Universidad del Rosario

Facultad de Economía

1960 - 2010

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ACADEMIC ACHIEVEMENT IN SCIENCES: THE ROLE OF PREFERENCES AND EDUCATIVE ASSETS

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SERIE DOCUMENTOS DE TRABAJO

No. 78

Enero 2010

Academic Achievement in sciences: The Role of Preferences and Educative Assets

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Abstract

This paper provides new evidence on the effect of pupil's self-motivation and academic assets allocation on the academic achievement in sciences across countries. By using the *Programme for International Student Assessment* 2006 (PISA 2006) test we find that both explanatory variables have a positive effect on student's performance. Self-motivation is measured through an instrument that allows us to avoid possible endogeneity problems. Quantile regression is used for analyzing the existence of different estimated coefficients over the distribution. It is found that both variables have different effect on academic performance depending on the pupil's score. These findings support the importance of designing focalized programs for different populations, especially in terms of access to information and communication technologies such as internet.

JEL Classification: C21, H75, I21, I28.

Keywords: PISA, self-motivation, academic assets, academic achievement, Quantile regression.

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The findings, recommendations, interpretations and conclusions expressed in this paper are those of the authors and not necessarily reflect the view of the Department of Economics at Universidad del Rosario.

1. Introduction.

Determinants of academic achievement in basic education have been widely studied in the literature. Most of the studies that are indented to evaluate the determinants of quality of education by using academic performance tests include as explanatory variables the student's socioeconomic background, school inputs, and inborn factors. Some of the most common findings of these studies are: *i)* Socioeconomic background, usually measured by the educational level of the student's parents, has a positive impact on the school achievement (Peragine and Serlenga, 2007; Checci and Peragine, 2005); *ii)* Boys do better than girls in standardized tests of Mathematics and Science (Hyde *et al*, 1990; Benbow and Stanley, 1980; and Fuchs and Woessmann, 2008); *iii)* the quality and quantity of school's resources maintain an unclear relation with school attainment (Altinok and Bennaghmouch, 2008; Al Samarrai, 2002 among others). However, the increase and efficiency of the amount of educational resources in the school will have a higher effect when the student is open to learning and has incentives to study because one of the main components of the 'effort' done by the student is his motivation to learn. The role of self-motivation is usually not included in empirical applications as a consequence of the information availability. Self-motivation could positively affect educational attainment by at least two different channels. On one hand, greater motivation is directly related to students' effort (attendance, discipline, time devoted to homework, among others) (Cooper, 1989; Betts, 1996; Bishop *et al.*, 2003). On the other hand, motivation could increase the perceived utility of learning. Several studies, carried out at personal level, showed that the outcomes of cognitive skills tests are good indicators of pupil's future income (Boissiere, Knight and Sabot, 1985; Bishop, 1989, 1992; Moll, 1998).

The purpose of this paper is to contribute to the body of literature by providing new evidence about some particular relationships. First, we want to explore the still unclear relation between self-motivation and school achievement; particularly we intend to measure how variations in self-motivation account for differences in achievement levels; second, we want to provide new empirical evidence on the effect of the student's academic assets at home (computer, internet, a place to study, and educational software) on academic performance but in contrast with previous literature, we analyze the relationship over the entire distribution. To control for particular features inherent to each country, both relations are measured taking into account country-level fixed effects. By using the *Programme for International Student Assessment* 2006 (PISA 2006) database, which includes information about several aspects from the environment of the student (personal characteristics and family backgrounds), schools characteristics (schools' resource endowments and location), student's habits and hobbies, among other aspects, we perform our empirical exercises.

The contribution of the paper is threefold. First, cross-country analysis allows for multivariate analyses when there is a higher comparability level as in PISA assessment. Gupta *et al.* (2002) point out the importance of including information from economic level in the Economic Production Function (EPF, hereafter) and it enriches the analysis around the world. The existence of curriculum-based external assessments could increase the focus on academics and forget some of other aspects of education. However, in the case of PISA, the focus is in competences which increase the comparability among countries. Second, given that technology based societies are more prone to development, and science is a crucial input in this process, a self-motivation index that includes choices toward scientific concepts and theories, and the ability to structure and solve scientific problems, is constructed. Third, non linear effect of gender composition and Quantile Regression approach are used. The former is important to disentangle the importance of having mixed populations in the classroom and the latter, lets us to analyze all the distribution, separating the population by different quantiles of the score. Several studies about the EPF of schools have been implemented by methodologies such as Ordinary Least Squares (OLS) and instrumental variables (IV). Most of them do not find that an increase in resources affects positively the result of the test, but they do not take into account that students in different point of the test distribution enjoy different productivity levels of their inputs. Eide and Showalter (1998) use quantile regression over a sample of U.S. students and they find that there seems to be differential school quality effects that policy makers have to take into account.

The rest of the paper is organized as follows. Section 2 presents some theoretical background on the determinants of school achievement. Section 3 is subdivided in two, first we describe the data used from PISA 2006, and then we present our results on the determinants of school achievement. Section 4 summarizes the main conclusions and some policy recommendations.

2. Background.

Economic literature on the determinants of quality of education have been mostly devoted to measure the role of several kinds of inputs on educational achievement by using test scores as an outcome variable from different approaches: The EPF, the internal rate of return of education and its effect of earnings and the study of the education as an input of development. In general, the first approach has been widely used around the world. Since Coleman report (1966), it was emerged a wide set of works about the educational production function. Some of them are Hanushek (1986), Colclough and Lewin, (1993); and Schultz (1995), among others. Al Samarrai (2002) carries out a review of literature concerning the relationships between school resources and educational performance. He concludes that there is no clear relationship between these two variables: while certain studies tend to confirm the conclusions of Hanushek and Kimko (Colclough and Lewin, 1993; Schultz, 1995), others confirm those of Lee and Barro (Gupta and al, 2002; Woessmann, 2000), others give statistical support in the opposite sense (McMahon, 1999; Al Samarrai, 2002).

The EPF approach assumes that education comes from an entity regarded as a manufacturing unit that carry out an input-output process and, in some cases they are not-for profit schools. Among the set of inputs, this literature includes physical resources, budget, teachers, institutions and students. It is also recognized that one important set of determinants of educational performance are the institutions as public versus private financing and provision (e.g., Epple and Romano 1998; Nechyba 1999, 2000; Chen and West 2000), the centralization of financing (e.g., Hoxby 1999, 2001; Nechyba 2003), external versus teacher-based standards and examinations (e.g., Costrell 1994; Betts 1998; Bishop and Woessmann 2004), centralization versus school autonomy in curricular, budgetary, personnel and process decisions (e.g., Bishop and Woessmann 2004) and performance-based incentive contracts (e.g., Hanushek et al. 1994).

Students have an interest in their own performance, when they weigh this objective against others such as the amount of leisure time or increasing social networks through studying less or more. Students' productivity in the EPF clearly depends on aspects such as initial endowments, the existence of 'complementary inputs' that foster their performance and the effort done in learning processes. The role of student's motivation and effort has not received the same attention in the economic literature as other aspects, due to the information availability of variables that reflect that conditions. Self-motivation and effort can be induced by parents and teachers. Parents affect children's performance through many channels. First, they provide a set of resources available to them (books, computers, educative software, and complimentary classes, among others). Second, parent's educative background help to assist their homework's and it could foster their learning. Third, they have a clear interest in schooling resources being used efficiently when they assume that education is an investment and nor a consumption activity.

