IDB WORKING PAPER SERIES No. IDB-WP-469

Re-estimating the Gender Gap in Colombian Academic Performance

Juan Sebastián Muñoz

January 2014

Inter-American Development Bank
Department of Research and Chief Economist

Re-estimating the Gender Gap in Colombian Academic Performance

Juan Sebastián Muñoz

Inter-American Development Bank

Inter-American Development Bank

2014

Cataloging-in-Publication data provided by the
Inter-American Development Bank
Felipe Herrera Library

Muñoz, Juan Sebastián.
Re-estimating the gender gap in Colombian academic performance / Juan Sebastián Muñoz.
p. cm. — (IDB Working Paper Series ; 469)
Includes bibliographic references.
1. Dropouts—Colombia. 2. Students—Economic conditions—Colombia. 3. Students—Social conditions—Colombia. I. Vela, Mauricio A. II. Inter-American Development Bank. Department of Research and Chief Economist. III. Title. IV. Series.
IDB-WP-469

http://www.iadb.org

Abstract[1]

This paper presents evidence of the relationship between the disparity in the academic performance of boys and girls in Colombia and the country's excessively high school dropout rates. By using the OLS and trimming for bounds techniques, and based on data derived from the PISA 2009 database, the presented findings show that the vast majority of this gender-related performance gap is explained by selection problems in the group of low-skilled and poor male students. In particular, the high dropout rate overestimates male performance means, creating a selection bias in the regular OLS estimation. In order to overcome this issue, unobservable male students are simulated and bounding procedures used. The results of this analysis suggest that low-income men are vulnerable to dropping out of school in the country, which leads to overestimating the actual performance levels of Colombian men.

JEL classifications: I21, I25, J16, J24
Keywords: High School, Latin America, School Dropout, Gender Gap, Selection Bias

[1] This paper has benefited from the insightful comments of Alejandro Gaviria, Adriana Camacho, Hugo Ñopo, Matías Busso, Juan Herreño, Carlos Rondón and Jaime Urrego. Any remaining mistakes in the paper are the sole responsibility of the author.

1. Introduction

Disparities in the academic performance of boys and girls (hereafter the gender performance gap) have been shown to negatively affect economic development in ways that include slower growth, lower household income levels, worse child health outcomes, and lower life expectancy (Ñopo, 2012). Against this background, many authors have described the positive effects of reducing gender gaps in academic performance levels.[2] Nevertheless, despite its well-known importance, the gender performance gap is usually computed incorrectly it uses the results of standardized tests that do not account for potential selection bias.

According to Heckman (1979), sample selection bias exists when the process of self-selection affects the individuals in a sample. In the case of academic performance, standardized tests only include those students enrolled when the test is carried out, thereby excluding all individuals that dropped out of school before the examination took place. Such students typically share common characteristics that correlate with the final decision on whether to remain in school. For example, if low-income students were more likely than high-income students to drop out of school, observations of high-income students would carry extra weight in the computation of average performance and, hence, the estimation would be biased.

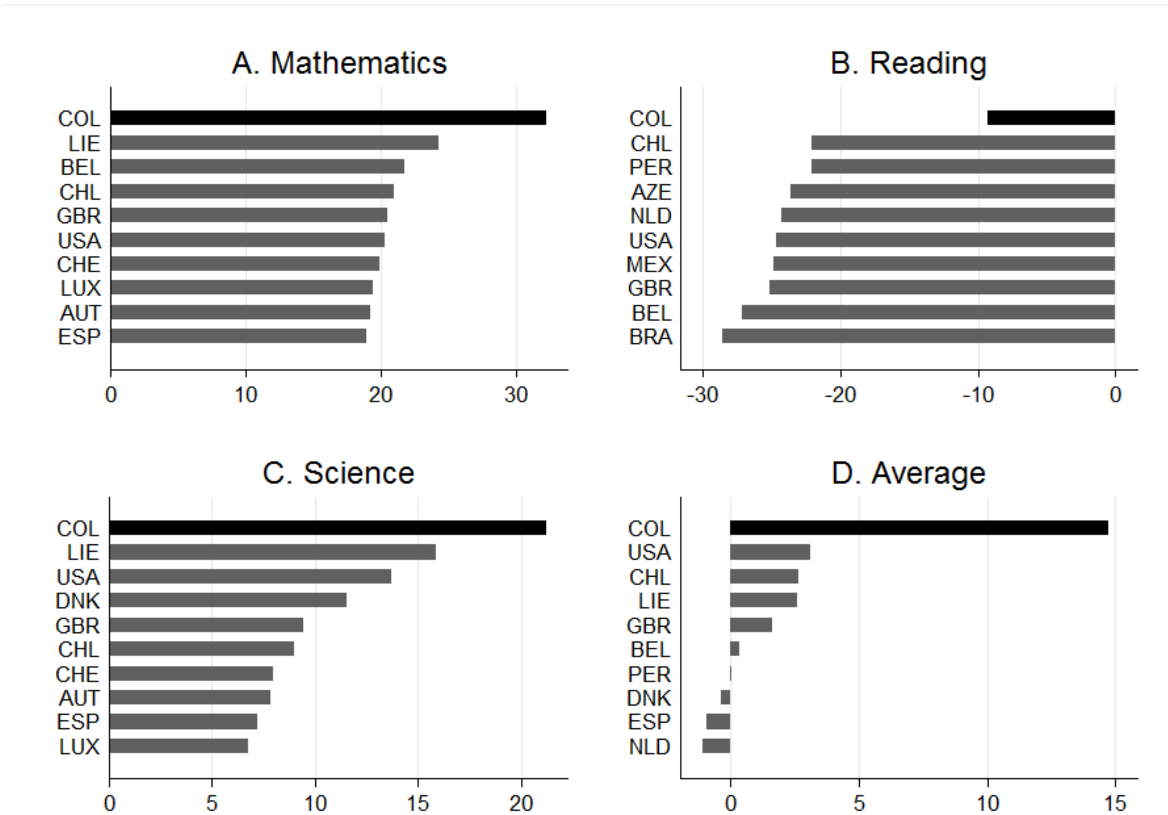
Similarly, gender is another characteristic that suffers from sample selection bias. Male students may drop out at higher rates than female students, or vice versa, depending on the incentives they have to enroll in the next grade. For example, boys have more incentive to quit school and enter the labor market (e.g., higher economic returns, higher probability of finding a job), while girls are more likely to drop out because of pregnancy. In any case, gender selection bias is another possible threat that must be taken into account when computing performance gaps.

