include one dummy for each variable, that takes the value 1 for observations with missing and thus imputed data and 0 for observations with original data. In this way we account for the possibility of non-randomly missing observations and we make sure that the results are not driven by imputed data.

5. Empirical findings

5.1. The effects of decision-making decentralization

5.1.1. The effects of decentralization on teacher quality

This section analyzes the effects of *education decision-making decentralization* on teacher quality, measured with *teacher's education* (Table A.4)*, teacher's certification* (Table A.5) and *disciplinary climate* (Table A.6). The total effects of decentralization on teacher quality are estimated by regressing specification (1), so that controls for school and students relevant characteristics are included in the regression, but variables that might be affected by decentralization are not included. Specification (2) includes controls for variables which are likely to be affected by decentralization and, at the same time, to have an influence on teacher quality. These controls include the student-teacher ratio and shortage of instructional material variables, to measure working conditions, principal's leadership, and parent's pressure.

Education decision-making decentralization has a positive and significant total effect on teachers' quality, with independence of whether it is measured as teacher's education, teacher's certification or disciplinary climate. According with these results, the percentage of teachers holding a master's degree in schools is on average 0.046 percentage points higher for each additional percentage point in *decision-making decentralization* towards subnational governments. This means that, if we compared a country such as Canada, with the 80 percent of their educational decisions decentralized to the subnational levels of government, with a country as Greece, with only the 7 percent of their educational decisions decentralized to the subnational level of government, we might expect (everything else equal) the percentage of teachers with a masters' degree to be almost three points and a half greater in schools in Canada than in Greece. Although this might seem a modest effect, if we have into account that the percentage of teachers with a master's degree in OECD countries is on average 85,23%, it is a quite significant effect.

The effect of *education decision-making decentralization* on teacher's certification is even higher. According with these results, the percentage of teachers with certification in schools would be on average 0.110 percentage points higher for each additional point in decision-making decentralization. Thus, if we made the comparison above between two countries with such different levels of decentralization, we might expect the difference in the percentage of teachers with certification to be above 8 percentage points. Having into account that the percentage of teachers in OECD countries is also above 80 percent, this is a quantitatively significant effect.

Finally, the effect of decentralization on the disciplinary climate in class is on average 0.003 points higher for each additional point in decision-making decentralization. The disciplinary climate indicator was normalized to have an OECD average of 0 and an standard deviation of 1, so that

this effect is also quantitatively significant. When comparing a highly decentralized country with a country with a low level of decentralization as before, it might be expected an average difference in their schools disciplinary climate equal to 0.22, i.e. around a 20 percent of an international standard deviation.

Table 3 presents the estimated beta coefficients for the effects of decision-making decentralization on each of these variables of teacher quality. These effects might be interpreted as the change in standard deviations of the dependent variable that results from a one standard deviation increase in decentralization. Also the decomposition of these total effects between a direct and an indirect effect is presented in Table 3.

Table 3. The effects of decision-making decentralization on teacher quality (beta coefficients)

	Teacher's education	Teacher's certification	Disciplinary climate
	(1)	(2)	(3)
Total Effects (α_1)	0.031**	0.099***	0.065***
Direct Effects (α'_1)	0.022**	0.099***	0.065***
Indirect Effects ($\alpha_1 - \alpha'_1$)	0.009**	0.000	0.000

Note: decomposition of the effect of decentralization on teacher quality, in base to the estimated beta coefficients of equations (1) and (2) with 3 alternative dependent variables: teachers' education (column 1), teachers' certification (column 2) and disciplinary climate (column 3). Total effects are obtained when estimating specification (1) for teachers' quality and direct effects are obtained when estimating specification (2). Results of the different regressions are in Tables A.4 to A.6 in the annex. Least squares estimation weighted by students sampling probability is conducted, with an equal weight for each country. Robust standard errors adjusted for clustering at the regional and school level are in parenthesis. *** p<0.01, ** p<0.05, * p<0.1.

As it can be observed, indirect effects explain little or nothing of the effect of decentralization on teacher quality. As explained above, the effects of decentralization on teacher quality are driven by numerous factors, which are likely not captured by the control variables included in this analysis. In addition, positive and negative indirect effects through the different variables included in this analysis compensate between them, so that the overall indirect effect results to be zero. For instance, indirect effects of decentralization through shortage of instructional material on teacher's certification are positive, indicating that with decentralization improves the availability of instructional material. However, indirect effects of decentralization through the student-teacher ratio on teacher's certification are negative, indicating that with decentralization the ratio of students to teachers is increased. Thus, it seems that with decentralization there is a change in the composition of educational inputs, what makes that indirect effects through these inputs compensate between them. The relevant point here, though, is that the total effect of decentralization on teacher quality is positive and significant, both if it is measured with observable characteristics, as teachers' qualification, or a proxy for non-observable characteristics, as disciplinary climate in class.

5.1.2. The effects of decentralization on educational outcomes

The objective of this section is quantifying the effects of decentralization on educational outcomes and analyzing the extent to which these effects are explained by the effects of decentralization on teachers' quality. The total effects of decentralization on educational outcomes are estimated by regressing specification (3), so that controls for school inputs and teacher quality are not included. Specification (4) includes teacher quality variables, in order to identify the indirect effects of decentralization through teacher quality as the difference between the coefficient of decentralization in specification (3) and specification (4). Educational outcomes are measured with the PISA test scores in three subjects, which include math's, science and reading. The complete results of estimating specifications (3) and (4) above are presented in Tables A.7 to A.9 in the Annex.

As expected, decentralization has a positive and significant *total effect* on students' test scores for the three subjects. According with these results, a one percentage point increase in decision-making decentralization increases the students' test scores by 0.373 score points in math's, 0.324 score points in science and 0.218 score points in reading. If two countries with different levels of decentralization were compared as above, it might be expected a difference of 27,2 score points in math's, 23,7 score points in science and 15,9 score points in reading. Given that test scores are scaled to have an international mean among OECD countries of 500 and standard deviation of 100, these are also quantitatively significant effects.

The effects of teacher quality on students' test scores are also positive and significant for the three subjects, except for teacher's education, the effect of which is non significant for math's. According with these results, a one percentage point increase in the quantity of teachers with a masters' degree increases the students' test scores by 0.097 score points in science and 0.094 score points in reading; a one percentage point increase in the quantity of teachers with certification increases the students' test scores by 0.172 score points in math's, 0.157 score points in science and 0.121 score points in reading. Finally, one standard deviation in disciplinary climate might increase the students' test scores by 11,26 in math's, 11,36 in science and 11.21 in reading[14].

Table 4 presents the decomposition of the total effects of decentralization on educational outcomes between direct effects and indirect effects through teacher quality. Also the contribution of each teacher quality variable to the indirect effect is presented in this table. According with these results,

[14] As disciplinary climate has been normalized to have a zero mean and an standard deviation equal to one for OECD countries, its coefficients can be interpreted as the effect of one standard deviation increase on test scores. As a mean of comparison, the effect of one standard deviation increase in teacher's education is 3.56 on science test scores and 3.47 on reading test scores, and the effect of one standard deviation increase in teacher's certification is 4.74 score points on math's, 4.32 on science and 3.32 on reading. Thus, the explanatory power of disciplinary climate seems to be higher, in line with the hypothesis that unobservable characteristics of teachers might have a greater effect on students' achievement (Hanushek et al., 2005; Rivkin et al., 2005).

a one standard deviation change in decentralization might imply a change in the students' grades scores of 9,24 points in math's, 8,01 points in science and 5,41 score points in reading. In addition, indirect effects through teacher quality might account for the 7,5% of the total effects for math's, the 12,2% of the total effects for science and the 16,7% of the total effects for reading. Thus, it remains more than an 80% of the effect of decentralization on educational outcomes which is not explained by these measures of teacher quality.

Table 4. The effects of decision-making decentralization on educational attainment (beta coefficients)

	Math's	Science	Reading
	(1)	(2)	(3)
Total Effects (β_1)	9.240***	8.013***	5.407***
Direct Effects (β'_1)	8.544***	7.038***	4.502***
Indirect Effects ($\beta_1 - \beta'_1$)	0.696***	0.975***	0.905***
Teachers' education	*0.003*	*0.332****	*0.303****
Teachers' certification	*0.120****	*0.099****	*0.078****
Disciplinary climate	*0.573****	*0.544****	*0.524****

Note: decomposition of the effect of decentralization on educational attainment in base to the estimated coefficients of equations (3) and (4) for students' test scores in math's (column 1), science (column 2) and reading (column 3). Total effects are obtained when estimating specification (3) and direct effects are obtained when estimating specification (4). Results of the different regressions are in Tables A.7 to A.9 in the annex. Least squares estimation weighted by students sampling probability is conducted, with an equal weight for each country. Robust standard errors adjusted for clustering at the regional and school level are in parenthesis. *** p<0.01, ** p<0.05, * p<0.1.

The decomposition of the indirect effects in base to each measure of teacher quality offers quite interesting results. Differences among the indirect effects of decentralization through each of these teacher quality variables depend both of the differences in the effect of decentralization on each one, and their differential effect on educational outcomes. The variable with a higher contribution to the indirect effect is disciplinary climate. According with the discussion above, once the characteristics of students have been controlled for in the regression equation, the variations in the disciplinary climate in class might be measuring variations in the non-observable characteristics of teachers such as ability and motivation. Since one of the channels through which decentralization is supposed to affect teachers' quality is through an effect on the incentives of teachers' and schools, it is a reasonable result the effect of decentralization to be especially significant on this variable. The indirect effects through teachers' education are also quantitatively significant for science and reading.

6. Summary and concluding remarks

The effects of decentralization have been widely analyzed, both from an empirical point of view and theoretically. Empirical analyses about the effects of decentralization have been developed for a wide variety of contexts and public policies, ranging from the more traditional analyses about the effects of decentralization on economic growth (Davoodi and Zou, 1998; Iimi, 2005; Rodriguez-Pose and Ezcurre, 2011; Blöchliger, 2013) or efficiency (Rodden, 2001) to the most recent research about the effects of decentralization on life satisfaction (Bjornskov et al., 2008; Diaz-Serrano and Rodriguez-Posé, 2012) or public sector innovation. In the education sector, the literature analyzing the effects of decentralization is somewhat scarce, and focused on the analysis of its effects on educational attainment.