Motivation is a complex concept with several distinct definitions associated. Walter and Hart (2009) defined it as an individual's desire, power and tendency to act in a particular way. Koaler et al, (2001) treat interest equally as motivation. In this sense, motivation, interest, preferences or positive attitudes could be synonyms. In a general approach, motivation is understood as an intrinsic and extrinsic process where individuals respond to internal as well as external rewards, teacher's praise, and positive feedback, among others (Deci et al, (1991)). Then, motivation is an important starting point in the EPF analysis due to motivated individuals are able to use higher cognitive process to learn, absorb and retain more knowledge and to seek challenges and persist even in difficulties. Motivation also differs and explains gender gaps as a consequence of historical and institutional factors. (See Meece et al (2006) for a detailed study of motivation differences between males and females). Steinkamp and Maehr (1983) say that in previous literature can be extracted that proficiency is before positive attitudes towards sciences. Then, there is a causality problem that needs to be studied in detail, but it is out of the scope of this paper.

The increase and efficiency of the amount of educational resources will be useful when the student is open to learning and has incentives to study. As Chiu and Xihua (2008) point out, students with more educational resources available at home could have more opportunities to learn and to have more intrinsic motivations, (see also Gottfried et al (1998) for a discussion about it). Learning is an activity that requires, among other things, time and active engagement of students. It is also worth mentioning that a student has an additional incentive to study as a consequence of the existence of penalties in case of failure and it determines the intensity of a student's investment in learning (Bishop 1999). Bishop (2006) analyzes the effects and determinants of student effort and cooperativeness, and how to use student motivation and behavior as an instrument for improving learning. From his approach, students face questions such as: How many years to spend in school? How much effort must be devoted to learning per year and whether to disrupt or assist the learning of classmates?. As it can be seen, there are many intrinsic and extrinsic rewards for learning (increases in monitoring imply increase student effort, discipline and learning as well).

Academic assets available at home, may have a positive impact on school achievement through the increase in the productivity of other resources used during the educational process (such as teachers and school's resources). Pupils with access to the internet at home are more likely to complement the lessons received at school, therefore are more likely to perform better. It is expected that the role of academic assets will be a complement and not a substitute of other 'inputs' such as parent's time or school resources. Some empirical applications have studied the relationship between inputs looking for establishing if they are substitutes or complements. Datar and Mason (2008) find that an increase in class size is associated with a decrease in parent-child interaction. In their work, parental and schooling inputs are substitutes which generate a crowd out effect. As it was mentioned before, much of the absence of this type of information comes from the design of surveys and databases. In order to account for the differences between countries, both in the effect of self-motivation and academic assets on the educational achievement, it is necessary to have comparability in the academic tests across countries. External standardized test also provides better information because of the signaling the student wants to give to others such as universities, employers and teachers.

The effect of motivation and effort on the quality of education could be from different perspective: *i)* more motivated students see in learning an activity with a higher utility than leisure; *ii)* motivation increases the number of questions in the student and this induces to look for answers; *iii)* motivation generates a positive externality, when students valuate the subjects they are studying; and *iv)* the existence of central examinations changes the students' incentives (Bishop, 1997). This kind of examination creates comparability to an external standard, they improve the signaling of its academic performance to future employers, and it should increase students' incentives to perform well, by increasing and making better use of their own resources spent on education (their time and attention).

When the student only has his course as a reference point, his performance could be limited to the course level. Woessman (2003) says that grading relative to class performance gives students an incentive to lower average class performance because this allows the students to receive the same grades at less effort. The cooperative solution of students to maximize their joint welfare is for everybody not to study very hard. Bishop (1999) also states that in many cases students have incentives to distract teachers from teaching a high standard and to apply peer pressure on their classmates for not being too studious with grades relative to the class level. Stinebricker and Stinebricker (2007) examine the causal effect of the time used studying on academic performance by using video games as an instrument and they find that effort measured by time studying is positively related to the academic achievements.

In specific areas such as math and sciences the role of self-motivation and effort is especially important as a consequence of the 'special pleasure for learning' because in these areas discipline and perseverance are associated with success. In many cases, effort is measured by the number of minutes or the amount of time dedicated to study. The incentives of students to learn should be influenced by institutional features of the education system which determine the time a student spends studying and the relative benefits of studying. Likewise, centralized examinations – which should make students' learning efforts more visible to external observers and wipe out students' incentives to lower the average performance level of the class – were shown to have a positive impact on students' educational achievement. Both in mathematics and in science, homework frequency is negatively related to student performance, while homework length is actually positively related to student performance. In any event, there is clearly no direct positive relationship between minutes per week a student spends on homework and her test score performance.

Dzama and Osborne (1999) study the causes of poor performance among African students including the interaction between traditional cultures and science and find that poor performance in science among African students is caused by the absence of vocational incentives rather than by the conflict between science and African traditional values and beliefs. They argue that conflict between science and traditional beliefs and values is not peculiar to Africans. They demonstrate that in the growth of science in developed countries, improvement in the performance of students succeeded rather than preceded industrial and technological development.

As it can be seen, student's motivation is crucial for better academic results when it is complemented with basic resources or assets. The relationship between student's test scores and school's capital stock is neither unique nor statistically significant. Altinok and Bennaghmouch (2008) using a database of international tests show that an increase in school resources do not imply an improvement in the quality of educational systems. Hanushek (1998) finds no clear and robust relationship between schools resources and student performance for American students. Krueger (1998), using information from the National assessment of Educational Progress in United States, concludes that there is a small increase in student's scores when public spending is increased. The work of Lee and Barro (2001) analyze the determinants of school quality for several countries with measures of education inputs and outputs and find that school capital stock have a significant impact on skill tests. Hanushek and Kimko (2000) use a similar database of countries for testing the existence of an EPF with a set of inputs as class size, public spending per student and the importance of educational expenditure on GDP, and they find that there is no significant effect on the results.

It is also documented that international differences concerning economic growth recognized the role of human capital and that quality of education is some of its components. Hanushek and Kimko (2000) and Barro (2001) found that results on tests in mathematics and sciences are positively correlated to the economic growth of the per capita GDP at international level.

Using results from PISA-2000, Fuchs and Wossmann (2008) find some interesting results. First, boys outperform girls in math and science but not in reading; second, there is a positive relationship between the country´s educational expenditure per student and the final score in math and science. Third, having better equipment materials and better educated teachers increases student performance in science. Fourth, students in publicly operated schools perform worse than those in privately operated schools. The estimation procedure is done by ordinary least squares solving endogeneity with instrumental variables and using clustering - robust linear regression to estimate standard errors that recognize this clustering of the student-level data within schools. Missing values are analyzed and reduced by using a specific methodology that increased the sample and it is controlled by dummies in the final estimation. (See details in Fuchs and Wossman, 2008).

Psalidas *et al.* (2008) examine the effect of gender, scientific process and context on the students' performance at PISA science component; by applying paper-and-pencil test for 94 Greek students. They include three scientific processes (interesting scientific evidence and conclusions; describing, explaining; and predicting scientific phenomena) and three contexts (earth and environment; life and health; and technology), and use statistical test for differences in means (t-tests, Friedman and Wilcoxon). They find that the difference in average performance by gender and scientific process are not statistically significant.

As it can be seen, traditional studies on quality on education has not included aspects such as self motivation and effort in their estimations. However, they influence academic performance through different channels but its measurement is very difficult.

3. Data and Results.

3.1 PISA: Whom and what is evaluated?

PISA was originally created by the governments of OECD countries but it has now become a major assessment tool in several countries around the world. It is an international initiative managed and oriented by the OECD carry out each three years since 2000. As we mentioned before, each Cycle of PISA has been conducted to specific cognitive areas. (2000-Reading, 2003-Mathematics and 2006- Science).[1] (See Table 1)

Table 1. Evaluated Countries in PISA.