A special case of the gender performance gap is the computation of the Colombian sample in PISA[3] 2009. In this edition of the OECD test, male students obtained significantly better results than their female peers in mathematics, while female students outperformed men in reading at the global level. Yet, Colombia was ranked as the most unequal country in terms of the gender performance gap regardless of subject. The Colombian average was one of the lowest

[2] For example, Dollar and Gatti (1999), Klasen and Lamanna (2008), and Ñopo (2012).
[3] PISA is an examination conducted by the OECD that evaluates academic performance around the world. A total of 65 countries participated in the 2009 edition. More information on PISA is provided in Section 3.

in the entire PISA 2009 ranking, but the female result was significantly lower than the male one (Figure 1). As shown in the figure, the Colombian performance gap was the largest of all countries in panels A, C, and D. By contrast, although the female reading result was greater than the male mean (panel B), its difference was the smallest in magnitude compared with the remaining sample countries.

Figure 1. Countries with the Top 10 Gender Gaps



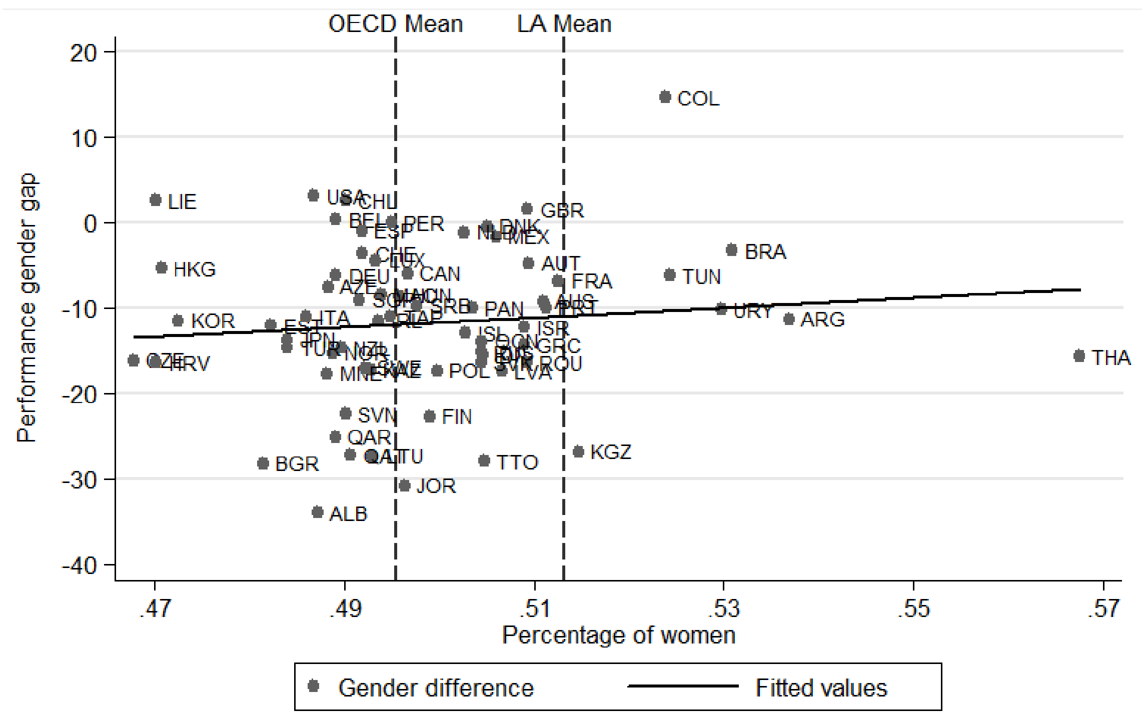
Source: PISA (2009), author's calculations.
Note: Values calculated as the male mean minus the female mean. The figure show only shows the top 10 countries of the 65 included in PISA 2009. The initials reported correspond to the country's ISO code.

The performance gaps presented in Figure 1 are, however, only average comparisons that do not take into account the variation within countries or possible selection bias. Hanushek and Woessman (2011b) show, for instance, that non-random differences, sample exclusions, and non-responses can all influence the academic performance of a country in a worldwide ranking.

In other words, a country that has a strong dropout rate is not comparable to a country in which all students are taking the test.

Figure 2 plots the relationship between the average gender performance gap and the percentage of women taking the PISA test by country. It illustrates that, while Colombia has the largest gender gap in the entire sample, it also has one of the largest proportions of girls taking the test. This value is far from Latin America's average (excluding Colombia), and even further from that of the OECD. Thus, selection bias seems to be a problem in the Colombian sample.

Figure 2. Relationship between the Gender Performance Gap and Gender Composition



Source: PISA (2009), author's calculations.
Note: OECD and LA means equal the average percentage of women in each region. LA mean excludes the Colombian sample. On the x-axis, the average PISA results among math, reading, and science are plotted. On the y-axis, the percentage of women taking the test is plotted.

Despite the magnitude of the gender gap, no explanation for its existence has been offered. Indeed, the literature on the topic is scarce, not only in Colombia but also in all of Latin America, for two main reasons. First, gender gaps in education have traditionally been measured as the difference in academic achievement[4] rather than in performance. Second, the few computations previously carried out have not accounted for potential selection bias.

Based on the foregoing, this paper presents evidence of the relationship between the gender performance gap and the existence of high non-random dropout rates in Colombia. By using the OLS and trimming for bounds techniques and based on data derived from the PISA 2009 database, the findings presented show that the vast majority of the gender performance gap is explained by selection problems in the group of low-skilled and poor male students. In particular, the high non-random dropout rate overestimates male averages, creating a selection bias in the regular OLS estimation and suggesting that low-income men are vulnerable to dropping out of school.

The remainder of this paper is organized as follows. Section 2 reviews the scarce research in this field for Latin America in general and Colombia specifically. Section 3 introduces the data used. Section 4 describes the selection problem and bounding procedures used for overcoming selection bias. Section 5 shows the estimations and results. Section 6 discusses the results obtained, and Section 7 concludes.