The general conclusion of this literature is that expenditure decentralization is positively related to educational attainment (Barankay and Lockwood, 2007; Falch and Fischer, 2012), and that it is more beneficial when subnational governments have a low fiscal deficit, i.e. when they are more efficient (Barankay and Lockwood, 2007; Galiani and Schargrodsky, 2001). Autonomy of subnational governments to make decisions in education and to raise their own revenues have also been shown to have a central role at determining the effects of decentralization on educational outcomes (Salinas, 2013). This study goes deeply into the analysis of the effects of decentralization in the education sector, by focusing on one of the most relevant determinants of educational attainment in school: teacher quality. More specifically, the role of teacher quality in a decentralization process will be analyzed, i.e how it might be affected by decentralization and to what extent this effect explains decentralization effects on educational attainment.

Defining teacher quality is not a simple task, as the criteria for doing so might vary from person to person, from one community to another and from one era to another (National Research Council, 2001; Umansky, 2005). In this study, we take advantage of the detailed information provided by PISA to define three variables of teacher quality. *Teacher's education,* which measures if teachers hold a masters' degree. *Teacher's certification*, which measures if teachers are certified by the competent authority. And *disciplinary climate*, which provides information on disciplinary climate in the classroom, and therefore it will be the result of the ability or incentives of teachers to create and sustain an effective learning environment in class.

These different dimensions of teacher quality are liable to be affected by decentralization in different ways. On the one side, applying the fiscal federalism theory to the education context, decentralization might lead to political decisions about educational inputs that better match population preferences and students' needs than those that would be taken under a centralized system. A direct effect of decentralization might be therefore improving teacher labor force quality by increasing the number of teachers with the desirable characteristics, in terms of qualification,

abilities and motivation, or setting down the right incentives to improve teacher quality. On the other side, decentralization might not only affect government incentives to act in the best interest of their citizens as predicted by the fiscal federalism theory, but it also might increase schools and teachers' incentives to work harder and to use educational resources to maximize students' performance, since they are made more accountable both to the government who is responsible for managing the educational system and to parents, who can more effectively demand better education for he taxes they pay (Healey and Crouch, 2012; Winkler and Yeo, 2007). However, these positive effects could be misled if the labor market where decentralized governments can hire teachers is smaller, and that makes more difficult to find "good" teachers (Darling-Hammond and Sykes, 2003), or if the shortened distance between policy-makers and schools make school based interests groups more influential, turning to an increase in the level of corruption[15] in the education sector (Woessman, 2001).

Theoretical analysis does not allow therefore predicting how decentralization might affect teacher quality, and empirical analysis is necessary. Despite of the great importance of this question for policy making, to the best of our knowledge the relationship between decentralization and teacher quality has not been empirically analyzed. The analysis conducted in this study show that decentralization has a quantitatively and statistically significant effect on teacher quality, measured with teacher's education, certification and disciplinary climate. These effects explain among a 7,5% and a 16,7% of the total effects of decentralization on educational attainment, depending on the specific subject.

[15] Corruption in the education sector can take different forms, such as the deviation of resources from effective uses to uses that benefit particular purposes or teachers' absenteeism.

7. References

Aaronson, D., Barrow, L. and Sander, W. (2007): "Teachers and Student Achievement in the Chicago Public High Schools", *Journal of Labor Economics*, 25(1), 95-135.

Barankay, I. and Lockwood, B. (2007): "Decentralization and the productive Efficiency of Government: Evidence from Swiss Cantons", *Journal of Public Economics,* 91, 1197-1218.

Bardhan, P. and Mookherjee, D. (2000): "Capture and governance at local and national levels", *American Economic Review* 90(2), 135-139.

Bardhan, P. and Mookherjee, D. (2005): "Decentralization, Corruption and Government Accountability: An Overview", in *Handbook of Economic Corruption*, Susan Rose-Ackerman (Ed.), Edward Elgar, forthcoming.

Baron, R.M. and Kenny, D.A., (1986): "The Moderator-Mediator Variable Distinction in Social Psychological Research: Conceptual, Strategic and Statistical Considerations", Journal of Personality and Social Psychology, 51(6), 1173-1182.

Besley, T. and Coate, S. (2003): "Centralizad versus decentralized provision of local public goods: a political economy approach", *Journal of Public Economics* 87, 2611-2637.

Bjornskov, C., Drehe, A. and Fischer, J. (2008): "On Decentralization and Life Satisfaction", Economic Letters 99(1), 147-151.

Clotfelter, C.T, Ladd, H.F., Vidgor, J.L. (2006): "Teacher-student matching and the assessment of teacher effectiveness", *Journal of Human Resources*, 41(4), 778-820.

Clotfelter, C.T, Ladd, H.F., Vidgor, J.L. (2007): "How and Why do Teacher Credentials Matter for Student Achievement?", NBER Working Paper, 12.828.

Clotfelter, C.T, Ladd, H.F., Vidgor, J.L. (2010): "Teacher credentials and student achievement in high school: a cross-subject analysis with student fixed effects", *Journal of Human Resources*, 45(3), 655-681.

Darling-Hammond, L. (2000): "Teacher Quality and Student Achievement: A Review of State Policy Evidence", Center for the Study of Teaching and Policy, Seattle, Wash.

Darling-Hammond, L. and Sykes, G. (2003): "Wanted: A National Teacher Supply Policy for Education: The Right Way to Meet", Education Policy Analysis Archives 11(33).

Davoodi, H. and Zou, H. (1998): "Fiscal Federalism and Economic Growth: a cross-country study", *Journal of Urban Economics* 43, 244-257.

Deaton, A. (1997): The Analysis of Household Surveys: a Microeconomic Approach to Development Policy, Johns Hopkins University Press, Baltimore.

Diaz-Serrano, L. and Rodríguez-Posé, A. (2012): "Decentralization, Subjective Well-Being and the Perception of Institutions", *KYKLOS* 65(2), 179-193.

Faguet, J.P. (2004): "Does decentralization increase government responsiveness to local needs? Evidence from Bolivia", *Journal of Public Economics* 88, 867-893.

Falch, T. and Fischer, J.A.V (2012): "Public Sector Decentralization and School Performance: International Evidence", *Economic Letters*, 114, 276-279.

Fuchs, T. and Woessman, L. (2007): "What Accounts for International Differences in Student Performance? A Re-examination using PISA Data", *Empirical Economics* 32, 433-464.

Galiani, S. and Schargrodsky, E. (2001): "Evaluating the Impact of School Decentralization on Education Quality", *Journal of the Latin American and Caribbean Economic Association* 2(2), 275-314.

Glewwe, P. Nauman-Ilias, P. and Kremer, M. (2010): "Teacher Incentives", *American Economic Journal* 2(3), 205-227.

Hallak, J. and Poisson, M. (2005): Ethics and corruption in education: an overview. *Journal of Education for International Development,* 1(1).

Hanushek, E.A. (1986): "The Economics of Schooling: Production and Efficiency in Public Schools", *Journal of Economic Literature* 24, 1141-1177.

Hanushek, E.A. (1989): "The Impact of Differential Expenditures on School Performance", *Educational Researcher* 18(4), 45-62.

Hanushek, E.A (2003): "The failure of input based schooling policies", *Economic Journal* 113, 64-98.

Hanushek, E.A, Kain, J.F. and Rivkin, S.G. (2004): "Why Public Schools Loose Teachers", Journal of Human Resources 39(2), 326-354.

Hanushek, E.A, Kain, J.F, O'Brien, D.M and Rivkin, S.G. (2005): "The Market for Teacher Quality", NBER Working Paper 11.154.

Hanushek, E.A and Kimko, D.D. (2000): "Schooling, Labor-Force Quality and the Growth of Nations", *American Economic Review* 90, 1184-1208.

Hanushek, E.A and Rivkin (2006): "Teacher Quality", In Handbook of the Economics of Education. Vol. 1, ed. Eric A.Hanushek and Finis Welch, 1051–78. Amsterdam: North-Holland.

Hanushek, E.A and Rivkin (2010): "Generalizations about using Value-Added Measures of Teacher Quality", *American Economic Review: Papers and Proceedings* 100, 267-271.

Hanushek, E.A and Rivkin (2010): "Constrained Job Matching: Does Teacher Job Search Harm Disadvantaged Urban Schools?" NBER Working Paper 15816.

Hanushek, E.A and Woessman, L. (2007): "The Role of Education Quality for Economic Growth", Policy Research Working Paper Series 4122, The World Bank.

Harris, D.N. and Sass, T.R. (2011): "Teacher Training, Teacher Quality and Student Achievement", Journal of Public Economics 95, 798-812.

Healey, F.H. and Crouch, L. (2012); "Decentralization for High-Quality Education: Elements and Issues of Design", Research Report, RTI Press Publication.

Hindriks, J. and Lockwood, B. (2005): "Centralization and Political Accountability", CEPR Discussion Paper 5125.

Hoxby, C.M (1996): "How Teachers' Unions Affect Education Production", *Quarterly Journal of Economics* 111(3), 671-718.

Iimi, A. (2005): "Decentralization and Economic Growth Revisited: an Empirical Note", *Journal of Urban Economics* 57(3), 449-461.

Kane, T.J., Rockoff, J.E. and Staiger, D.O. (2006): "What does Certification Tell us about Teacher Effectiveness", NBER Working Paper 12.155.

Koedel, C. and Betts, J.R. (2011): "Does Student Sorting Invalidate Value-Added Models of Teacher Effectiveness? An Extended Analysis of the Rothstein Critique", Education Finance and Policy 6(1), 18-42.

Krueger, A.B. (2003): "Economic Considerations and Class Size", *The Economic Journal* 113(485), 34-63.