	2000	
OECD countries	Whole OECD except Slovakia and Turkey.	28
Non OECD	Argentina, Latvia, Liechtenstein, Brazil, Albania, Bulgaria, Hong Kong, China, Indonesia, Russia, Macedonia, Thailand, Israel, Peru, Romania, and Chile	16
	2003	
OECD countries	Whole OECD.	30
Non OECD	Brazil, Hong Kong, Indonesia, Latvia, Liechtenstein Macao-China, Russian Federation, Serbia and Montenegro, Thailand, Tunisia, and Uruguay	11
	2006	
OECD countries	Whole OECD.	30
Non OECD	Argentina, Azerbaijan, Brazil, Bulgaria, Croatia, Chile, Colombia, Estonia, Hong Kong, Indonesia, Israel, Jordan, Kyrgyz Republic, Latvia, Liechtenstein, Lithuania, Macao, Qatar, Montenegro, Serbia, Romania, Russian Federation, Slovenia, Taipei, Thailand, Tunisia, and Uruguay	27

Source: OECD.

Adding to the cross-country comparability of PISA, the 2006 version includes an extended sample of Non-OECD countries (27), allowing the comparison between developed and less developed countries.

[1] During 2009 it was carried out other test but the results are not available yet.

PISA assesses the competencies in mentioned areas and the test seeks to assess not merely whether students can reproduce what they have learned, but also to examine how well they can extrapolate it in understanding novel settings. PISA 2006 focused on students' competency in science in the following aspects: Knowledge of scientific concepts; Competencies that students need to apply in specific situations immerse in a particular scientific process; Contexts in which students encounter scientific problems and relevant knowledge and skills are applied (*e.g.* making decisions in relation to personal life, understanding world affairs); and the existence of attitudes of students towards science. (See PISA 2006, for details). Then, PISA 2006 science questions required students to identify scientific issues, explain phenomena scientifically and use scientific evidence. As OECD (2007) states, "…*these three competencies were selected because of their importance to the practice of science and their connection to key cognitive abilities such as inductive/deductive reasoning, systems-based thinking, critical decision making, transformation of information (e.g. creating tables or graphs out of raw data), construction and communication of arguments and explanations based on data, thinking in terms of models, and use of science*" (p.36).

According to PISA, scientific literacy is associated to the ability to use scientific knowledge in order to understand and make choices about future, the natural world and other topics that affects humans. In today's technology-based societies, there is a consensus about the importance of subjects such as science for increasing development which implies better understanding of scientific concepts and theories, and the ability to structure and solve scientific problems and they are more important and valued than ever. Given that, the relevance of measuring what are the determinants of scientific literacy and the availability of self-motivation is crucial for the future of developing countries.

Our dependent variable to measure school performance will be the pupil's score of science at PISA 2006. The sample of students used in PISA 2006 comes from a two step random selection process. First, it was chosen a sample of schools in each country. Second, in each school was extracted a sample of 15 –years old students. As a result of this process, 400,000 students were randomly selected representing about 20 million from 57 participating countries. Each participating student spent two hours carrying out pencil-and-paper tasks. In contrast with other academic test, PISA includes some questions in which requiring students to construct their own answers as well as multiple-choice questions. Additionally, questionnaires about family background, learning habits and attitudes to science, school characteristics are implemented. This is an important feature of the test because of the reported gender gaps in academic achievement due to standardized test.

3.2 Self-motivation, academic assets, and country-level effect.

In this paper, we construct a basic index of motivations towards the sciences as a proxy variable of self-motivation. The information used for the construction of this index classifies pupils into one of three levels of motivation (High, Medium, and Low) according to the answers to the following question: "How much interest do you have in learning about topics in (astronomy, human biology, and geology)?" It is important to remark that this index happens to be an instrumental measure of self-motivation, and the variable from which it is constructed, clearly is not affected by PISA's scores, thus we avoid possible endogeneity problems. This index is complemented with the inclusion of a variable of academic assets available for each student in her or his house. The academic assets index is the sum of four dummy variables associated to the possession of academic tools such as: a desk to study, a computer, educational software, and internet access[2]. The inclusion of these assets could be subjective but they give us additional information than other traditional assets as number of books.

It is evident that OECD countries outperform in sciences the rest of the countries in the sample (See Figure 1.a). Latin American countries have a similar mean to the rest of Non-OECD countries, but with less dispersion, mainly because the latter is a more heterogeneous group of countries (*e.g.* Hong Kong, Jordan, and Lithuania). A more intriguing result is obtained from the density functions by country (Fig. 1.b), the U.S. shows a great standard deviation, even compared with that of commonly labeled as unequal countries, such as Brazil and Colombia. From this figure, the difference between the country with the lowest average performance (Kyrgyzstan) and the one with highest (Finland) is evident; both density functions had their modes quite separately, and have almost no common area.

Finally when the relation between standard deviation and mean score by country is depicted (Fig. 1c), another unexpected finding arises, the two extreme countries, in terms of the mean score (Kyrgyzstan and Finland) have almost the same standard deviation. This finding just

[2] Each asset has the same value in the index, thus the index goes from 0 to 4. Nonetheless, there is a positive correlation between the possessions of each asset.

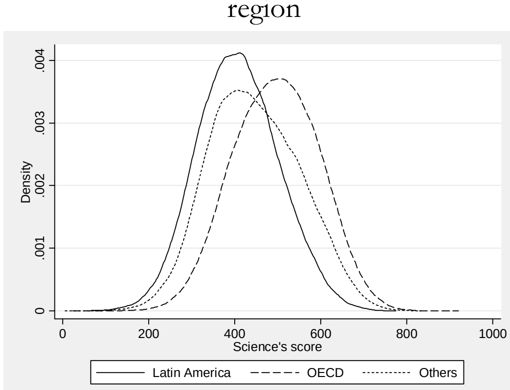
adds to the general observation that there is no clear relation between dispersion and mean score. Again the U.S. appears as one of the countries with highest standard deviation.

Regarding our hypothesis of the positive impact of self-motivation and academic assets at home on the student's performance, we compute the density functions by a self-motivation and by an academic assets index.

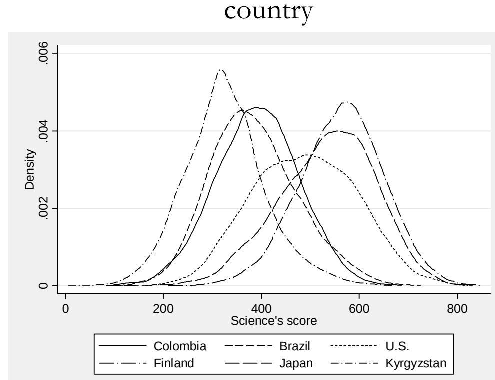
According to the Figure 2 both self-motivation and academic assets have a positive impact on the score's mean. For the case of self-motivation, the change in the density function is slight, however the Kruskal-Wallis test (K-W) for equality of distribution function, rejects the equality between the score's distributions by self-motivation level. In the case of academic assets the difference between density functions is more evident, density functions are different not only in position but also in shape; this observation is validated through the (K-W) test mentioned before.