2. Literature Review

The study of gender disparities in terms of educational performance has been neglected in the Latin American economics literature. Previous studies in the region focus on educational attainment as the only indicator of gender differences. Ñopo (2012) and Duryea et al. (2007), for example, suggest that gender performance gaps have closed—and even reversed—in Latin America over recent decades, partly because of the rise in female educational attainment in terms of years of education. In addition, most scholars who have studied gender performance gaps focus on developed economies, finding that advanced nations display smaller disparities compared with developing countries (Magnoli, 2005).

[4] Academic achievement refers to the average years of education pursued by an individual. In contrast, academic performance refers to how much the student learned and how well he performed on standardized tests.

At the subject level, studies in the United States have demonstrated that boys outperform girls in mathematics but underperform in reading. Fryer and Levitt (2009) find no gender gap in the early primary school years, but show that boys overtake girls over time, while Burgess et al. (2003) find that boys underperform in English owing to poorer reading skills.

Complementarily, female performance has increased over recent decades. Gammie et al. (2003) use data collected in Scotland to measure gender differences and find evidence of girls' secondary-level performances increasing over time. Similarly, Lewis and Lockheed (2008) argue that, despite the existence of women's social exclusion, female enrollment has grown over the past few decades. Murnane (2013) and Bailey and Dynarski (2011) also find that US women outpace men in educational attainment in every demographic group, while Flabbi and Tejada (2012) suggest that female over-performance continues into postgraduate studies based on Master's and PhD. graduation rates. Lastly, Spencer, Steel, and Quinn (1999) find that girls underperform in math because of the stereotype that women have weaker mathematical ability.

Research on this topic is even scarcer for Colombia than it is across the rest of Latin America. Gaviria (2010) discusses the "female revolution," as he calls it, in terms of education aspirations since the 1950s based on changes in female expectations, the introduction of women into labor markets, and the widespread use of contraception. These social changes, the author suggests, explain the rise in female attainment, but not academic performance gaps. The only attempt in this direction was carried out by Gaviria and Barrientos (2001), who run regressions in order to determine the principal influencing factors behind education performance in the country. The male dummy in their estimations was always positive and significant, indicating constant male over-performance, but they never accounted for selection bias. According to Gaviria and Barrientos (2001), three issues may explain the gender gap in education performance: difference in answering strategies, difference in the choices of elective courses, and male non-random dropout rates. The first two hypotheses affect all students regardless of their country, while the probability of dropping out is more likely to be country-specific. In fact, the high dropout rate is one of the largest problems in both the Colombian and Latin American academic systems.

In 2002, the Economic Commission for Latin America and the Caribbean distinguished high dropout rates as one of the greatest challenges in Latin American education systems (CEPAL, 2002). A decade later, Alfonso et al. (2012) and Bassi, Busso, and Muñoz (2013) showed that dropout rates remain very high despite the region's improvement in educational attainment. Furthermore, Cárdenas, Hoyos, and Székely (2011) identify idle youth, caused by excessively high school dropout rates, as a large problem in all Latin American economies, including Colombia.

The literature also suggests that risky behavior (which is more likely to occur in boys), peer effects, and the existence of conflict (also more probable in boys) have a strong correlation with the probability of dropping out of school. Chatterji and DeSimone (2005) find that alcohol consumption diminishes the probability of graduating by 11 percentage points, while McCaffrey et al. (2010) determine a strong correlation between marijuana and cigarette consumption with dropping out of school. Moreover, Gaviria and Raphael (2001) suggest that peer effects also influence the probability of committing risky behaviors and thereby dropping out.

Furthermore, social conflict creates substitute alternatives that encourage students to drop out of school. Rodríguez and Sánchez (2012) estimate a positive and significant effect on the probability of dropping out if a student is exposed to an armed conflict (stronger for male students), and Lochner and Moretti (2004) even relate dropping out with the higher likelihood of incarceration. In the same vein, in countries where drug use and conflict are commonplace, such as Colombia, male students can be more likely to drop out.

3. Data

PISA, the standardized test administered to 15-year-old boys and girls every three years since 1997, tests students' performances in mathematics, science, and reading. Its results provide valuable information on the student, his or her parents (in some countries), and participating schools. PISA 2009 included 65 countries (34 OECD nations and 31 non-OECD nations including Colombia) and tested 475,460 students (7921 Colombians across 275 schools).

As the purpose of the present study is to measure the gender performance gap regardless of subject,[5] I analyzed the average score of the three tested areas.[6] Table 1 describes the results in mathematics, reading, science, and the average of these three subjects for Colombia, Latin America, OECD nations, and non-OECD nations. Taking into account that girls always

[5] Figure 1 shows that the gender performance gap in Colombia is not related to the subject. In all three subjects, Colombian boys outperform Colombian girls more than in any other country in the sample.

[6] The average of mathematics, science, and reading was calculated as the dependent variable in all estimations. The estimations were also carried out with the mathematics score only, but the results and analysis did not change (indeed, they were even more robust). Only the magnitude of the coefficients grew, but this had no effect on the interpretation.

outperform boys in reading regardless of the country, it is clear that Colombia displays the largest degree of male over-performance in all three subjects. In reading, although the female mean is greater than the male mean, the difference for Colombia is the closest to zero of all the groups. It is also worth noting that the Colombian average of the three fields is the only one that reports a positive value.

Table 1. Mean Results for Colombia, Latin America, OECD, and Non-OECD

		Overall	Male	Female	Gender gap
Colombia	Mathematics	380.85	397.71	365.52	32.19
	Reading	413.18	408.31	417.61	-9.30
	Sciences	401.75	412.87	391.64	21.23
	Average	398.59	406.30	391.59	14.71
Latin America	Mathematics	395.00	401.98	388.32	13.66
	Reading	407.27	391.84	421.72	-29.88
	Sciences	406.01	406.86	405.08	1.77
	Average	402.76	400.23	405.04	-4.82
OECD	Mathematics	495.71	501.43	489.92	11.51
	Reading	493.45	474.08	513.19	-39.12
	Sciences	500.84	500.91	500.81	0.09
	Average	496.67	492.14	501.31	-9.17
Non-OECD	Mathematics	436.81	439.70	433.97	5.73
	Reading	432.46	411.82	453.08	-41.25
	Sciences	439.76	435.86	443.68	-7.82
	Average	436.34	429.13	443.57	-14.45

Note: Means calculated using the final student weights of the PISA 2009 Database.