Krull, J.L. and Mackinon, D.P. (1999): "Multilevel Mediation Modeling in Group-Based Intervention Studies", *Evaluation Review* 23(4), 418-444.

Lockwood, B. (2002): "Distributive Politics and the Costs of Centralization", *Review of Economic Studies* 69, 313-337.

Lockwood, B. (2005): "Fiscal Decentralization: A Political Economy Perspective", in Handbook of Fiscal Federalism, E.Ahamad and G.Brosio (Ed.), Edward Elgar Publishing, 2006.

MacKinnon, D. P., Warsi, G. and Dwyer, J. H. (1995): "A simulation study of mediated effect measures", *Multivariate Behavioral Research* 30, 41-62.

Metzler, J. and Woessmann, L. (2012): "The Impact of Teacher Subject Knowledge on Student Achievement: Evidence from Within-Teacher Within-Student Variation", *Journal of Development Economics* 99, 486-496.

Murillo, M.V., Tommasi, L., Ronconi, L. and Sanguinetti, J. (2002): "The Economic Effects of Unions in Latin America: Teachers' Unions and Education in Argentina", Inter-American Development Bank, Washington, D.C.

National Research Council. *Testing Teacher Candidates: The Role of Licensure Tests in Improving Teacher Quality*. Washington, DC: The National Academies Press, 2001.

Oates, W.E. (1972): *Federalismo Fiscal*, Instituto de estudios de administración local, 25.

OECD (1992): *Education at a Glance: OECD indicators*, Organization for Economic Co-operation and Development, 1992.

OECD (2004): *The Quality of the Teaching Workforce*, OECD Policy Brief.

OECD (2009): *PISA Data Analysis Manual, SPSS Second Edition*, Organization for Economic Co-operation and Development, 2009.

OECD (2012): *PISA 2009 Technical Report*, PISA, OECD Publishing. http://dx.doi.org/10.1787/9789264167872-en

Preacher, K.J. and Hayes, A.F. (2004) "SPSS and SAS procedures for estimating indirect effects in simple mediation models", *Behavior Research Methods, Instruments, & Computers* 36, 717-731.

Pritchett, L. and Filmer, D. (1997): "What Education Production Functions Really Show: A Positive Theory of Education Spending", Policy Research Working Paper 1795, World Bank.

Persson, T. and Tabellini, G. (2000): *Political Economics: Explaining Economic Policy*, MIT Press.

Prud'homme, R. (1995): "The Dangers of Decentralization", *The World Bank Research Observer* 10 (2), 201-220.

Redoano, M. (2007): "Does decentralization affect the number and size of lobbies?", CESifo Working Paper 1968.

Rivkin, S.G., Hanushek, E.A. and Kain, J.F. (2005): "Teachers, Schools and Academic Achievement", *Econometrica* 73(2), 417-458.

Rockoff, J.E. (2004): "The Impact of Individual Teachers on Student Achievement: Evidence from Panel Data", *American Economic Review: Papers and Proceedings*, 92(2), 247-252.

Rodden, J. (2001): "The Dilemma of Fiscal Federalism: Grants and Fiscal Performance Around the World".

Rodden, J. (2003): "Reviving Leviathan: Fiscal Federalism and the Growth of Government", *International Organization*, 57(4), 695-729.

Rodriguez-Pose, A. and Ezcurra, R. (2011): "Is Fiscal Decentralization Harmful for Economic Growth? Evidence from OECD countries", *Journal of Economic Geography* 11(4), 619-643.

Rothstein, J. (2009): "Student Sorting and Bias in Value-Added Estimation: Selection on Observables and Unobservables", *Education Finance and Policy* 4(4), 537-571.

Salinas, P. (2013): "Key Questions to Ensure the Success of Education Decentralization: Evidence from OECD Countries", *XX Encuentro de Economía Pública.*

Seabright, P. (1996): "Accountability and decentralisation in government: An incomplete contracts model", *European Economic Review* 40, 61-89.

Shah, A. (1998): "Balance, Accountability, and Responsiveness. Lessons about Decentralization", Policy Research Working Paper, 2021, World Bank.

Solé-Ollé, A. and Esteller-Moré, A. (2005): "Does decentralization improve the efficiency in the allocation of public investment? Evidence from Spain", Working Paper 2005/5, Institut d'Economia de Barcelona.

Todd, P.E. and Wolpin, K.I. (2003): "On the specification and estimation of the production function for cognitive achievement", *The Economic Journal* 113, 3-33.

Umansky, I. (2005): "A Literature Review of Teacher Quality and Incentives. Theory and Evidence", in Incentives to Improve Teaching: Lessons from Latin America, E. Vegas (Ed.), The World Bank, Washington D.C., 2005.

Vegas, E. (2005): *Incentives to Improve Teaching: Lessons from Latin America,* The World Bank, Washington D.C., 2005.

Winkler, D. and Yeo, B.L. (2007): "Identifying the impact of education decentralization on the quality of education", EQUIP2 Working Paper.

Wiswall, M. (2013): "The Dynamics of Teacher Quality", *Journal of Public Economics* 100, 61-78.

Woessman, L. (2001): "Why students in some countries do better?", *Education matters*, 1(2), 67-74

Woessmann, L. (2003): "Schooling Resources, Educational Institutions and Student Performance: the International Evidence", *Education matters*, 1(2), 67-74

Woessmann et al. (2007): "School Accountability, Autonomy, Choice and the Level of Student Achievement. International evidence from PISA 2003", OECD Education Working Papers 13, OECD publishing

Zegarra, E. and Ravina, R. (2003): "Teacher Unionization and the Quality of Education in Peru: an Empirical Evaluation Using Survey Data", Research Network Working Paper 474, Inter-American Development Bank.

Table A.1. Definition of variables included in the model

Model	Variable	Definition	Level	Source	Expected effect on educational attainment
	Teacher quality				
	Teachers' qualification				
(1) / (2) / (4)	Teachers' education	This variables measures the proportion of teachers that hold a master degree in each school .	School	PISA 2009	Mixed results about its effect on educational attainment. See section 2.1 for a detailed analysis.
(1) / (2) / (4)	Teachers' certification	This variables measures the proportion of teachers that are fully certified in each school.	School	PISA 2009	Mixed results about its effect on educational attainment. See section 2.1 for a detailed analysis.
	Teachers' qualities				
(1) / (2) / (4)	Disciplinary climate	Index constructed from questions to the students about disciplinary climate in class. Positive scores on this index indicate a better disciplinary climate. This variable has been averaged at the school level.	School	PISA 2009	The ability of teachers to create and sustain an effective learning environment in class has been outlined as an important characteristic that a high quality teacher might have (Craig et al., 1998; Darling-Hammond, 2000), but there is no empirical evidence.
	Decentralization				
(1) / (2) / (3) / (4)	Education decision-making decentralization	Percentage of educational decisions which are taken at the subcentral level of government, in four different areas: choice and teaching methods, personnel, curriculum, certification and infrastructures and school budget. We also control for the percentage of decisions taken at the school level (*Percentage school decisions*), so that the residual cathegory is the percentage of decisions taken at the central level of government.	Country/ Region	Education at a Glance (OECD)	These variables have been used in Woessman (2001, 2003), although they did not differenciate among the effect of the percentage of decisions taken at the subcentral level of government and at the school level. Therefore, there is not previous evidence about the effect of these variables on teacher quality nor on educational attainment.
	Achievement variables				
(3) / (4)	Mathematical literacy	Literacy is concerned with the capacity of students to apply knowledge and skills in key subject areas (Mathematics, Science and Reading) and to analyse, reason and communicate effectively as they pose, solve and interpret problems in a variety of situations. Thus, PISA seeks to assess not merely whether students can reproduce what they have learned, but also to examine how well they can extrapolate from what they have learned and apply their knowledge in novel settings, both in school and non-school contexts.	Student	PISA 2009	-
(3) / (4)	Scientific literacy		Student	PISA 2009	-
(3) / (4)	Reading literacy		Student	PISA 2009	-
	School inputs				
	School resources				
(2)	Student-teacher ratio	The student-teacher ratio was computed by dividing the school size by the total number of teachers. The number of part-time teachers is weighted by 0.5 and the number of full-time teachers is weighted by 1.0.	School	PISA 2009	Students in schools with a lower student-teacher ratio are expected to perform better than schools with a higher student-teacher ratio. However, the endogeneity problems associated with this variable have lead to mixed results in the literature.
(2)	Shortage of Instructional Material	Dummy variable that measures the school principal's perception that the shortage of instructional material is hindering instruction at school.	School	PISA 2009	We expect that students in schools whose principals reported that they do not suffer from inadequate instructional material perform better relative to students in schools whose principals reported that they were somewhat limited by inadequate materials (Fuchs and Woessman, 2007; Woessman et al., 2007).
	School organization				
(1) / (2) / (3) / (4)	Type of school	Set of dummy variables that indicate if the school is public (residual cathegory); private, government dependent (defined such as those private schools that receive more than 50% of their core funding from government agencies); or private, government independent (defined such as those private schools that receive less than 50% of their core funding from government agencies), which is the baseline category.	School	PISA 2009	Once demographic and socio-economic factors have been taken into account, students in schools that are privately operated are not expected to perform different from students in schools that are publicly operated (OECD, 2009).
(1) / (2)	School size	Number of students enrolled in the school.	School	PISA 2009	
(1) / (2)	Grades 7 to 13	Dummy variable to indicate if the school offers grades 7 to 13 or not.	School	PISA 2009	
(1) / (2)	Ungraded school	Dummy variable to indicate if the school is an ungraded school or not.	School	PISA 2009	
(1) / (2) / (3) / (4)	Availability of other schools	Dummy variable that takes value 1 if there is another school in the area, and 0 otherwise.	School	PISA 2009	Students in schools which are not under the competence from other schools are expected to perform worse than otherwise.
(1) / (2)	School location	Set of dummy variables which indicate if the school is in a village or rural area (fewer than 3000 inhabitants); small town (3000-15000 inhabitants); town (15000-100000 inhabitants); city (100000-1000000 inhabitants); large city (>1000000 inhabitants). City and large city are the baseline categories.	School	PISA 2009	
	Principal characteristics and practices				
(2)	Leadership of principal	Index constructed from questions about the principal attitude and practices. Positive WLE scores on this index indicate greater involvement of school leadership in school affairs.	School	PISA 2009	
	Accountability				
(2)	Parents pressure	Set of dummy variables that indicate if parents pressure for academic standards is absent (residual cathegory), it affects a minority of parents or many parents.	School	PISA 2009	Students in schools where parents pressure is important are expected to perform better than otherwise.
	Student characteristics				
	Schools' aggregate characteristics of the students				
(1) / (2)	Zero percentage of inmigrant students	Dummy variable to indicate if there are no inmigrants at the school.	School	PISA 2009	
(1) / (2) / (3) / (4)	School selectivity		School	PISA 2009	
(1) / (2)	Transfer because of behavior		School	PISA 2009	