Figure 1. Scores' Descriptive Statistics by Region

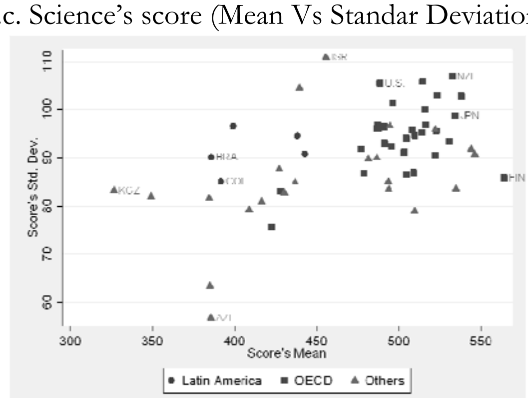
1.a. Science's score denstity function by region



1.b. Science's score denstity function by country



1.c. Science's score (Mean Vs Standar Deviation)

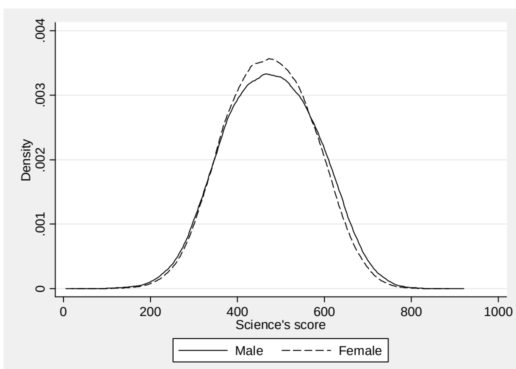


Source: PISA 2006

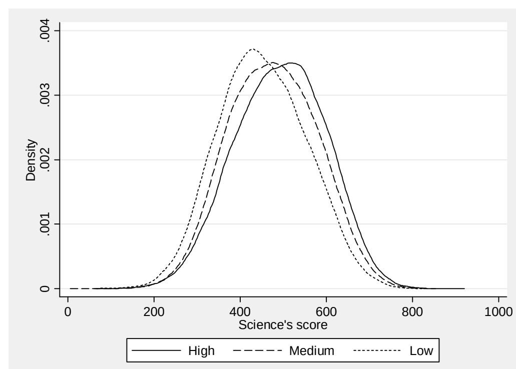
Figure 2.c. also presents the density functions by gender, in order to evaluate with our data-set the literature's common finding of boys outperforming girls in standardized science tests. Boys have a higher mean score and a higher standard deviation which let us to say that, in terms of academic score, girls are a more homogeneous group than boys, and it also justify the necessity of using quantile regression for the comparison of this relation over different quantile of the distribution. Previous literature has been focused only in 'average effects' and it provides limited information about what happen in the tails of the distribution. The (K-W) test is computed, and it rejects the equality in the distribution functions of these two groups. These characteristics need to be confirmed by a conditional analysis in order to isolate the existence of confounding factors.

Figure 2. Score Density for Gender and Academic Characteristics

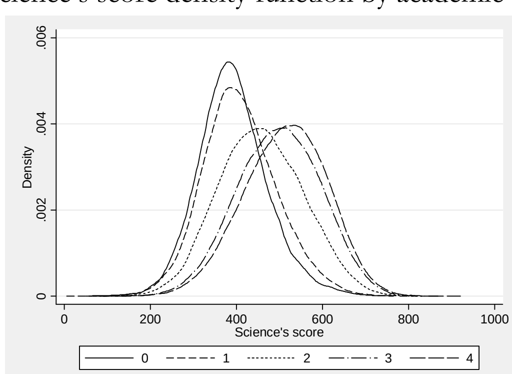
2.a Science's score denstity function by Gender



2.b Science's score denstity function by self-Motivation



2.c Science's score density function by academic assets



Source: PISA 2006

3.3 Econometric exercises.

As it can be seen in the literature, most of works about the effect of changes in resources on the academic performance them do not include important aspects such as the student's motivation. Through some econometric specifications we proof the statistical significance of the effect of self-motivation and academic assets on the pupil's score. Whereby, we include control variables that may be classified in three groups: *i)* individual features (gender, scientific skills, and mother's educational level); *ii)* school's characteristics (private or public, and gender); and *iii)* location variables (OECD membership, city's population).

Gender, mother's educational level, type of school (private or public), OECD membership and city's population are included as dummy variables, where female, less than college, private, non-OECD, and village are the reference category. Science skills are measured as a principal component index, by aggregating the reported ability to understand eight different issues (health, earthquakes, antibiotics, garbage, species survival, food labels, life on Mars, and acid rain). Finally, we include a proxy variable of gender interaction within the school which is measured by the boys to total students (at the school) ratio. The purpose of this variable is to get information about the importance of coeducation or single-sex schools on the score.

Different econometric specifications were estimated in order to consider particular features among countries that may cause systematic differences on the pupil's performance. We also control for the differential effect of academic assets and self-motivation over the scores' distribution. In particular, it is possible to argue that since countries have particular educational systems (*e.g.* the *trade-off* between coverage and quality could be diverse), students with similar profile across countries could obtain different scores. And, since self-motivation and academic assets are expected to be less disperse on the higher score's quartiles, their impact on the results could be different along the distribution of scores.

A first step to test our hypothesis considers linear models that were estimated using Ordinary Least Squares (OLS), with the logarithm of science's scores as dependent variable. In every model, each coefficient is significant (individually and jointly) and they have the expected signs. For the case of individual characteristics controls, being boy, having a good understanding of scientific issues and a having a mother with a high educational level increase the scores in science; particularly, in average a boy has a score 1 percentage point (pp) higher than a girl; an increase of 1 additional unit in the skill's index increases the score by almost 3 pp; and a student whose mother's educational level is college, will obtain a score 3.5 pp higher than that of a student whose mother's level is less than college. Regarding the school's characteristics, private school's students outperform public school's students; and science' score increases with the boys to total ratio. Finally, on the associated variables with our hypothesis, results support that academic assets and scientific interests are positively related with science's scores. The former might be due to the fact that academic assets complement student's skills and other educational inputs; and the latter, is explained by the motivation of the students to explore on specific topics, allowing her or him to deepen their understanding of scientific issues. From these findings, we can extract that there seems to have strong influences of motivation and resources on academic achievement when they are taken jointly.

Table 2. Results of Linear Regressions for Determinants of Students' Score

Variables	(1)	(2)	(3)	(4)
Gender	0.0101***	0.0113***	0.0089***	0.0089***
	(0.0007)	(0.0007)	(0.0007)	(0.0007)
Academic assets	0.0517***	0.0437***	0.0286***	0.0286***
	(0.0003)	(0.0003)	(0.0003)	(0.0003)
Skill index	0.0273***	0.0269***	0.0292***	0.0292***
	(0.0002)	(0.0002)	(0.0002)	(0.0002)
Mother's educational level	0.0377***	0.0001	0.0333***	0.0334***
	(0.0007)	(0.0008)	(0.0007)	(0.0007)
High scientific self-motivation	0.0510***	0.0543***	0.0660***	0.0661***
	(0.0012)	(0.0012)	(0.0011)	(0.0011)
Medium scientific self-motivation	0.0298***	0.0323***	0.0355***	0.0356***
	(0.0010)	(0.0010)	(0.0010)	(0.0010)
Public schools	-0.0416***	-0.0386***	-0.0317***	-0.0318***
	(0.0009)	(0.0009)	(0.0010)	(0.0010)
Boys to Total ratio	0.2800***	0.1317***	0.0812***	0.0844***
	(0.0144)	(0.0142)	(0.0167)	(0.0167)
Squared Boys to Total ratio	-0.1085***	-0.0589***	-0.0479***	-0.0490***
	(0.0047)	(0.0046)	(0.0055)	(0.0055)
OECD country	0.0864***	0.0961***	0.1862***	
	(0.0007)	(0.0007)	(0.0043)	
Small town	0.0162***	0.0212***	0.0139***	0.0139***
	(0.0013)	(0.0013)	(0.0012)	(0.0012)
Town	0.0312***	0.0315***	0.0253***	0.0254***
	(0.0012)	(0.0012)	(0.0012)	(0.0012)
City	0.0410***	0.0384***	0.0378***	0.0379***
	(0.0013)	(0.0012)	(0.0012)	(0.0012)
Large city	0.0450***	0.0396***	0.0467***	0.0468***
	(0.0015)	(0.0015)	(0.0015)	(0.0015)
Peer effect		0.0080***		
		(0.0001)		
Constant	5.7321***	4.9955***	5.8512***	0.0099***
	(0.0111)	(0.0130)	(0.0131)	(0.0003)
Observations	329266	329266	329266	329266
R-squared	0.277	0.300	0.389	0.177
F Statistic	9002.63	9424.13	3227.44	5447.19
Prob > F	0.00	0.00	0.00	0.00