Table 2 presents the descriptive statistics of the variables used as controls in the estimations analyzed herein. Of the 7,921 students, 53 percent (4,210) are girls, while the vast majority of students (83 percent) live with their mothers, 29 percent live in a single-parent household and 76 percent live with brothers/sisters. Eleven years of education is the mean of the highest parental education, while 20 percent of students attend private schools and 40 percent live in rural areas.[7]

[7] The rural variable was not included in the PISA database but rather constructed by using information on the size of the student's municipality and the number of nearby schools. Urban was defined as a city that had a population greater than 15,000.

The sample used in the present study had several missing values for different variables because not all students answered every question. After omitting the missing values for each of these variables, 6,395 students with complete information remained. Removing these observations did not change the gender balance or control statistics because the missing values were randomly distributed. Therefore, the sample on which the estimations were performed consisted of 6,395 participants.[8]

Table 2. Descriptive Statistics for the Control Variables

	N	Mean	SE	Min	Max
Male dummy	7921	0.476	0.012	0	1
Mother at home dummy	7465	0.825	0.008	0	1
Brothers or sisters at home dummy	7128	0.763	0.009	0	1
Single parent household dummy	7375	0.293	0.010	0	1
Highest parental education in years	7858	10.722	0.136	3	15.5
Private school dummy	7877	0.195	0.024	0	1
Single-sex school dummy	7652	0.033	0.012	0	1
Rural school dummy	7716	0.406	0.040	0	1

Note: Standard errors calculated using the replicate weights of the PISA 2009 database. Calculations done following the PISA manual available in "http://browse.oecdbookshop.org/oecd/pdfs/free/9809021e.pdf"

In addition to the PISA 2009 database, I used data derived from the *Gran Encuesta Integrada de Hogares* (GEIH) 2008, a Colombian household survey[9] that includes 15-year-old children regardless of whether they are enrolled in school. As PISA is only administered to students who attend school, the use of the GEIH complemented the current analysis.

4. Model

Poor male students in Colombia face a tradeoff between studying and dropping out of school. Bassi, Busso, and Muñoz (2013) find that the probability of dropping out of school is greater for lower-income students in all Latin American countries, and that Colombian male students have larger dropout rates than Colombian women. As a consequence, lower-income men in Colombia

[8] The controls were varied in the estimations in order to use some of the omitted observations. The results continued to be the same for all estimations.

[9] The GEIH is administered monthly and is nationally representative. The data used included all 2008 observations.

are a particular subpopulation that displays a very high dropout rate compared with other subgroups in the country.

The non-random dropout threat is therefore a potentially serious issue in the Colombian sample. If the low-skilled male population, which is associated with lower-income students, drops out more than low-skilled women, then the male average will be overestimated and the estimated performance gap biased. In this section, I thus present a model that overcomes the potential existence of sample selection in Colombia's PISA data.

4.1. Sample Selection in the Colombian Sample

As a first strategy for determining the potential existence of the dropout threat, I estimated a model that quantifies the gender differential of the probability of attending school. For this, I used the GEIH for 2008 and restricted the sample to children between six and 15 years old (six is the legal age for starting school and 15 is the age at which students take PISA). As the PISA 2009 test was carried out during 2008, I used the same year in order to ensure comparability.

The estimated model used as the dependent variable a dummy variable on whether the child attends school. I also used a male dummy and a set of covariates that included parents' highest education, an urban dummy, household size, a dummy if either parent worked, and village fixed effects as independent variables. Standard errors were clustered at the city level.

In this model, the male marginal effect captures the difference in the estimated conditional probabilities of attending school by gender. Formally, this value is expressed as follows:

$$\widehat{Male\ dummy} = \hat{P}[assisting \mid Male = 1, X] - \hat{P}[assisting \mid Male = 0, X]$$

where X is a vector that includes the set of covariates and $\hat{P}[.]$ is a probability function.

Table 3 shows the results of this estimation using linear probability models and probits. Columns [1] and [2] include the entire sample, columns [3] and [4] include only children under the median income, and columns [5] and [6] use children under the 25th income percentile. In all specifications, the male dummy is negative and significant, meaning that the probability of girls attending school is always larger than that for boys. In addition, an interesting monotonic effect occurs in the population of children under the 25th income percentile as the coefficient's magnitude increases by more than 50 percent compared with the entire sample.