Table A.1. Definition of variables included in the model

Model	Variable	Definition	Level	Source	Expected effect on educational attainment
(1) / (2)	Wealth	Index constructed from the students' responses about the availability at home of a room of their own, a link to internet, a dishwasher and a DVD player.	School	PISA 2009	Previous studies do not always obtain significant coefficients of the expected sign for family resource variables, because they include in the same regression these variables and the per capita GDP (Woessman, 2003; Fuchs and Woessman, 2007; Woessman et al., 2007), what can seriously bias the coefficients.
(1) / (2)	Cultural possessions	Index constructed from the students' responses about the availability at home of a classical literature books, books of poetry and works of art.	School	PISA 2009	
(1) / (2)	Students behavior	Index constructed from principals perceptions of student related factors such as students absenteeism, disruption of classes, students skipping classes, students lacking respect, and students' use of alcohol and students intimidating other students. Higher values indicate positive behaviour of students.	School	PISA 2009	We would expect higher values to be related to superior performance.
	Student level characteristics				
(1) / (2) / (3) / (4)	Grade	Set of dummy variables that indicate which grade the student is attending (grades 7 to 11, which is the residual cathegory)	Student	PISA 2009	Students in higher grades are expected to perform better than students in lower grades (Fuchs and Woessman, 2007; Woessmann et al., 2007)
(3) / (4)	Age	Student age, measured in months.	Student	PISA 2009	Higher age students are expected to perform better after controlling for grade and repetition (Crawford et al., 2010; Woessmann et al., 2007).
(1) / (2) / (3) / (4)	Education programme	Dummy variable that indicate if the student is enrolled in a general programme designed to give access to the next programme level, or not (General programme).	Student	PISA 2009	Students enrolled in a general programme are expected to perform higher than students enrolled in a pre-vocational programme, a pre-labour market programme or a modular programme. We should expect students with a higher innate ability to be enrolled in general programmes, aimed to give access to the university. (there is not previous evidence on this variable)
(3) / (4)	Expected level of education	Dummy variable that indicates if the student expects to finish university studies.	Student	PISA 2009	Students who expect to finish a university degree are expected to perform better than students that do not. We should expect that students with a higher innate ability expect to obtain a university degree.
(3) / (4)	Enjoyment of reading	Index constructed from questions about student's enjoyment of reading, defined so that positive scores on this index 2009 indicate higher levels of enjoyment of reading.	Student	PISA 2009	Those students who are habitual readers and who enjoy reading are more likely than others to perform better, at least in reading.
(3) / (4)	Library use	Index, defined such that a higher value indicate a greater use of libraries.	Student	PISA 2009	We would expect the effect of this variable to be positive if time spent in library is more productive than time spent studying at home, and negative if the opposite is true.
(3) / (4)	Attitude towards school	Index constructed from questions about the student attitude toward school, and defined so that positive scores indicate a better attitude.	Student	PISA 2009	Students with higher scores are expected to perform better than students with lower scores.
(3) / (4)	Female	Dummy variable which equals 1 if female, and 0 otherwise.	Student	PISA 2009	Girls are expected to perform worse in maths and science, and better in reading (Fuchs and Woessman, 2007; Woessmann et al., 2007)
(3) / (4)	Pre-primary education	Set of dummy variables that indicate if the student did not attend pre-primary education, attended less than 1 year or attended more than 1 year, which is the residual cathegory.	Student	PISA 2009	Students that did not attend pre-primary education or attended less than one year are expected to perform worse than students who attended more than one year (Woessmann et al., 2007).
(3) / (4)	Grade repetition	Set of dummy variables that indicate if the student has repeated or not primary education, lower-secondary education and if they have repeated upper-secondary education once, more than once or never (residual cathegory).	Student	PISA 2009	Students who have repeated are expected to perform worse than students that have not repeated (Woessmann et al., 2007).
(3) / (4)	Learning strategies	5 indices which measure the importance attached to different reading strategies: memorisation, elaboration, control strategies, understand and remembering a text and summarizing a text. These indices are measured so that positive values indicate higher importance attached to the given reading strategy.	Student	PISA 2009	The evidence from PISA suggests that students who are more self-confident and highly motivated do better at school largely because they are more inclined to invest in learning strategies that work (OCDE, 2009). Thus, students with higher indices on strategies that work are expected to perform better than students with low indices, while the opposite is true for strategies that do not work.
	Family inputs				
	Family resources				
(3) / (4)	Parents work status	Set of dummy variables that indicate if the student's mather and father work full time (*Mother full-time, Father full-time*), part time (*Mother part-time, Father part-time*) or do not work (residual cathegory).	Student	PISA 2009	If we controlled by family income, this variable would be a proxy of time spent with parents. But as we do not control by family income, the effect of this variable will be confounded with the income effect. Previous studies use a different set of variables that do not differenciate among the effect of the mother and father work status (none working, at least one half time, at least one full time, both full time), and find mixed results (Fuchs and Woessman, 2007; Woessman et al., 2007).
(3) / (4)	Out of school lessons	Set of dummy variables that indicate how much time do the student attend to out of school lessons in the specific subject (zero hours, between 0 and 2 hours, between 2 and 4 hours, between 4 and 6 hours, and more than 6 hours). The baseline cathegory is between 0 and 2 hours, to differenciate among students that do not attend out of school lessons at all, and students that attend out of school lessons.	Student	PISA 2009	Students that do not attend out of school lessons are expected to perform better, since they might be good students. Among students that attend out of school lessons, we should expect them to perform better as more hours they spend. This variable could be endogenous, as is might be correlated to the innate ability of the student.
(3) / (4)	Home educational resources	Index constructed from the students' responses about the availability at home of a desk, a quiet place to study, a computer to use for school work, educational software, textbooks, technical books and a dictionary.	Student	PISA 2009	As home possessions might be related to family wealth (families with higher income purchase more such goods), we would expect these variables to positively influence educational outcomes. Previous studies do not always

Table A.1. Definition of variables included in the model

Model	Variable	Definition	Level	Source	Expected effect on educational attainment
(3) / (4)	Home possessions	Set of two dummy variables that indicate if the student has or not a *DVD* and *Internet;* and a set of variables that indicate how many *TVs* and *Cars* their family have, being the residual cathegory not having each of these items.	Student	PISA 2009	obtain significant coefficients of the expected sign for family resource variables, because they include in the same regression these variables and the per capita GDP (Woessman, 2003; Fuchs and Woessman, 2007; Woessman et al., 2007), what can seriously bias the coefficients.
	Family background				
(3) / (4)	Parent's education	Set of dummy variables that indicate the highest level of education of the student's parents, among primary education or less (residual cathegory), lower secondary, upper secondary and university education.	Student	PISA 2009	Students whose parents have a higher level of education are expected to performe better than students whose parents have a lower level of education (Fuchs and Woessman, 2007).
(3) / (4)	Parent's job	Set of dummy variables that classify parents' jobs into white collar high skilled (ISCO 1-3), white collar low skilled (ISCO 4-5), blue collar high skilled (ISCO 6-7) and blue collar low skilled (ISCO8-9), which is the residual cathegory.	Student	PISA 2009	Students whose parents are white collar high skilled workers are expected to perform better than white collar low skilled workers and better than blue collar low skilled workers. Students whose parents are blue collar high skilled workers are also expected to perform better than blue collar low skilled workers (Fuchs and Woessman, 2007; Woessman et al., 2007).
(3) / (4)	Books at home	Set of dummy variables that indicate how many books there are at the student home (between 1 and 10, between 11 and 25, between 26 and 100, between 101 and 200, between 201 and 500, more than 500). The residual cathegory is between 1 and 10 books.	Student	PISA 2009	Books at home are considered as a mesure of the educational and social background of the family. Students are expected to perform better the more the books at home (Fuchs and Woessman, 2007; Woessman et al., 2007).
(3) / (4)	Family structure	Set of dummy variables that indicate if the student is *living with a single father, a single mother, with both parents* or no parents, which is the residual cathegory. We also include a dummy variable that indicate if the student has brothers or sisters or not (*Living with brothers*), and a dummy variable that indicate if the student is *living with grandparents* .	Student	PISA 2009	Students who live with both parents are expected to perform better than students who live with a single mother, the latter to perform better than students who live with a single father, and the latter to perform better than students who do not live with any parent (Fuchs and Woessman, 2007; Woessman et al., 2007).
(3) / (4)	Immigration status	Dummy variable that indicate if the student was born in the country of assessment or had at least one parent born in the country (*Native students*).	Student	PISA 2009	Native students are expected to perform better than second generation students and non-native students (Woessman et al., 2007).
(3) / (4)	Language at home	Dummy variable that indicates if the student speaks the test language at home or not (*Speak test language*).	Student	PISA 2009	Students that speak the test language at home are expected to perform better than the rest of the students (Woessman et al., 2007).

Source: own made

[1] Data about lower-secondary education expenditure were not available for some countries. In such cases, we computed the education expenditure decentralization variable using data on expenditure in primary and lower-secondary education (in Belgium, Greece, Israel and Portugal), data on expenditure in primary and secondary education (in Canada), and data on expenditure in education as a whole (in Sweden).