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Though models consider different specifications, they exhibit similar results. Model (1) is the benchmark model, given that it was estimated using all control variables and applying OLS. In Model (2) mothers' educational level average by school is included to evaluate the peer effect but, since the peer effect is strongly correlated with mothers' educational level, the latter loses its statistical significance. Models (3) and (4), consider the same independent variables than Model (1) but, in order to approximate the idiosyncratic effects, they include country-level effect; such that, while Model (3) uses the Least Squares Dummy Variables estimator, Model (4) implements the specification in differences to the average effect, following Eq. 1 to 3, where α_j represents the country-level fixed effect. Estimates from Model (4) are more efficient than those of Model (3), because it computes the fixed effects but loses less freedom degrees.

$$Y_{ij} = \alpha_j + X_{ij}\beta + \varepsilon_{ij} \tag{1}$$

$$\left(Y_{ij} - \overline{Y}_{.j}\right) = \left(X_{ij} - \overline{X}_{.j}\right)\beta + \left(\varepsilon_{ij} - \overline{\varepsilon}_{.j}\right) \tag{2}$$

$$\hat{\alpha}_j = \overline{Y}_{.j} + \overline{X}_{.j}\hat{\beta} \tag{3}$$

The findings obtained from Models (3) and (4) support that, when they were controlled for country effect, the explanatory variables' marginal effect is decreased, except for the self-motivation; but in all cases, the estimated models are jointly significant. Fixed effects[3] obtained from Model (4) are presented in the Table 3; measures on mean and standard deviation of the scores by country are reported, as well as self-motivation distribution and academic assets' mean. It is easy to see that fixed effects are positively correlated with unconditional scores' mean, where it may be highlighted that Finland and Kyrgyzstan present the highest and the lowest indicator of both fixed effect and scores' mean. Moreover, a negative correlation between fixed effects and two estimated score's inequality measures (quantile 90 to quantile 10 ratio) is found[4]. By considering score's dispersion measures, while Israel (score's standard deviation and quantile 90 to quantile 10 ratio) and Kyrgyzstan (Gini) present the highest indicators, Azerbaijan shows the lowest. As a result, Azerbaijan exhibits the maximum covariance coefficient, in contrast to Kyrgyzstan.

[3] By using a *F* test, significant differences among fixed effects were found.
[4] Gini coefficients are also estimated and the results are similar but they are not reported.

According to our measures of academic assets and self-motivation, a positive correlation with fixed effects is found. Israel, Netherlands and Denmark reported the largest proportion of students with high scientific self-motivation (27.1%, 26%, and 24.7%, respectively), and regarding to the academic assets index's mean, Netherlands, Iceland, and Israel are the top three countries (3.628, 3.596, and 3.579 respectively).

Finally, taking into account the six scientific proficiency levels[5] defined from PISA scores, it is notable that there are significant differences in the percentage of students at each level by country. Pupils classified in higher levels have more developed scientific knowledge, and thus are more capable to apply it in different situations. For example, according to OECD (2009) a student in level 6 "can consistently identify, explain and apply scientific knowledge and knowledge about science in a variety of complex life situations", while a student at level 1 "have such a limited scientific knowledge that it can be only applied to a few, familiar situations". By computing the percentage of students who are at the highest level (level 6), it is found that New Zealand, Finland and Czech Republic show the highest percentage (4.27%, 4.18% and 3.79% respectively); while some countries have no students at this level.

When this indicator is estimated for an intermediate level (level 3), there are important changes in the order of countries. It is stressed that New Zealand remains among the countries with the highest percentage of students at the intermediate level, while Azerbaijan and Kyrgyzstan are the countries with the lowest values in this indicator. This implies that the scores' distribution by countries present significant differences, in fact, by comparing countries' ranking for level 6 to that of level 3 , it is obtained that the United States and Israel are the countries with the larger negative change; in contrast to Macao and Spain, which have the most favorable change. This ranking provides an important issue which is the differences between OECD and non-OECD student´s representation in the upper tail of the distribution.

[5] According to scores, band definition of each level is: level 1 (bellow 409.5), level 2 (409.5 to 484.1), level 3 (484.1 to 558.7), level 4 (558.7 to 633.3), level 5 (633.3 to 707.9), and level 6 (above 707.9).

Table 3. Fixed effects, Self-motivation, Academic Assets and scores' level by Country

Country	Fixed effect	Scores' mean	Scores' SD	P90/P10	High SM	Low SM	Academic Assets	% in Level 6	% in Level 3
Finland	6.158	563.75	85.86	1.490	19.28%	18.15%	3.239	4.18%	82.31%
Japan	6.140	534.11	98.73	1.637	14.56%	24.66%	2.366	2.49%	70.51%
Czech Republic	6.099	537.72	102.85	1.677	13.59%	24.00%	3.173	3.79%	69.03%
Liechtenstein	6.097	521.86	95.93	1.638	16.22%	20.12%	3.409	2.65%	65.49%
Estonia	6.094	534.50	83.53	1.509	8.07%	29.28%	3.220	1.77%	72.58%
Chinese Taipei	6.089	543.89	91.83	1.582	9.84%	27.12%	3.146	2.10%	74.90%
New Zeland	6.087	532.31	106.93	1.715	17.63%	18.51%	3.415	4.27%	67.18%
Austria	6.078	513.84	95.36	1.648	18.51%	20.85%	3.238	1.20%	62.70%
Korea	6.076	521.69	90.55	1.581	17.62%	20.62%	3.379	1.02%	67.41%
Switzerland	6.071	507.63	95.96	1.648	19.03%	19.32%	3.365	1.13%	60.15%
Hungary	6.062	508.94	86.91	1.568	15.29%	26.96%	2.758	0.78%	61.45%
Canada	6.061	522.50	95.66	1.625	14.32%	23.06%	3.438	2.02%	65.96%
Netherlands	6.058	530.41	93.38	1.602	26.04%	10.71%	3.628	1.83%	68.77%
Germany	6.057	515.95	100.02	1.684	17.89%	21.34%	3.404	1.78%	63.83%
United Kingdom	6.049	514.34	105.94	1.736	18.11%	16.95%	3.460	2.88%	61.15%
Poland	6.047	503.02	91.23	1.623	11.69%	18.90%	2.947	0.99%	57.47%
Spain	6.047	504.45	86.54	1.567	18.19%	15.96%	3.113	0.49%	60.38%
Belgium	6.046	516.21	96.93	1.658	18.60%	22.42%	3.430	0.78%	65.02%
Ireland	6.044	509.35	94.65	1.640	22.60%	19.10%	3.188	1.18%	60.39%
Sweden	6.043	504.27	94.03	1.633	14.26%	17.52%	3.373	0.99%	58.45%
Macao	6.041	509.45	78.96	1.505	12.14%	24.50%	3.214	0.29%	62.77%
Slovak Republic	6.038	491.07	93.02	1.647	16.28%	19.33%	2.565	0.76%	52.46%
Slovenia	6.031	494.34	96.73	1.681	14.94%	30.72%	3.446	1.20%	52.87%
Denmark	6.026	495.12	92.46	1.633	24.68%	13.28%	3.437	0.77%	54.55%
Italy	6.025	487.16	96.05	1.692	10.03%	28.15%	3.083	0.62%	52.16%
Latvia	6.022	493.66	83.44	1.559	6.97%	27.69%	2.820	0.34%	54.95%
Croatia	6.019	493.31	85.10	1.573	13.05%	30.95%	2.952	0.46%	54.06%
Luxembourg	6.016	486.97	96.90	1.708	19.88%	19.50%	3.287	0.53%	52.49%
Greece	6.012	476.76	91.91	1.659	20.36%	30.58%	2.493	0.23%	49.03%
Russia	6.006	481.38	89.85	1.635	8.48%	26.76%	2.332	0.53%	48.61%
Lithuania	6.003	486.46	89.97	1.637	9.09%	30.97%	2.797	0.38%	51.50%
Iceland	5.999	490.80	96.54	1.684	14.83%	26.77%	3.596	0.61%	53.81%
Portugal	5.993	478.69	86.81	1.626	12.07%	19.05%	3.008	0.10%	48.58%
Norway	5.990	486.43	96.22	1.680	15.78%	18.77%	3.540	0.62%	51.13%
United State	5.988	488.29	105.57	1.785	13.15%	23.08%	3.279	1.64%	51.40%
Turkey	5.930	427.92	83.05	1.668	14.64%	30.19%	1.733	0.08%	23.74%
Chile	5.921	442.55	90.89	1.725	10.73%	27.36%	2.012	0.10%	31.91%
Thailand	5.920	429.99	82.76	1.642	2.27%	32.79%	1.744	0.02%	24.98%
Serbia	5.912	436.76	84.90	1.653	13.57%	33.59%	2.557	0.00%	29.37%
Israel	5.906	455.43	110.90	1.932	27.07%	22.20%	3.579	0.81%	40.40%
Uruguay	5.903	438.12	94.59	1.788	18.01%	23.87%	2.319	0.12%	31.08%
Mexico	5.894	422.46	75.62	1.596	5.30%	35.82%	1.813	0.00%	20.89%
Jordan	5.894	427.01	87.67	1.697	12.24%	24.99%	2.212	0.00%	26.18%
Indonesia	5.894	384.77	63.46	1.530	4.48%	21.63%	0.924	0.00%	6.57%
Romania	5.890	416.26	80.91	1.679	10.80%	28.72%	2.184	0.00%	20.32%
Azerbaijan	5.868	385.35	56.72	1.457	9.96%	32.18%	1.325	0.00%	5.84%
Montenegro	5.858	408.78	79.20	1.657	15.42%	38.08%	2.295	0.00%	17.46%
Tunisia	5.826	384.31	81.59	1.749	16.48%	34.03%	1.602	0.00%	12.05%
Argentina	5.825	398.91	96.63	1.907	18.79%	23.51%	1.904	0.02%	18.78%
Colombia	5.811	391.53	85.14	1.785	5.40%	43.95%	1.482	0.00%	13.62%
Brazil	5.807	385.48	90.14	1.837	14.93%	23.07%	1.720	0.03%	14.47%
Qatar	5.679	348.99	81.88	1.805	17.53%	27.49%	3.156	0.02%	6.37%
Kyrgyzstan	5.659	326.43	83.21	1.929	6.48%	33.25%	1.191	0.00%	4.05%