Table 3. Attends School Dummy as the Dependent Variable

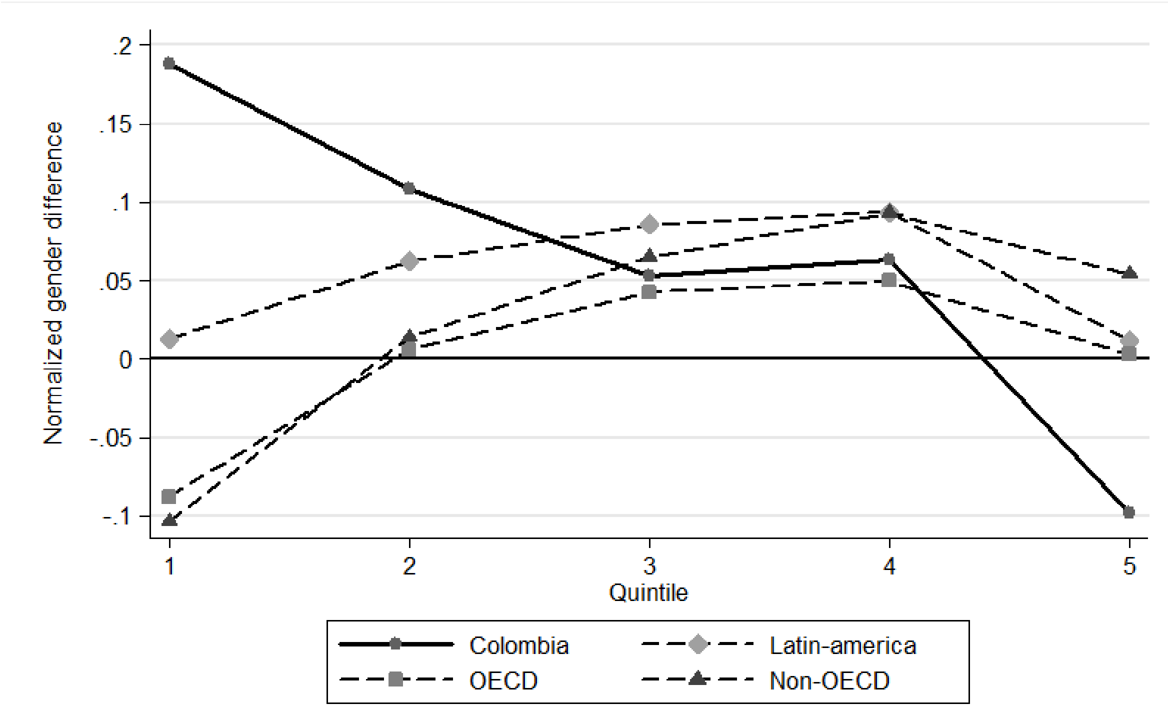
	All		Income < p(50)		Income < p(25)	
	[1]	[2]	[3]	[4]	[5]	[6]
	LPM	Probit	LPM	Probit	LPM	Probit
Male dummy	-0.009***	-0.008***	-0.009***	-0.007***	-0.014***	-0.012**
	[0.002]	[0.002]	[0.003]	[0.003]	[0.005]	[0.005]
Parents highest education (in years)	0.004***	0.005***	0.006***	0.006***	0.006***	0.006***
	[0.000]	[0.000]	[0.001]	[0.001]	[0.001]	[0.001]
Urban dummy	0.047***	0.037***	0.042***	0.036***	0.053***	0.048***
	[0.010]	[0.012]	[0.011]	[0.013]	[0.014]	[0.018]
Household size	-0.002	-0.001*	-0.001	-0.001	-0.001	-0.002
	[0.001]	[0.001]	[0.002]	[0.001]	[0.002]	[0.001]
Dummy if any parent works	0.001	0.002	0.003	0.004	0.005	0.009*
	[0.003]	[0.003]	[0.004]	[0.003]	[0.006]	[0.005]
Constant	0.927***		0.959***		0.853***	
	[0.014]		[0.010]		[0.020]	
Observations	40,806	40,806	26,712	26,712	15,417	15,417
Village FE	X		X		X	

Note: Dummy indicator on whether the individual studies or not is the dependent variable. Only children from 6 to 15 years old taken into account. Column [1] and [2] show the estimates for the entire sample. Columns [3] and [4] show the estimates for the children under the household income average. Columns [5] and [6] show the estimations for the children under the 25th percentile of the income distribution. Columns [1], [3], and [5] show the estimates for a linear probability model. Columns [2], [4], and [6] display the estimates using a probit. *** p<0.01, ** p<0.05, * p<0.1

These results suggest that boys drop out of school in Colombia more often than girls do and that this difference is even larger in the poorest population. Linked to the performance gap in the PISA 2009 data for Colombia, these numbers suggest that selection bias may be affecting the sample. However, in addition to these estimations, I computed the gender difference (number of girls – number of boys) by each quintile of the performance distribution in the PISA 2009 sample for Colombia. Figure 3 plots these differences for Colombia, Latin America, and OECD and non-OECD nations. These plotted values are rescaled by the number of people in each quintile. If the plotted value is positive (negative), it means that there are more women (men).

Colombia displays 20 percent and 10 percent more girls than boys in the first and second quintiles of the distribution, respectively. The Colombian distribution has a lack of low-skilled male students and high-skilled female students compared with Latin America as a whole, as well as with OECD and non-OECD countries. In fact, Colombia's peak in the first and second quintiles suggests a clear correlation between performance and the male dropout rate, while in the other samples this correlation is less clear.

Figure 3. Gender Differences by Quintile

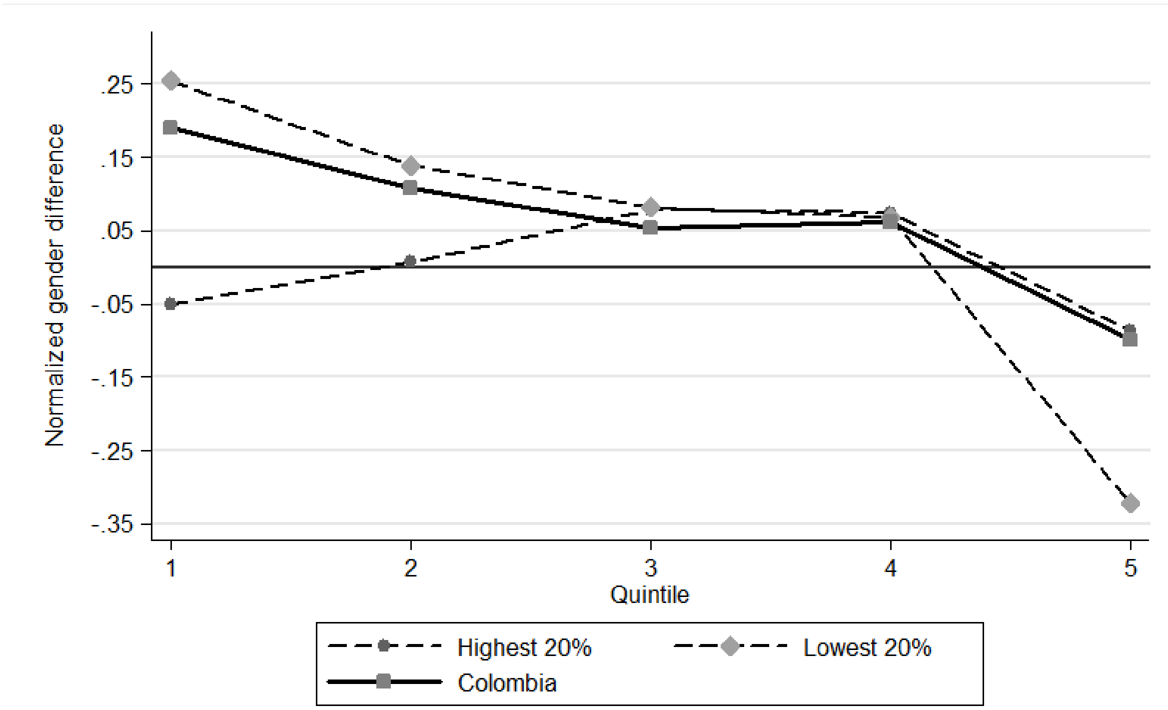


Source: PISA (2009), author's calculations.
Note: Values calculated as the number of girls minus the number of boys over the total number of students in each quintile.