Table A.2. Average test scores, decentralization and educational expenditure by country and region. OECD countries.

Country name	Students	Schools	Teacher quality						Mean test scores					
			Teachers' education		Teachers' certification		Disciplinary clima		Maths		Science		Reading	
			mean	s.e.	mean	s.e.	mean	s.e.	mean	s.e.	mean	s.e.	mean	s.e.
Australia	14,251	353	94.64	0.88	98.44	0.55	-0.08	0.02	514.34	2.53	527.27	2.53	514.90	2.34
Austria	6,590	282	46.60	1.97	89.23	1.26	0.11	0.04	495.91	2.66	494.33	3.24	470.28	2.95
Belgium	8,501	278	36.69	0.76	91.14	0.93	-0.07	0.02	515.27	2.25	506.58	2.52	505.95	2.35
Belgium (Fl.)	4,596	158	37.71	1.10	96.79	0.71	-0.11	0.03	536.72	3.06	526.11	2.91	518.57	2.34
Belgium (Fr.)	3,905	120	35.44	1.19	84.15	2.18	-0.01	0.04	488.78	3.82	482.44	4.17	490.34	4.16
Canada	23,207	978	91.72	1.02	91.03	1.09	-0.08	0.01	526.81	1.61	528.70	1.62	524.24	1.48
Chile	5,669	200	93.35	0.80	15.26	1.55	-0.11	0.02	421.06	3.06	447.47	2.92	449.37	3.13
Czech Republic	6,064	261	86.65	0.85	87.77	1.20	-0.18	0.03	492.81	2.83	500.50	2.97	478.19	2.89
Denmark	5,924	285	3.38	0.54	91.61	1.02	0.01	0.02	503.28	2.60	499.34	2.48	494.92	2.07
Estonia	4,727	175	90.77	1.24	90.77	1.24	0.05	0.03	512.10	2.57	527.83	2.67	500.96	2.64
Finland	5,810	203	91.11	0.96	91.11	0.96	-0.29	0.02	540.50	2.17	554.08	2.34	535.88	2.25
France [2]	4,298	168	-	-	-	-	-0.20	0.03	496.78	3.09	498.23	3.60	495.62	3.44
Germany	4,979	226	92.81	1.22	92.81	1.22	0.25	0.02	512.78	2.86	520.41	2.80	497.31	2.66
Greece	4,969	184	93.88	1.11	96.42	0.77	-0.40	0.02	466.10	3.88	470.12	4.04	482.78	4.32
Hungary	4,605	187	95.49	1.39	95.49	1.39	-0.02	0.03	490.17	3.45	502.64	3.14	494.18	3.17
Iceland	3,646	131	66.83	0.13	85.14	0.07	-0.06	0.01	506.67	1.39	495.60	1.41	500.28	1.41
Ireland	3,937	144	94.83	1.46	97.45	0.45	-0.03	0.03	487.14	2.54	507.98	3.27	495.64	2.97
Israel	5,761	176	90.31	0.89	78.46	2.32	0.07	0.02	446.86	3.28	454.85	3.11	473.99	3.63
Italy	30,905	1,097	76.71	1.15	87.65	0.67	0.03	0.02	482.91	1.86	488.83	1.77	486.05	1.57
Japan	6,088	186	98.14	0.31	97.92	0.59	0.75	0.02	528.99	3.33	539.43	3.41	519.86	3.47
Korea	4,989	157	98.13	0.69	97.83	0.90	0.38	0.03	546.23	4.02	537.99	3.44	539.27	3.46
Luxembourg	4,622	39	90.43	0.04	72.06	0.04	-0.21	0.02	489.07	1.18	483.93	1.23	472.17	1.25
Mexico	38,250	1,535	89.37	0.67	47.00	1.15	0.11	0.01	418.51	1.83	415.91	1.79	425.27	1.95
Netherlands	4,760	186	25.95	1.82	82.88	1.92	-0.28	0.02	525.84	4.75	522.22	5.42	508.40	5.15
New Zealand	4,642	162	90.96	0.55	96.15	0.42	-0.12	0.02	519.30	2.31	532.01	2.58	520.88	2.35
Norway	4,660	197	17.42	1.39	90.21	1.41	-0.24	0.02	497.96	2.40	499.88	2.60	503.23	2.58
Poland	4,917	185	94.11	1.60	98.82	0.26	0.07	0.03	494.80	2.84	508.07	2.41	500.48	2.60
Portugal	6,298	214	7.36	0.70	92.65	0.69	0.19	0.03	486.89	2.91	492.95	2.90	489.33	3.07
Slovak Republic	4,555	189	21.47	1.31	76.67	1.23	-0.02	0.03	496.68	3.08	490.27	2.99	477.44	2.54
Slovenia	6,155	341	87.54	0.21	95.28	0.03	-0.11	0.02	501.47	1.23	511.76	1.15	483.08	1.03
Spain	25,887	888	100.00	0.00	100.00	0.00	0.08	0.02	483.49	2.11	488.25	2.05	481.04	2.02
Sweden	4,567	189	78.81	2.22	90.94	0.80	-0.04	0.03	494.24	2.90	495.11	2.72	497.45	2.88
Switzerland	11,812	426	61.76	2.37	85.46	1.25	0.09	0.03	533.96	3.30	516.57	2.82	500.50	2.44
Turkey	4,996	170	96.51	1.18	3.49	1.18	0.03	0.02	445.45	4.44	453.91	3.60	464.19	3.52
United Kingdom	12,179	482	9.62	0.35	96.03	0.55	0.11	0.03	492.41	2.42	513.71	2.52	494.18	2.28
England [1]	9,548	384	2.91	0.24	95.89	0.59	0.12	0.03	491.84	2.66	513.67	2.75	493.66	2.51
Scotland	2,631	98	86.47	2.54	97.69	1.01	0.03	0.03	499.02	3.27	514.23	3.55	500.11	3.16
United States	5,233	165	96.22	1.23	94.53	1.46	0.16	0.02	487.40	3.57	502.00	3.64	499.83	3.65
OECD	**298,453**	**11,039**	**85.23**	**0.40**	**82.10**	**0.44**	**0.14**	**0.01**	**488.40**	**1.18**	**496.44**	**1.23**	**491.55**	**1.19**

[1] PISA data includes England, Wales and Northem Ireland

[2] France is not included in the analyses, since the variables of the school questionnaire were not available for this country.

Table A.3. Description of variables included in the model

Variable	Missing rate (%)	Mean	Std. Dev.	95% Confidence interval	
Teacher quality					
Teachers education	11.41%	85.23	0.40	84.43	86.02
Teachers certification	13.36%	82.10	0.44	81.22	82.97
Disciplinary clima	2.00%	0.16	0.01	0.14	0.17
Student assignments					
Student assignments					
Student assignments	2.05%				
Decentralization					
Education decision-making decentralization	0.00%	50.62	0.14	50.34	50.89
Choice and teaching methods	0.00%	17.41	0.10	17.21	17.60
Personnel	0.00%	62.26	0.21	61.84	62.67
Curriculum, certification and infrastructures	0.00%	53.91	0.29	53.33	54.48
School budget	0.00%	69.04	0.11	68.81	69.26
Education expenditure decent.	0.00%	80.92	0.16	80.59	81.24
Tax decentralization	0.00%	13.58	0.06	13.46	13.70
School inputs					
School resources					
Student-teacher ratio	8.39%	16.06	0.12	15.83	16.29
Educ. resources quality	1.48%	0.07	0.02	0.02	0.11
Extra-curricular activities	1.73%	0.45	0.02	0.41	0.49
Math instruction time	7.21%	232.08	1.05	229.98	234.17
Science instruction time	9.95%	221.12	1.13	218.87	223.38
Language instruction time	7.38%	233.98	0.93	232.13	235.84
Computer-student ratio	7.06%	0.56	0.01	0.53	0.58
Expenditure per student					
School organization					
Public school	3.04%	0.84	0.00	0.83	0.85
Private government dependent	3.04%	0.06	0.00	0.05	0.06
Private government independent	3.04%	0.08	0.01	0.06	0.09
Percentage school decisions	0.00%	35.70	0.08	35.54	35.85
School size	3.67%	960.52	15.23	930.20	990.84
Grades 7 to 13	1.60%	0.20	0.01	0.19	0.21
Ungraded school	47.16%	0.02	0.00	0.02	0.03
Non availability of other schools	1.60%	0.19	0.01	0.17	0.21
School location: village	1.38%	0.09	0.01	0.08	0.10
School location: small town	1.38%	0.16	0.01	0.14	0.18
School location: town	1.38%	0.31	0.01	0.29	0.33
Ability grouping	1.93%	0.74	0.01	0.72	0.75
Principal characteristics and practices					
Leadership of principal	1.41%	0.23	0.03	0.18	0.29
Professional development: seldom	1.78%	0.10	0.01	0.09	0.11
Professional development: quite often	1.78%	0.39	0.01	0.37	0.41
Professional development: very often	1.78%	0.48	0.01	0.45	0.50
Accountability					
Achievement to evaluate teacher	1.93%	0.47	0.01	0.45	0.50
School achievement tracked	2.14%	0.70	0.01	0.69	0.72
School achievement other schools	3.08%	0.34	0.01	0.33	0.36
Parents pressure many	2.12%	0.23	0.01	0.20	0.25
Parents pressure minority	2.12%	0.48	0.01	0.45	0.51
Parents pressure absent *(residual)*	2.12%	0.27	0.01	0.25	0.29
School achievement made public	1.86%	0.48	0.01	0.46	0.50
Student characteristics					
Schools' aggregate characteristics of the students					
Zero percentage of inmigrant students	22.76%	0.23	0.01	0.21	0.25
School selectivity	1.92%	0.39	0.01	0.38	0.41
Transfer because of behavior	10.76%	0.45	0.01	0.43	0.47
Wealth	1.03%	-0.17	0.01	-0.20	-0.15
Cultural possessions	1.87%	-0.10	0.01	-0.12	-0.08
Student behavior	1.39%	-0.05	0.02	-0.09	-0.01