*Self-Motivation

As a consequence of this fact and the fact that traditional works in the literature of economics of education have estimated the effect of a set of variables on the 'average' of the population with a non conclusive evidence, we adopt other strategy. In order to assess the effect of our independent variables on different points of the science's score conditional distribution, we estimated Quantile Regression models following Kroenker and Bassett (1978). In this kind of models, parameters are estimated minimizing the Eq. (4):

$$\underset{\beta\in\Re^K}{Min} \sum_{i\in\{i:Y_i\geq X_i\beta\}} \theta\left|Y_i - X_i\beta\right| + \sum_{i\in\{i:Y_i<X_i\beta\}} (1-\theta)\left|Y_i - X_i\beta\right|$$

Where θ represents the θ-th quantile for which β is estimated.

Mean and standard deviation of each explanatory variable by score's quartile are summarized in Table 4. As it can be seen, every variable exhibits important changes on both indicators across the selected quartiles. By comparing quartile 1 with quartile 4, educative assets' mean increases from 2.7 to 3.37, while its standard deviation diminishes by a 40%. In the case of self-motivation, the share of students with high and medium levels increases by 10 pp.

The estimated coefficients of the Quantile Regression results for 5 particular percentiles (5, 25, 50, 75 and 95) are shown in Table 5. It is worth to mention that when we compare these results with those of OLS, the signs and significance of the coefficients do not change. Furthermore, the goodness of fit measure indicates that our control variables have a good explanatory power.

By examining each coefficient's behavior along the score's distribution[6], it is observed that the effect of gender, public school, and boys to total ratio (squared) increase with the quantile. The variable 'boys to total ratio' (lineal and squared) is not statistically significant in the highest quartiles, while the same is observed for the gender's effect in the lowest ones. These findings support the pertinence of using a Quantile Regression approach when we are studying cases in which there are considerable development differences.[7]

It is also important to point out that the marginal effects of OECD membership and city size decrease. Other variables show a particular behavior; that is the case of the skills index which

[6] See the Appendix for more details about the changes in the estimated coefficients across the entire distribution.

[7] As stated by Sula interpretation of country-level effects in Quantile Regression models, is unclear.

has a non-monotonic shape, and mother's educational level impact which is not statistically different from the OLS estimated effect.

Table 4 – Socio-economic Characteristics by score's quartile.

	Total	Quartile 1	Quartile 2	Quartile 3	Quartile 4
Gender	0.495	0.499	0.479	0.480	0.521
	(0.499)	(0.500)	(0.499)	(0.499)	(0.499)
Academic assets	2.780	2.002	2.604	3.074	3.374
	(1.269)	(1.366)	(1.302)	(1.079)	(0.839)
Skill index	0.000	-0.705	-0.360	0.096	0.913
	(1.867)	(1.962)	(1.801)	(1.699)	(1.595)
Mother's educational level	0.441	0.328	0.389	0.471	0.577
	(0.496)	(0.469)	(0.487)	(0.499)	(0.494)
High scientific self-motivation	0.249	0.201	0.229	0.261	0.303
	(0.432)	(0.400)	(0.420)	(0.439)	(0.459)
Medium self-motivation	0.613	0.617	0.620	0.615	0.599
	(0.487)	(0.486)	(0.485)	(0.486)	(0.490)
Public school	0.820	0.885	0.840	0.793	0.759
	(0.384)	(0.318)	(0.366)	(0.404)	(0.427)
Boys to Total ratio	1.501	1.516	1.501	1.494	1.495
	(0.188)	(0.197)	(0.187)	(0.184)	(0.184)
Squared Boys to Total ratio	2.290	2.338	2.287	2.267	2.268
	(0.576)	(0.609)	(0.572)	(0.559)	(0.561)
OECD country	0.630	0.442	0.611	0.701	0.767
	(0.482)	(0.496)	(0.487)	(0.457)	(0.422)
Small town	0.225	0.257	0.231	0.213	0.197
	(0.417)	(0.437)	(0.421)	(0.409)	(0.397)
Town	0.314	0.303	0.318	0.319	0.317
	(0.464)	(0.459)	(0.465)	(0.465)	(0.465)
City	0.252	0.216	0.246	0.266	0.281
	(0.434)	(0.411)	(0.430)	(0.442)	(0.449)
Large city	0.107	0.083	0.105	0.113	0.129
	(0.309)	(0.276)	(0.306)	(0.316)	(0.335)

Source: PISA 2006. Std. Dev. in parenthesis.