Moreover, as suggested by the latter model, this phenomenon is also related to household income. Figure 4 plots the same graph as in Figure 3, but rather compares income distribution by quintile. The lower-income values show an even larger lack of low-skilled boys and high-skilled girls than previously. By contrast, however, high-income people have more moderate values, implying the absence of a selection problem.

These results provide evidence of a potential sample selection threat in the computation of the gender performance gap that does not exist for Latin America or the OECD. Poor low-skilled male students seem to be a vulnerable population that has a large incentive to leave school at an early age. The lack of low-skilled male students overestimates the male means, creating a biased estimation in the regressions. In fact, the male distribution seems to be bounded because of the high amount of low-skilled men dropping out of the system. This selection problem is thus related to the strong male over-performance in the Colombian sample.

Figure 4. Income Differences by Quintile



Source: PISA (2009), author's calculations.
Note: Values calculated as the number of girls minus the number of boys over the total number of students in each quintile.

4.2. Trimming for Bounds and Simulation: A Way to Overcome Selection Bias

The results presented in the previous subsection suggest that the computation of the gender performance gap in Colombia needs to account for selection bias. A possible strategy for overcoming this discrepancy is to use the bounding procedure introduced by Lee (2009). This procedure trims the bounds of the uncensored sample in order to achieve better comparability. Formally, following Lee (2002) and (2009), we consider a sample selection model in which

$$\{Y_1^*, Y_0^*, S_1, S_0,\} \text{ is i.i.d. across individuals}$$
$$S = S_1 G + S_0(1 - G)$$
$$Y = S\,[Y_1^* G + Y_0^*(1 - G)]$$
$$(Y, S, G) \text{ is observed}$$

where Y_1^* and Y_0^* are the latent performance outcomes for men and women, respectively, G $\subseteq \{1,0\}$ denotes the gender of the individual, and S_1 and S_0 are indicators of whether the individual is observed depending on his or her gender. In other words, if S_1= 0 and S_0= 1 the outcome will be missing (not missing) if the individual is a boy (girl). Further, $S \subseteq \{1,0\}$ indicates whether the individual is observed (S = 1) or not (S = 0). Finally, Y is the student's performance that can only be observed if the individual is in the sample and takes the values of Y_1^* or Y_0^*.[10]

Now, let us assume the following conditions:

Condition 1: (Y_0^*, Y_1^*, S_1, S_0) is independent of G.

Condition 2: $S_1 \leq S_0$ with a probability of 1.

If conditions 1 and 2 hold, then Δ_0^{LB} and Δ_0^{UB} represent the lower and upper bounds of $E[Y_1^* - Y_0^* \, | S_0 = 1, S_1 = 1]$:

$$\Delta_0^{LB} = E[\, Y \mid G = 1, S = 1] - \, E[Y \mid G = 0, S = 1, Y \leq y_{(1-p_0)}]$$

$$\Delta_0^{UB} = E[\, Y \mid G = 1, S = 1] - \, E[Y \mid G = 0, S = 1, Y \geq y_{p_0}]$$

where y_q is the corresponding value of the *q*th percentile in the cumulative distribution function of Y, conditional on *G* = 1, *S* = 1. Lastly, p_0 corresponds to

$$p_o \equiv \frac{\Pr[S = 1 \mid D = 1] - \Pr[S = 1 \mid D = 0]}{\Pr[S = 1 \mid D = 1]}$$

For the purposes of this paper, conditions 1 and 2 hold. Condition 1 holds because the gender of an individual is a random and independent process that does not correlate with performance or with the indicators of whether being or not observed. Condition 2 holds because S_1 is always less than or equal to S_0, as being a boy (girl) induces the individual to drop out (not drop out).

Thus, Δ_0^{UB} and Δ_0^{LB} are shown to be the upper and lower bound estimators of the performance of Colombian students under the threat of sample selection bias. However, only Δ_0^{UB} is used because it reflects the scenario in which only the poorest-performing male students

[10] For more information on the model, the identification, the estimators, or their asymptotic properties, please see Lee (2002, 2009).

drop out. On the contrary, Δ_0^{LB} estimates the effect when the best performing male students drop out. As shown earlier, the male dropout rate increases in the lowest performance percentile. Therefore, Δ_0^{UB} captures this situation.

In addition, another issue remains: the proportion of male and female students that drop out is unobservable. Hence, it is not possible to compute the p_0 percentile unless the probabilities of being observed, conditional on gender, are assumed. In order to overcome this barrier, it is possible to assume a 50/50 distribution of men and women or, because the real-life gender distribution is not 50/50, an observed empirical proportion can be also used. In the following sections, I thus use the Latin America (excluding Colombia) and OECD gender proportions of students in the PISA database in order to compute the upper bound (Δ_0^{UB}).

5. Results

This section presents the results of the estimations in two subsections. Subsection 5.1 describes the computation of the gender performance gap without accounting for selection bias. Subsection 5.2 presents the results of the estimations when using Lee's upper bound estimator.

5.1. OLS in the Complete Sample

The first estimations use a regular OLS model with log-performance as the dependent variable and the gender dummy as the variable of interest. Following Hanushek and Woessman (2011a), the household and school controls were also used as covariates. The estimated model is expressed as follows:

$$Log(Performance)_{ij} = \beta_0 + \beta_1 G_i + \theta H_i + \gamma S_j + \mu_j + \varepsilon_i$$

where G_i refers to the gender dummy (1 if male), H_i is a vector of household characteristics, S_j is a vector of school characteristics, μ_j is a school fixed effect, and ε_i is the residual term that follows common properties. These variables are indexed by *i* meaning individual and *j* meaning school.