Table A.3. Description of variables included in the model

Variable	Missing rate (%)	Mean	Std. Dev.	95% Confidence interval	
Student level characteristics					
Grade 7	0.36%	0.00	0.00	0.00	0.00
Grade 8	0.36%	0.03	0.00	0.03	0.03
Grade 9	0.36%	0.23	0.00	0.23	0.24
Grade 10	0.36%	0.61	0.00	0.60	0.61
Grade 11	0.36%	0.13	0.00	0.12	0.13
Age (months)	0.00%	189.21	0.03	189.16	189.27
General programme	0.26%	0.56	0.00	0.55	0.57
Expected university	69.82%	0.16	0.00	0.16	0.17
Enjoyment of reading	2.59%	0.06	0.01	0.05	0.08
Library use	2.26%	0.13	0.01	0.11	0.14
Attitude towards school	7.33%	0.06	0.01	0.05	0.08
Female	0.00%	0.49	0.00	0.49	0.50
Pre-primary education no	2.05%	0.09	0.00	0.08	0.09
Pre-primary education less 1 year	2.05%	0.21	0.00	0.21	0.22
Pre-primary education more 1 year *(residual)*	2.05%	0.68	0.00	0.68	0.69
Repeat primary education	20.19%	0.07	0.00	0.07	0.08
Repeat lower-secondary education	27.65%	0.05	0.00	0.04	0.05
Repeat upper-secondary education no *(residual)*	40.74%	0.57	0.00	0.57	0.58
Repeat upper-secondary education once	40.74%	0.02	0.00	0.02	0.02
Repeat upper-secondary education more	40.74%	0.00	0.00	0.00	0.00
Memorisation strategies	1.59%	-0.04	0.01	-0.05	-0.02
Elaboration strategies	1.72%	-0.04	0.01	-0.05	-0.03
Control strategies	1.62%	-0.03	0.01	-0.04	-0.01
Understand text	4.58%	-0.06	0.01	-0.07	-0.05
Summarize text	4.63%	-0.07	0.01	-0.09	-0.06
Family inputs					
Family resources					
Mother full-time	4.01%	0.43	0.00	0.42	0.43
Mother part-time	4.01%	0.19	0.00	0.19	0.20
Mother looking for job *(residual)*	4.01%	0.06	0.00	0.05	0.06
Mother other *(residual)*	4.01%	0.28	0.00	0.28	0.29
Father full-time	7.37%	0.73	0.00	0.72	0.73
Father part-time	7.37%	0.08	0.00	0.08	0.08
Father looking for job *(residual)*	7.37%	0.04	0.00	0.04	0.04
Father other *(residual)*	7.37%	0.08	0.00	0.07	0.08
Out school math lessons 0 hours	22.64%	0.48	0.00	0.47	0.49
Out school math lessons 0-2 hours	22.64%	0.12	0.00	0.12	0.13
Out school math lessons 2-4 hours	22.64%	0.09	0.00	0.09	0.10
Out school math lessons 4-6 hours	22.64%	0.05	0.00	0.05	0.05
Out school math lessons More 6 hours	22.64%	0.03	0.00	0.03	0.03
Out school science lessons 0 hours	24.24%	0.55	0.00	0.54	0.55
Out school science lessons 0-2 hours	24.24%	0.10	0.00	0.10	0.11
Out school science lessons 2-4 hours	24.24%	0.06	0.00	0.06	0.07
Out school science lessons 4-6 hours	24.24%	0.03	0.00	0.03	0.03
Out school science lessons More 6 hours	24.24%	0.01	0.00	0.01	0.02
Out school language lessons 0 hours	22.93%	0.56	0.00	0.55	0.57
Out school language lessons 0-2 hours *(residual)*	22.93%	0.10	0.00	0.10	0.10
Out school language lessons 2-4 hours	22.93%	0.06	0.00	0.06	0.07
Out school language lessons 4-6 hours	22.93%	0.03	0.00	0.03	0.03
Out school language lessons More 6 hours	22.93%	0.01	0.00	0.01	0.02
Home educational resources	1.25%	-0.17	0.01	-0.19	-0.16
DVD	1.73%	0.89	0.00	0.89	0.89
Internet	1.93%	0.80	0.00	0.79	0.81
TV none	1.46%	0.01	0.00	0.01	0.01
TV one	1.46%	0.15	0.00	0.15	0.16
TV two	1.46%	0.28	0.00	0.27	0.28
TV more	1.46%	0.55	0.00	0.54	0.55
Cars none	1.92%	0.13	0.00	0.12	0.13
Cars one	1.92%	0.30	0.00	0.30	0.31

Table A.3. Description of variables included in the model

Variable	Missing rate (%)	Mean	Std. Dev.	95% Confidence interval	
Cars two	1.92%	0.33	0.00	0.32	0.33
Cars more	1.92%	0.23	0.00	0.22	0.23
Family background					
Parents' educ. none *(residual)*	3.14%	0.02	0.00	0.01	0.02
Parents' educ. primary *(residual)*	3.14%	0.05	0.00	0.05	0.05
Parents' educ. lower-sec.	3.14%	0.09	0.00	0.09	0.10
Parents' educ. upper-sec.	3.14%	0.34	0.00	0.33	0.35
Parents' educ. university	3.14%	0.47	0.00	0.46	0.48
Parents' job white high skilled	5.47%	0.51	0.00	0.51	0.52
Parents' job white low skilled	5.47%	0.23	0.00	0.22	0.23
Parents' job blue high skilled	5.47%	0.12	0.00	0.11	0.12
Parents' job blue low skilled *(residual)*	5.47%	0.09	0.00	0.09	0.09
Books 1-10 *(residual)*	2.03%	0.16	0.00	0.16	0.17
Books 11-25	2.03%	0.18	0.00	0.17	0.18
Books 26-100	2.03%	0.29	0.00	0.28	0.29
Books 101-200	2.03%	0.16	0.00	0.16	0.17
Books 201-500	2.03%	0.12	0.00	0.12	0.13
Books more 500	2.03%	0.07	0.00	0.06	0.07
Living with both parents	8.01%	0.76	0.00	0.75	0.77
Living with single mother	8.01%	0.11	0.00	0.11	0.11
Living with single father	8.01%	0.02	0.00	0.02	0.02
Living with no parents *(residual)*	8.01%	0.03	0.00	0.03	0.03
Living with brothers	22.44%	0.79	0.00	0.78	0.79
Living with grandparents	25.17%	0.14	0.00	0.13	0.14
Native students	2.50%	0.88	0.00	0.87	0.88
Speak test language	3.32%	0.89	0.00	0.89	0.90

Table A.4. The effect of decision-making decentralization on teachers' education

	Specification (1)		Specification (2)	
	(1)	(2)	(3)	(4)
	coef	se	coef	se
Decentralization				
Education decision-making decentralization	0.046***	0.016	0.032**	0.016
School characteristics				
Public school	-0.034	0.021	-0.016	0.021
Private government dependent school	-0.059***	0.022	-0.040*	0.022
School size	0.000***	0.000	0.000***	0.000
Grades 7 to 13	0.117***	0.006	0.118***	0.006
Ungraded school	-0.520***	0.022	-0.519***	0.022
Availability of other schools	0.017*	0.010	0.013	0.010
School location: village	-0.085***	0.016	-0.076***	0.015
School location: small town	-0.087***	0.010	-0.080***	0.009
School location: town	-0.069***	0.010	-0.066***	0.010
Schools decision-making power	-0.436***	0.018	-0.459***	0.019
Students characteristics				
Zero percentage of inmigrant students	0.066***	0.010	0.066***	0.010
School selectivity	0.046***	0.008	0.047***	0.008
Transfer because of behavior	-0.049***	0.009	-0.044***	0.008
Student behavior	-0.006	0.005	-0.018***	0.005
Wealth	-0.113***	0.005	-0.119***	0.006
Cultural possessions	0.052***	0.007	0.049***	0.007
Programme characteristics controls				
Grade 7	-0.086***	0.026	-0.069***	0.025
Grade 8	-0.090***	0.012	-0.068***	0.012
Grade 9	-0.031***	0.008	-0.010	0.008
Grade 10	-0.006	0.008	0.013	0.009
General programme	0.088***	0.007	0.093***	0.007
School inputs				
Student-teacher ratio	-	-	0.001**	0.001
Shortage of instructional material	-	-	-0.148***	0.021
Principal leader	-	-	0.016***	0.004
Accountability				
Parents pressure many	-	-	0.070***	0.012
Parents pressure minority	-	-	0.031***	0.008
Constant	0.980***	0.026	0.929***	0.027
R2	0.297		0.314	
Number of students	294,136		294,136	
Number of schools	10,872		10,872	
Number of regions	35		35	

Notes: the dependent variable is the teachers education variable. Columns (1) and (2) present the results of estimating specification (1) and columns (3) and (4) the results of estimating specification (2). Both regressions control by the missing dummy variables. Coefficients estimated by least-squares weighted by students' sampling probability, with equal weights for each country. Robust standard errors adjusted for clustering at the regional level and school level. *** p<0.01, ** p<0.05, * p<0.1

Table A.5. The effect of decision-making decentralization on teachers' certification