For our two main interest variables (self-motivation and academic assets), their importance decreases with the quantile but, it is always positive. This indicates that for students with the poorest performance the tenure of academic assets and a higher level of self-motivation could foster their academic achievements, in a more accelerated pace. This implies that a policy oriented to elevate the pupil's level of self-motivation towards science, would have a positive impact both on the mean score and on the reduction of school achievement gap. The same holds for a policy directed to increase the provision of educative assets at home. Given the expected positive relationship between information access and individual interest on a specific topic, social programs devoted to improve the ICT's coverage would have a positive outcome on the student's school performance mean and gap, through two channels: *i)* students with more academic tools perform better (direct channel); *ii)* easier access to information has an inertial effect, when a student meets a topic for the first time, and she or he has easy access to more information on the subject, she or he would be motivated to deepen her or his knowledge on the area (indirect channel).

Table 5. Results of Quantile Regressions for Determinants of Students' Score

	Q(0.05)	Q(0.25)	Q(0.5)	Q(0.75)	Q(0.95)
Gender	-0.0041**	0.0069***	0.0125***	0.0148***	0.0181***
	(0.0020)	(0.0011)	(0.0009)	(0.0008)	(0.0010)
Academic assets	0.0545***	0.0559***	0.0542***	0.0485***	0.0360***
	(0.0008)	(0.0005)	(0.0004)	(0.0003)	(0.0004)
Skill index	0.0228***	0.0266***	0.0292***	0.0299***	0.0276***
	(0.0006)	(0.0003)	(0.0002)	(0.0002)	(0.0003)
Mother's educational level	0.0309***	0.0386***	0.0404***	0.0398***	0.0370***
	(0.0020)	(0.0011)	(0.0009)	(0.0008)	(0.0010)
High scientific self-motivation	0.0774***	0.0645***	0.0485***	0.0366***	0.0238***
	(0.0033)	(0.0018)	(0.0014)	(0.0014)	(0.0017)
Medium scientific self-motivation	0.0514***	0.0367***	0.0272***	0.0189***	0.0120***
	(0.0029)	(0.0016)	(0.0013)	(0.0012)	(0.0015)
Public schools	-0.0733***	-0.0550***	-0.0392***	-0.0244***	-0.0097***
	(0.0026)	(0.0014)	(0.0011)	(0.0010)	(0.0013)
Boys to Total ratio	0.7099***	0.3776***	0.1990***	0.0990***	-0.0204
	(0.0430)	(0.0228)	(0.0175)	(0.0164)	(0.0200)
Squared Boys to Total ratio	-0.2684***	-0.1452***	-0.0807***	-0.0426***	0.0024
	(0.0139)	(0.0074)	(0.0057)	(0.0054)	(0.0066)
OECD country	0.1253***	0.0940***	0.0800***	0.0695***	0.0557***
	(0.0021)	(0.0011)	(0.0009)	(0.0009)	(0.0011)
Small town	0.0374***	0.0194***	0.0115***	0.0073***	0.0039**
	(0.0036)	(0.0020)	(0.0016)	(0.0015)	(0.0018)
Town	0.0477***	0.0336***	0.0262***	0.0216***	0.0183***
	(0.0035)	(0.0019)	(0.0015)	(0.0014)	(0.0017)
City	0.0570***	0.0410***	0.0334***	0.0314***	0.0320***
	(0.0036)	(0.0020)	(0.0015)	(0.0015)	(0.0018)
Large city	0.0579***	0.0404***	0.0361***	0.0356***	0.0362***
	(0.0044)	(0.0024)	(0.0019)	(0.0018)	(0.0022)
Constant	5.0789***	5.5429***	5.8103***	6.0086***	6.2661***
	(0.0334)	(0.0177)	(0.0135)	(0.0126)	(0.0154)
Observations	329,266	329,266	329,266	329,266	329,266
Pseudo R-squared	0.1313	0.1581	0.1702	0.1625	0.1310

Standard error in parenthesis.

4. Concluding Remarks

PISA 2006 allows us to have a comparable measure of school performance across developed and less developed countries and to get information on student's self-motivation and academic assets' tenure and its relationship with academic performance in sciences. Our findings confirm the intuition that some of the most important inputs as the self-motivation and academic tools have a positive impact on school attainment. Their effect on academic performance is different across the score's distribution and it gives support to the importance of designing focalized programs for different populations. As a consequence of the existence of several works in which there are no consensus about the input-output relation in education, we proceed to estimate quantile regression models that, allow us to evaluate the importance of changing some inputs at different types of populations. This estimation lets us to assess whether the increase in one input (i.e. academic asset) on the student's performance is similar over the entire population. The estimation of linear regressions with country-level fixed effects lets us to calculate the intrinsic differences between OECD and non-OECD countries, which could be used for assessing the added value of each educative system. Those countries with better socioeconomic and institutional environments need less investment to get the same performance than less developed countries.

Although, in terms of inequality we find that there is no pattern between each inequality index and PISA score in science, the main results of the quantile regression says us that, on one hand, the effect of gender, public school, and boys to total ratio (squared) increase with the quantile. On the other hand, gender interaction proxied by (boys to total ratio variable) is not statistically significant in the highest quartiles, while gender's effect also seems to be not significant in the lowest scores.

According to our findings, the access to modern technologies such as internet will be useful for increasing the benefits of learning when it could be used everywhere, mainly at home. Most of the great advances in education come from the creation of software packages specially designed for increasing skills such as reading comprehension, spatial analysis, and phenomena description, among others. In our case, Internet could be a substitute of another input which is the number of books at home. The positive outcome of ICT's on the academic performance mean and gap, may occur through two channels: *i)* students with more academic tools perform better (direct channel); *ii)* easier access to information has an inertial effect on students' proclivity to deepen their knowledge (indirect channel). However, it is important to state that internet access should be provided in all public schools in order to reduce the technology gap between students because those without access will be in less favorable conditions with respect to those who have access in their households.

Therefore, public policy in education in less developed countries has to increase investments in modern pedagogy techniques in order to increase motivation levels and it should take into account differences in initial endowments of populations. Finally, it seems to be a strong link between academic assets and self-motivation, which is an important result if we consider that in some cases parents could invest in materials but they do not success in translate their preferences into student's motivations.