Moreover, I used dummies for whether the mother lives at home, if the student lives with his/her brother/sister, if it is a single-parent household, and a continuous variable for education of the parents as household covariates. Private, single-sex, and rural school dummies were used as school controls. Finally, a specification with school fixed effects was also estimated. The provided replicate weights and the plausible values approach were used to correct the standard errors.[11]

The results of these estimations are shown in Table 3. The first three specifications used the described controls, while the fourth one used the school fixed effects. The gender dummy is significant in all four specifications and suggests that, ceteris paribus, boys outperform girls by approximately three percentage points. The gender gap is persistent in this estimation even when using variation within schools and accounting for multiple covariates. It is also worth noting that the other coefficients in Table 3 hold as expected; in other words, the education of the parents, the presence of the mother, private schools, and urban schools have a positive impact on academic performance. Furthermore, single-sex schools improve performance by approximately 6.3 percentage points. Although this estimation confirms the serious male over-performance in Colombian PISA scores after controlling for different characteristics, these coefficients do not account for non-random sample selection as Lee's upper bound estimator does.

[11] The performance estimations based on data derived from the PISA 2009 database must be carried out by using the procedure explained in the following link: http://browse.oecdbookshop.org/oecd/pdfs/free/9809021e.pdf. Each regression must be conducted five times with a different performance measurement. The final β parameter is the average of the parameters estimated in each of these five regressions. Finally, 80 estimations must be performed with the different weights provided by the survey in order to estimate the correct standard errors.

Table 3. OLS Using Individual Log-Performance as Dependent Variable

	(1) Mean difference	(2) Household controls	(3) School controls	(4) School fixed-effects
Male dummy	0.034***	0.031***	0.034***	0.036***
	[0.009]	[0.008]	[0.007]	[0.007]
Mother at home		0.136***	0.123***	0.091***
		[0.016]	[0.015]	[0.012]
Brothers or sisters at home		-0.005	-0.003	0.005
		[0.011]	[0.011]	[0.009]
Highest parental education in years		0.012***	0.008***	0.004***
		[0.001]	[0.001]	[0.001]
Single parent family		-0.012	-0.011	-0.008
		[0.008]	[0.007]	[0.007]
Private school dummy			0.100***	
			[0.014]	
Single Sex Schools			0.063***	
			[0.021]	
Urban school			0.029*	
			[0.015]	
Constant	7.075***	6.832***	6.848***	6.947***
	[0.009]	[0.019]	[0.019]	[0.014]
Observations	6,395	6,395	6,395	6,395
School FE				X

Note: Standard errors calculated using plausible values and student replicate weights. For further information see: http://browse.oecdbookshop.org/oecd/pdfs/free/9809021e.pdf. Standard errors reported in brackets. *** p<0.01, ** p<0.05, * p<0.1

5.2. Simulation and Trimming the Female Distribution

Lee's bound methodology compares the gender samples by trimming the female distribution. The upper bound (Δ_0^{UB}) estimator assumes that selection takes place in the lowest percentile of the male performance distribution, while the lower bound estimator assumes that it occurs in the highest. As Colombian attrition is caused by low-skilled men, only the upper bound parameter is estimated herein. In order to estimate the upper bound, it is still necessary to compute the p_0 percentile; however, this value is unobservable because the PISA data only include enrolled students. Therefore, male dropouts need to be simulated by using an empirical distribution that does not suffer from sample selection bias.

As shown in Section 4, the Latin American (excluding Colombia) and OECD PISA samples have no sample selection bias in the lowest performance percentile. Because the dropout rate seems to be uncorrelated with performance in these samples, sample selection is no issue and those samples can thus be used in order to compute the p_0 percentile. Indeed, they are a more credible distribution than even a regular 50/50 assumption because a real-life gender distribution is never 50/50. Although these two values differ because the proportion of girls that attend school in OECD nations is more than that in Latin America, the correlation between dropout rate and performance in both cases is less obvious than that for the Colombian sample.

Therefore, by using the LA and OECD samples, I carried out two simulations in order to trim the female bounds. In the first simulation, the female sample was trimmed in a percentile in which the gender ratio was equal to that observed in Latin America (51.3 percent women; see Figure 2). In the second simulation, I used a larger percentile in which the ratio was equal to the ratio in the OECD (49.5 percent women). Table 4 presents the estimations for Lee's upper bound in the first simulation. The table shows that the gender gap disappears in all specifications, while the covariate coefficients keep the same effects as in the estimation presented in Table 3. This finding means that if we assume that Colombia's dropout rate is similar to that across Latin America, the average gender gap may disappear.

Table 5 shows the results of the same estimation in the second simulation. In this case, girls outperform boys to a minor degree in the first three specifications, but this difference is not significant in the fixed effects model. Similar to the first simulation, if we assume that Colombia's dropout rate is at the same level as that in the OECD, the average gender gap would disappear and probably reverse.

Table 4. Trimming for Bounds Based on the LA Mean

	(1) Mean difference	(2) Household controls	(3) School controls	(4) School fix-effects
Male dummy	-0.002	0.000	0.004	0.010
	[0.009]	[0.008]	[0.007]	[0.006]
Mother at home		0.116***	0.104***	0.078***
		[0.017]	[0.016]	[0.012]
Brothers or sisters at home		-0.013	-0.011	-0.004
		[0.009]	[0.010]	[0.008]
Highest parental education in years		0.011***	0.007***	0.004***
		[0.001]	[0.001]	[0.001]
Single parent family		-0.010	-0.010	-0.006
		[0.007]	[0.007]	[0.006]
Private school dummy			0.091***	
			[0.013]	
Single Sex school			0.052***	
			[0.020]	
Urban School			0.029**	
			[0.012]	
Constant	7.111***	6.902***	6.916***	7.00***
	[0.007]	[0.018]	[0.018]	[0.013]
Observations	6,147	6,147	6,147	6,147
School FE				X

Note: Standard errors calculated using plausible values and student replicate weights. For further information see: http://browse.oecdbookshop.org/oecd/pdfs/free/9809021e.pdf. Standard errors reported in brackets. *** p<0.01, ** p<0.05, * p<0.1

These results suggest that if non-random dropout disappears and the low-skilled male dropout rate in Colombia diminishes, the performance gap may disappear altogether. In other words, a large proportion (if not all) of the gender performance gap is caused by sample selection problems in the population of low-skilled and poor male students.