	Specification (1)		Specification (2)	
	(1)	(2)	(3)	(4)
	coef	se	coef	se
Decentralization				
Education decision-making decentralization	0.110***	0.010	0.110***	0.009
School characteristics				
Public school	0.045**	0.019	0.051***	0.018
Private government dependent school	-0.047**	0.020	-0.029	0.019
School size	0.000***	0.000	0.000***	0.000
Grades 7 to 13	-0.008	0.006	-0.019***	0.006
Ungraded school	0.027**	0.013	-0.004	0.014
Availability of other schools	0.028***	0.007	0.029***	0.007
School location: village	-0.009	0.010	-0.010	0.009
School location: small town	-0.009	0.007	-0.011	0.007
School location: town	-0.017**	0.007	-0.018**	0.007
Schools decision-making power	0.274***	0.016	0.257***	0.016
Students characteristics				
Zero percentage of inmigrant students	-0.071***	0.008	-0.050***	0.008
School selectivity	-0.025***	0.007	-0.021***	0.006
Transfer because of behavior	-0.018***	0.006	-0.020***	0.006
Student behavior	0.055***	0.004	0.043***	0.003
Wealth	0.126***	0.005	0.093***	0.005
Cultural possessions	-0.048***	0.005	-0.030***	0.005
Programme characteristics controls				
Grade 7	0.054***	0.017	0.021	0.015
Grade 8	0.034***	0.008	0.000	0.008
Grade 9	0.032***	0.007	0.003	0.007
Grade 10	0.014**	0.006	-0.006	0.006
General programme	-0.040***	0.006	-0.050***	0.006
School inputs				
Student-teacher ratio	-	-	-0.006***	0.001
Shortage of instructional material	-	-	-0.226***	0.024
Principal leader	-	-	-0.024***	0.003
Accountability				
Parents pressure many	-	-	0.002	0.008
Parents pressure minority	-	-	0.013**	0.007
Constant	0.751***	0.024	0.860***	0.025
R2	0.244		0.307	
Number of students	294,136		294,136	
Number of schools	10,872		10,872	
Number of regions	35		35	

Notes: the dependent variable is the teachers certification variable. Columns (1) and (2) present the results of estimating specification (1) and columns (3) and (4) the results of estimating specification (2). Both regressions control by the missing dummy variables. Coefficients estimated by least-squares weighted by students' sampling probability, with equal weights for each country. Robust standard errors adjusted for clustering at the regional level and school level. *** p<0.01, ** p<0.05, * p<0.1

Table A.6. The effect of decision-making decentralization on disciplinary climate

	Specification (1)		Specification (2)	
	(1)	(2)	(3)	(4)
	coef	se	coef	se
Decentralization				
Education decision-making decentralization	0.003***	0.000	0.003***	0.000
School characteristics				
Public school	-0.117***	0.028	-0.105***	0.028
Private government dependent school	-0.110***	0.031	-0.095***	0.031
School size	0.000***	0.000	0.000***	0.000
Grades 7 to 13	0.025**	0.013	0.025*	0.013
Ungraded school	0.182***	0.025	0.181***	0.025
Availability of other schools	0.036***	0.012	0.032***	0.012
School location: village	0.045**	0.019	0.048**	0.019
School location: small town	0.026*	0.014	0.029**	0.014
School location: town	-0.000	0.013	0.002	0.013
Schools decision-making power	0.000	0.000	0.000	0.000
Students characteristics				
Zero percentage of inmigrant students	0.031**	0.012	0.033***	0.012
School selectivity	0.087***	0.009	0.087***	0.009
Transfer because of behavior	-0.074***	0.011	-0.070***	0.011
Student behavior	0.103***	0.005	0.098***	0.005
Wealth	-0.034***	0.009	-0.045***	0.009
Cultural possessions	0.094***	0.012	0.090***	0.012
Programme characteristics controls				
Grade 7	-0.112***	0.032	-0.104***	0.032
Grade 8	-0.132***	0.017	-0.122***	0.017
Grade 9	-0.125***	0.015	-0.116***	0.016
Grade 10	-0.104***	0.014	-0.096***	0.014
General programme	0.013	0.012	0.011	0.012
School inputs				
Student-teacher ratio	-	-	-0.000	0.000
Shortage of instructional material	-	-	-0.041	0.026
Principal leader	-	-	-0.004	0.005
Accountability				
Parents pressure many	-	-	0.087***	0.013
Parents pressure minority	-	-	0.035***	0.012
Constant	-0.014	0.038	-0.047	0.040
R2	0.244		0.307	
Number of students	294,136		294,136	
Number of schools	10,872		10,872	
Number of regions	35		35	

Notes: the dependent variable is the disciplinary climate variable. Columns (1) and (2) present the results of estimating specification (1) and columns (3) and (4) the results of estimating specification (2). Both regressions control by the missing dummy variables. Coefficients estimated by least-squares weighted by students' sampling probability, with equal weights for each country. Robust standard errors adjusted for clustering at the regional level and school level. *** p<0.01, ** p<0.05, * p<0.1

Table A.7. The effect of decision-making decentralization on math's test scores

	Specification (3)		Specification (4)	
	(1)	(2)	(3)	(4)
	coef	se	coef	se
Decentralization				
Education decision-making decentralization	0.373***	0.018	0.345***	0.018
Teacher quality				
Teachers education	-	-	-0.096	1.201
Teachers certification	-	-	17.237***	1.879
Disciplinary clima	-	-	11.264***	0.959
School characteristics				
Public school	1.022	2.316	1.525	2.276
Private government dependent school	-1.345	2.749	0.802	2.684
Availability of other schools	0.386	0.899	-0.821	0.911
School selectivity	5.416***	0.398	5.467***	0.401
Schools decision-making power	0.400***	0.023	0.389***	0.025
Student characteristics				
Female	-32.050***	0.402	-32.321***	0.393
Grade 7	-41.140***	3.738	-41.406***	3.569
Grade 8	-27.370***	1.751	-27.116***	1.756
Grade 9	-9.282***	1.186	-8.267***	1.211
Grade 10	-4.236***	1.086	-2.308**	1.133
Age (months)	0.575***	0.049	0.544***	0.050
General programme	11.864***	0.905	13.496***	0.953
Pre-primary education no	-8.767***	0.782	-7.002***	0.780
Pre-primary education less 1 year	-6.215***	0.600	-5.634***	0.583
Repeat primary education	-25.816***	0.911	-25.646***	0.865
Repeat lower-secondary education	-24.218***	1.326	-23.319***	1.282
Repeat upper-secondary education once	-30.410***	1.782	-26.913***	1.756
Repeat upper-secondary education more	-27.475***	6.224	-27.370***	6.171
Expected university	27.416***	0.684	26.917***	0.684
Enjoyment of reading	10.996***	0.254	10.682***	0.260
Memorisation strategies	-11.045***	0.237	-11.143***	0.234
Elaboration strategies	0.082	0.213	0.205	0.218
Control strategies	8.441***	0.236	8.530***	0.235
Understand text	9.741***	0.224	9.423***	0.220
Summarize text	14.689***	0.208	14.495***	0.200
Library use	-8.556***	0.224	-8.353***	0.220
Peer effects				
Student behavior	5.815***	0.485	4.210	0.481
Family inputs				
Family resources				
Mother full-time	1.178**	0.483	0.848*	0.490
Mother part-time	5.561***	0.532	5.027***	0.529
Father full-time	2.485***	0.569	2.538***	0.545
Father part-time	-9.301***	0.739	-8.478***	0.716
Out school lessons 0 hours	18.175***	0.585	18.923***	0.588
Out school lessons 2-4 hours	-0.309	0.787	-0.499	0.762
Out school lessons 4-6 hours	-0.970	1.055	-1.226	1.034
Out school lessons More 6 hours	1.587	1.517	1.304	1.395
Home educational resources	6.037***	0.271	6.164***	0.248
DVD	-9.676***	0.840	-9.245***	0.825
Internet	17.499***	0.761	15.505***	0.799
TV one	11.180***	2.586	14.371***	2.720

Table A.7. The effect of decision-making decentralization on math's test scores

	Specification (3)		Specification (4)	
	(1)	(2)	(3)	(4)
	coef	se	coef	se
TV two	5.041***	2.456	8.379***	2.571
TV more	-1.113	2.497	2.193	2.601
Cars one	11.313***	0.795	9.237***	0.789
Cars two	14.832***	0.817	12.339***	0.838
Cars more	11.458***	0.911	8.655***	0.967
Family background				
Parents' educ. lower-sec.	-5.389***	1.255	-5.083***	1.278
Parents' educ. upper-sec.	-0.695	1.229	-0.754	1.283
Parents' educ. university	4.347***	1.244	4.397***	1.284
Parents' job white high skilled	16.443***	0.816	16.104***	0.815
Parents' job white low skilled	7.188***	0.836	6.535***	0.829
Parents' job blue high skilled	3.364***	0.782	2.698***	0.771
Books 11-25	5.014***	0.616	4.788***	0.609
Books 26-100	15.879***	0.602	15.367***	0.597
Books 101-200	26.488***	0.599	25.793***	0.594
Books 201-500	37.742***	0.818	36.878***	0.815
Books more 500	38.454***	0.898	37.549***	0.888
Living with both parents	28.862***	1.954	27.690***	1.956
Living with single mother	28.729***	1.378	27.758***	1.398
Living with single father	30.570***	1.295	29.466***	1.298
Living with brothers	1.896***	0.454	1.921***	0.459
Living with grandparents	-5.654***	0.532	-5.953***	0.531
Native students	3.908***	0.842	5.109***	0.853
Speak test language	-2.477***	0.819	-2.953***	0.833
Constant	268.588***	10.798	260.631***	10.979
R2	0.514		0.516	
Number of students	294,136		294,136	
Number of schools	10,872		10,872	
Number of regions	35		35	

Notes: the dependent variable is students' test scores in maths in PISA 2009. Columns (1) and (2) present the results of estimating specification (3) and columns (3) and (4) the results of estimating specification (4). Both regressions control by the missing dummy variables. Coefficients estimated by least-squares weighted by students' sampling probability, with equal weights for each country. Robust standard errors adjusted for clustering at the regional level and school level. *** p<0.01, ** p<0.05, * p<0.1