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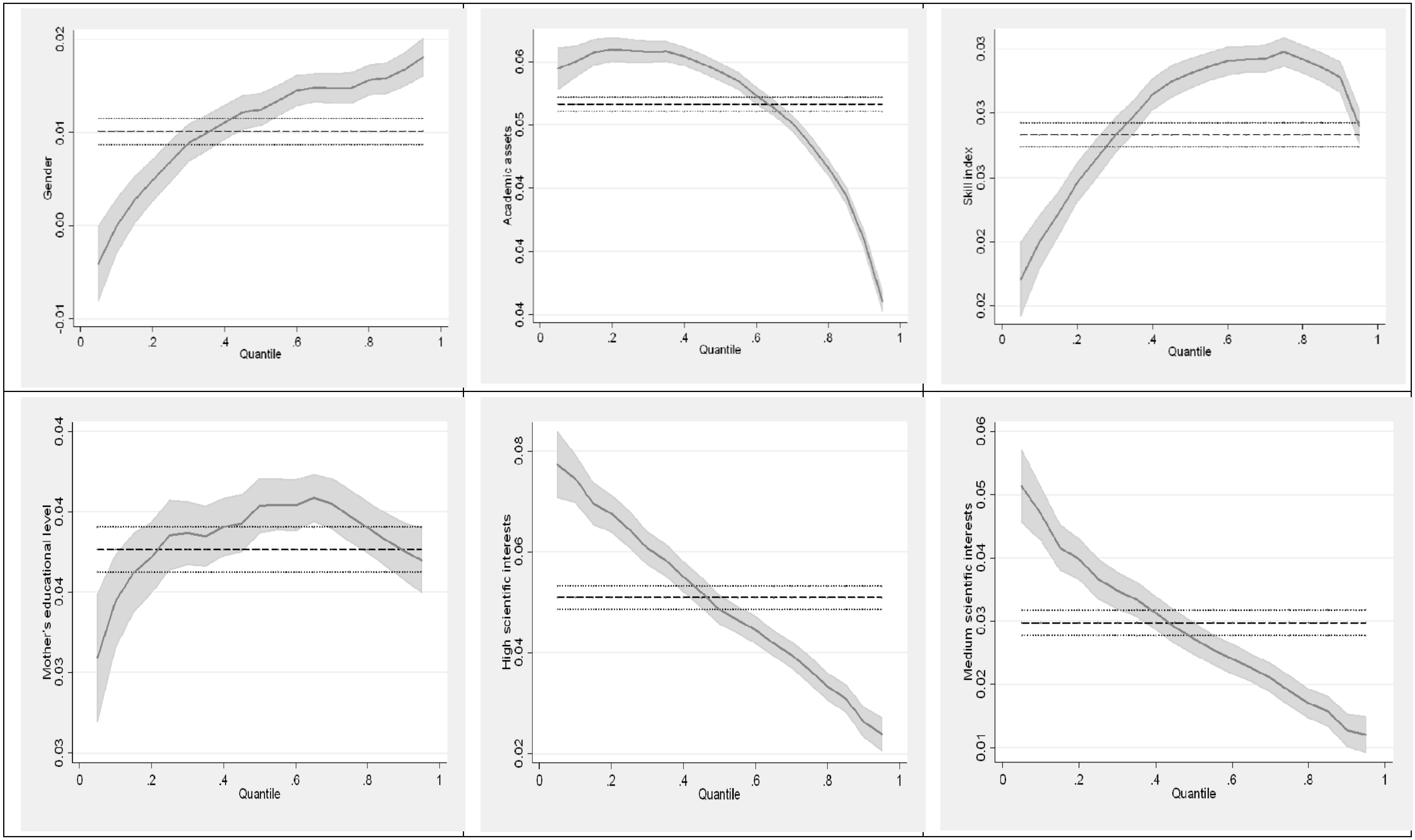
Appendix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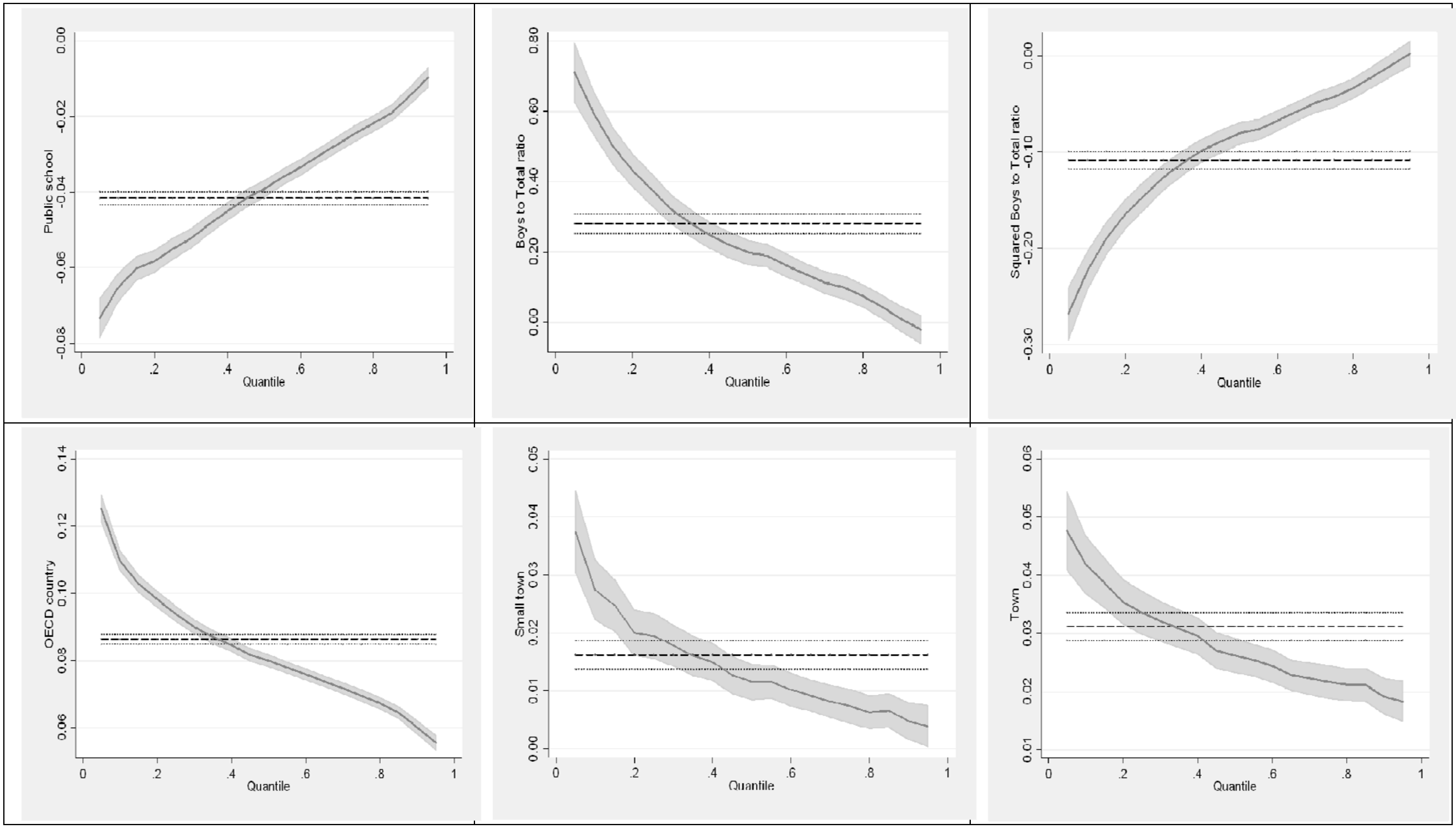
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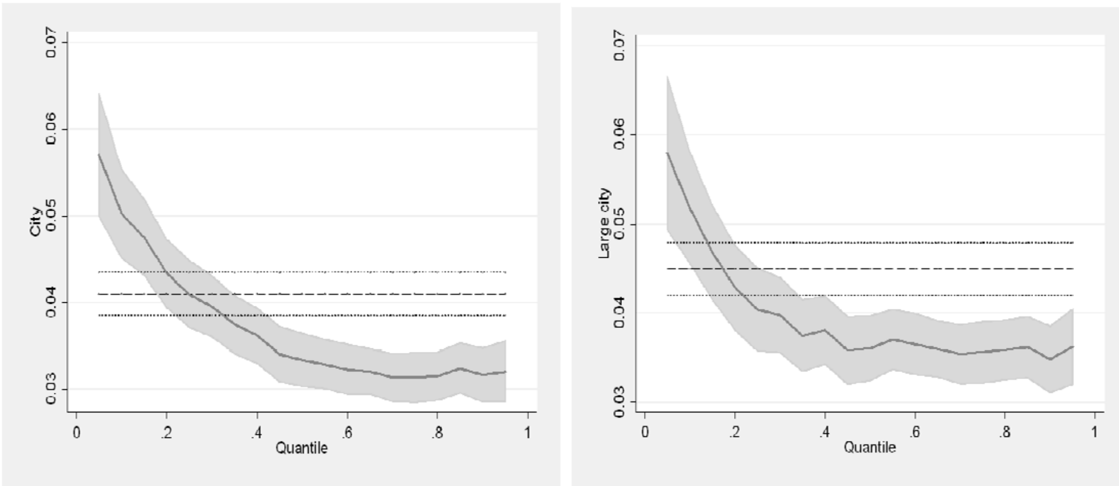

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