Table A.8. The effect of decision-making decentralization on science test scores

	Specification (3)		Specification (4)	
	(1)	(2)	(3)	(4)
	coef	se	coef	se
Decentralization				
Education decision-making decentralization	0.324***	0.020	0.284***	0.020
Teacher quality				
Teachers education	-	-	9.712***	1.072
Teachers certification	-	-	15.695***	1.601
Disciplinary clima	-	-	11.355***	0.880
School characteristics				
Public school	-1.949	2.302	-0.655	2.219
Private government dependent school	-4.336*	2.601	-1.543	2.509
Availability of other schools	1.595*	0.821	0.099	0.830
School selectivity	4.823***	0.412	4.009***	0.424
Schools decision-making power	0.466***	0.023	0.512***	0.025
Student characteristics				
Female	-26.109***	0.406	-26.161***	0.402
Grade 7	-47.730***	4.460	-45.962***	4.072
Grade 8	-30.806***	1.747	-27.691***	1.782
Grade 9	-15.604***	1.293	-12.886***	1.326
Grade 10	-12.349***	1.147	-9.657***	1.170
Age (months)	0.608***	0.054	0.587***	0.054
General programme	8.736***	0.959	8.933***	0.962
Pre-primary education no	-5.002***	0.731	-3.966***	0.680
Pre-primary education less 1 year	-0.402	0.501	-0.271	0.500
Repeat primary education	-20.647***	0.930	-20.693***	0.907
Repeat lower-secondary education	-23.275***	1.258	-22.510***	1.257
Repeat upper-secondary education once	-22.229***	1.522	-20.605***	1.512
Repeat upper-secondary education more	-26.651***	5.649	-26.901***	5.612
Expected university	23.031***	0.706	22.096***	0.719
Enjoyment of reading	18.523***	0.250	18.148***	0.249
Memorisation strategies	-9.952***	0.227	-10.420***	0.226
Elaboration strategies	-0.843***	0.175	-0.525***	0.178
Control strategies	9.179***	0.223	9.207***	0.214
Understand text	10.1***	0.206	9.756***	0.198
Summarize text	16.533***	0.234	16.467***	0.224
Library use	-8.943***	0.204	-8.933***	0.204
Peer effects				0.000
Student behavior	4.509***	0.430	3.057***	0.427
Family inputs				
Family resources				
Mother full-time	0.809*	0.481	0.914*	0.482
Mother part-time	4.849***	0.531	4.801***	0.532
Father full-time	-0.003	0.579	0.210	0.565
Father part-time	-11.226***	0.774	-10.468***	0.750
Out school lessons 0 hours	11.350***	0.691	12.558***	0.708
Out school lessons 2-4 hours	-7.152***	1.012	-6.929***	1.022
Out school lessons 4-6 hours	-14.517***	1.219	-13.544***	1.203
Out school lessons More 6 hours	-17.918***	2.198	-16.880***	2.155
Home educational resources	4.008***	0.247	4.400***	0.234
DVD	-7.633***	0.854	-6.198***	0.825

Table A.8. The effect of decision-making decentralization on science test scores

	Specification (3)		Specification (4)	
	(1)	(2)	(3)	(4)
	coef	se	coef	se
Internet	15.255***	0.815	13.851***	0.863
TV one	16.134***	2.740	17.648***	2.760
TV two	11.068***	2.740	12.674***	2.755
TV more	5.126*	2.672	7.094***	2.672
Cars one	6.517***	0.752	4.836***	0.761
Cars two	9.873***	0.810	7.640***	0.847
Cars more	7.323***	0.908	4.446***	0.963
Family background				
Parents' educ. lower-sec.	-5.016***	1.093	-5.156***	1.103
Parents' educ. upper-sec.	4.002***	1.095	3.347***	1.123
Parents' educ. university	8.705***	1.154	8.328***	1.163
Parents' job white high skilled	15.668***	0.853	15.334***	0.862
Parents' job white low skilled	6.635***	0.852	6.022***	0.865
Parents' job blue high skilled	3.596***	0.732	2.957***	0.752
Books 11-25	6.856***	0.659	6.460***	0.642
Books 26-100	17.689***	0.644	16.873***	0.636
Books 101-200	26.53***	0.612	25.437***	0.595
Books 201-500	37.378***	0.889	36.009***	0.879
Books more 500	37.787 ***	1.011	36.272***	1.006
Living with both parents	28.282***	1.873	27.333***	1.876
Living with single mother	29.442***	1.370	28.878***	1.376
Living with single father	29.295***	1.325	28.687***	1.320
Living with brothers	-1.452***	0.479	-1.602***	0.480
Living with grandparents	-3.477***	0.598	-4.031***	0.601
Native students	10.28***	0.895	11.295***	0.900
Speak test language	6.161***	0.879	5.919***	0.894
Constant	263.678***	11.852	246.911***	11.876
R2	0.521		0.523	
Number of students	294,136		294,136	
Number of schools	10,872		10,872	
Number of regions	35		35	

Notes: the dependent variable is students' test scores in science in PISA 2009. Columns (1) and (2) present the results of estimating specification (3) and columns (3) and (4) the results of estimating specification (4). Both regressions control by the missing dummy variables. Coefficients estimated by least-squares weighted by students' sampling probability, with equal weights for each country. Robust standard errors adjusted for clustering at the regional level and school level. *** p<0.01, ** p<0.05, * p<0.1

Table A.9. The effect of decision-making decentralization on reading test scores

	Specification (3)		Specification (4)	
	(1)	(2)	(4)	(5)
	coef	se	coef	se
Decentralization				
Education decision-making decentralization	0.218***	0.018	0.182***	0.018
Teacher quality				0.000
Teachers education	-	-	9.445***	0.948
Teachers certification	-	-	12.070***	1.510
Disciplinary clima	-	-	11.207***	0.744
School characteristics				0.000
Public school	-1.605	2.160	-0.345	2.049
Private government dependent school	-0.602	2.442	1.943	2.298
Availability of other schools	3.977***	0.774	2.608***	0.775
School selectivity	2.230***	0.386	1.271***	0.383
Schools decision-making power	0.233***	0.021	0.267***	0.022
Student characteristics				0.000
Female	10.617***	0.351	10.636***	0.353
Grade 7	-53.932***	3.503	-53.097***	3.430
Grade 8	-36.885***	1.553	-34.719***	1.550
Grade 9	-15.746***	1.115	-13.772***	1.136
Grade 10	-7.086***	0.965	-5.001***	0.997
Age (months)	0.363***	0.054	0.340***	0.053
General programme	14.085***	0.820	14.445***	0.834
Pre-primary education no	-6.961***	0.688	-6.228***	0.677
Pre-primary education less 1 year	-0.394	0.480	-0.436	0.469
Repeat primary education	-25.362***	0.858	-24.731***	0.834
Repeat lower-secondary education	-16.983***	1.172	-16.133***	1.144
Repeat upper-secondary education once	-23.702***	1.577	-22.251***	1.518
Repeat upper-secondary education more	-37.02***	6.946	-37.226***	6.901
Expected university	25.641***	0.506	24.537***	0.504
Enjoyment of reading	20.394***	0.226	20.025***	0.225
Memorisation strategies	-6.839***	0.187	-7.223***	0.190
Elaboration strategies	-4.332***	0.188	-3.994***	0.187
Control strategies	9.816***	0.231	9.710***	0.227
Understand text	9.521***	0.194	9.165***	0.188
Summarize text	16.177***	0.215	16.075***	0.204
Library use	-7.794***	0.195	-7.784***	0.192
Peer effects				0.000
Student behavior	5.322***	0.364	3.948***	0.374
Family inputs				0.000
Family resources				0.000
Mother full-time	1.176***	0.410	1.491***	0.408
Mother part-time	2.327***	0.500	2.447***	0.494
Father full-time	-0.740	0.466	-0.493	0.458
Father part-time	-10.005***	0.642	-9.354***	0.625
Out school lessons 0 hours	13.791***	0.693	14.830***	0.710
Out school lessons 2-4 hours	-4.914***	0.878	-4.904***	0.850
Out school lessons 4-6 hours	-15.106***	1.261	-14.461***	1.268
Out school lessons More 6 hours	-22.196***	1.596	-21.357***	1.544
Home educational resources	2.868***	0.214	3.328***	0.210
DVD	-8.551***	0.820	-7.367***	0.806

Table A.9. The effect of decision-making decentralization on reading test scores

	Specification (3)		Specification (4)	
	(1)	(2)	(4)	(5)
	coef	se	coef	se
Internet	16.394***	0.743	15.528***	0.790
TV one	12.942***	2.501	14.601***	2.435
TV two	9.272***	2.461	11.153***	2.378
TV more	4.992***	2.468	7.158***	2.386
Cars one	4.437***	0.615	3.138***	0.644
Cars two	6.002***	0.696	4.223***	0.763
Cars more	1.366*	0.810	-1.038	0.910
Family background				0.000
Parents' educ. lower-sec.	-3.764***	1.092	-3.787***	1.067
Parents' educ. upper-sec.	2.648**	1.141	2.308**	1.125
Parents' educ. university	7.091***	1.123	6.907***	1.096
Parents' job white high skilled	18.243***	0.743	17.951***	0.744
Parents' job white low skilled	7.299***	0.736	6.779***	0.735
Parents' job blue high skilled	1.932***	0.727	1.400*	0.733
Books 11-25	4.789***	0.645	4.444***	0.641
Books 26-100	14.789***	0.596	14.133***	0.599
Books 101-200	23.292***	0.643	22.382***	0.636
Books 201-500	31.766***	0.804	30.609***	0.785
Books more 500	30.465***	0.913	29.259***	0.896
Living with both parents	25.801***	1.829	25.332***	1.816
Living with single mother	27.975***	1.394	27.626***	1.399
Living with single father	27.830***	1.411	27.208***	1.413
Living with brothers	-1.449***	0.437	-1.468***	0.442
Living with grandparents	-6.050***	0.558	-6.613***	0.548
Native students	3.928***	0.784	4.659***	0.800
Speak test language	8.715***	0.756	8.431***	0.755
Constant	303.926***	12.268	290.969***	12.231
R2	0.557		0.559	
Number of students	294,136		294,136	
Number of schools	10,872		10,872	
Number of regions	35		35	

Notes: the dependent variable is students' test scores in reading in PISA 2009. Columns (1) and (2) present the results of estimating specification (3) and columns (3) and (4) the results of estimating specification (4). Both regressions control by the missing dummy variables. Coefficients estimated by least-squares weighted by students' sampling probability, with equal weights for each country. Robust standard errors adjusted for clustering at the regional level and school level. *** p<0.01, ** p<0.05, * p<0.1