Table 5. Trimming for Bounds Based on the OECD Mean

	(1) Mean difference	(2) Household controls	(3) School controls	(4) School fix-effects
Male dummy	-0.024**	-0.019**	-0.015**	-0.005
	[0.010]	[0.008]	[0.008]	[0.007]
Mother at home		0.111***	0.100***	0.076***
		[0.017]	[0.016]	[0.013]
Brothers or sisters at home		-0.012	-0.011	-0.004
		[0.010]	[0.010]	[0.008]
Highest parental education in years		0.010***	0.007***	0.003***
		[0.001]	[0.001]	[0.001]
Single parent family		-0.008	-0.007	-0.005
		[0.007]	[0.007]	[0.006]
Private school dummy			0.090***	
			[0.013]	
Single Sex school			0.042*	
			[0.023]	
Urban School			0.025**	
			[0.012]	
Constant	7.134***	6.930***	6.943***	7.022***
	[0.006]	[0.018]	[0.018]	[0.013]
Observations	5,911	5,911	5,911	5,911
School FE				X

Note: Standard errors calculated using plausible values and student replicate weights. For further information see: http://browse.oecdbookshop.org/oecd/pdfs/free/9809021e.pdf. Standard errors reported in brackets. *** p<0.01, ** p<0.05, * p<0.1

6. Discussion

Over recent decades, Latin America has striven to increase its rates of education enrollment, but educational quality and dropout rates remain a major problem across the region (Bassi, Busso, and Muñoz, 2013). The gender performance gap addressed herein has also arisen as a new and under-researched issue. Figure 1 shows that, in addition to Colombia, Chile, Peru, Brazil and Mexico have gender gaps in terms of boys outperforming girls. Although the disparities in these countries are not as large as that in Colombia, there remains a lack of academic investigation into understanding whether these gender performance gaps are associated with non-random dropout rates or other observable issues.

The results presented herein suggest that the dropout rate of low-skilled poor students is an important determinant of the illustrated gender-based discrepancies. However, the answer to why Colombia has larger selection problems than other countries in the region can be divided into two parts. First, the occurrence of armed conflict negatively affects the probability of a male student finishing secondary school (Rodríguez and Sánchez, 2009). Therefore, in a country characterized by social conflict such as Colombia, students may drop out of school to join illegal organizations or migrate. Second, risky behavior, such as drug and alcohol consumption as well as drug dealing, also significantly affects the probability of dropping out of school (Gaviria and Raphael, 2001; Chatterji and DeSimone, 2005; McCaffrey et al., 2010). These two facts, coupled with a lack of social mobility and limited access to tertiary education, help explain why low-skilled male students in Colombia leave school at an early age.

In addition to the high male dropout rate, this paper demonstrated that the selection problem is even stronger in the lowest percentile of the income distribution. Although poor female students who drop out of school often do so because of pregnancy or to take care of household tasks, conflict and risky behavior have an even stronger effect on low-income men. Hence, the gender performance gap in Colombia reflects the country's largest social problem, which mostly affects mostly the low-income population.

Another issue that deserves attention is the low presence of female students in the top 20 percent of the performance distribution. Figure 3 showed that in Colombia's highest quintile there are 10 percent more male students than their female counterparts, which is an outlier case compared with Latin America and with OECD and non-OECD nations. The dropout rate cannot explain this discrepancy because a high-skilled girl has no more incentive to leave school than a low-skilled one. By contrast, observable (e.g., pregnancy, household tasks) or unobservable (e.g., classroom discrimination, social norms) issues might be affecting the academic performance of girls. However, the estimations carried out herein offer no clues about the relationship between observable characteristics and this result. González de San Román and De la Rica Goricelaya (2012) use the same PISA database to show that in societies where gender equality is enhanced, girls perform better in mathematics and reading. While this may be one explanation, further investigation in this direction is required.

The findings reported in this paper suggest, lastly, that the gender performance gap is explained by low-income male students who drop out at a very high rate. However, Latin American countries' facing high dropout rates is not a new phenomenon. What is new and important, however, is the causal relationship between the non-random male dropout rate and the existence of huge gender performance gaps.

7. Conclusion

Few previous studies have examined the determinants of the academic performances of Latin American students. Researchers and policymakers in the region have rather focused on student enrollment, and major advances have been made on this topic. However, educational quality and dropout rates are issues that must also be taken into account in the public education agenda. In this paper, I found evidence of the linkage between the gender performance gap and school dropout rates in Colombia. Dropping out thus seems to be a crucial issue that ultimately affects the economic development of a country. Once a student is enrolled, it is important to prevent him or her from abandoning the system prematurely. Social conditions such as low expected returns on secondary education, high returns on illegal activities, risky behavior, and armed conflicts may all be possible causes of this phenomenon.

Further analysis, however, should be carried out to understand what happens to Colombian girls when they do not reach the highest performance percentile and to explain why male students are dropping out at such a high rate. Moreover, more Latin American studies of the academic gender gap are needed to understand if the Colombian situation is replicated in other countries in the region.

References

Alfonso, M. et al. 2012. "Panorama General de la Educación en América Latina y el Caribe. In: M. Cabrol and M. M. Székely, editors. *Educación para la Transformación*. Washington, DC, : Banco Interamericano de Desarrollo.

Bailey, M., and S. Dynarski. 2011. "Gains and Gaps: Changing Inequality in U.S. College Entry and Completion." NBER Working Paper 17633. Cambridge, United States: National Bureau of Economic Research.

Bassi, M., M. Busso and J.S. Muñoz. 2013. "Is the Glass Half Empty or Half Full? Enrollment, Graduation, and Dropout Rates in Latin America." Working Paper IDB-WP-462. Washington, DC, United States: Inter-American Development Bank.

Burgess, S. et al. 2003. "Girls Rock, Boys Roll: An Analysis of the Age 14-16 Gender Gap in English Schools." CMPO Working Paper Series No. 03/084. Bristol, United Kingdom: University of Bristol.

Cárdenas, M., R.D. Hoyos and M. Székely. 2011. "Idle Youth in Latin America: A Persistent Problem in a Decade of Prosperity." Washington, DC, United States: Brookings Institution. Working Paper.

CEPAL. 2002. "Deserción Escolar, un Obstáculo para el Logro de los Objetivos del Desarrollo del Milenio." In: *Panorama Social de América Latina 2001-2002*. Santiago, Chile: Comisión Económica para América Latina.

Chatterji, P., and J. DeSimone. 2005. "Adolescent Drinking and High School Dropout." NBER Working Paper 11337. Cambridge, United States: National Bureau of Economic Research.

Dollar, D., and R. Gatti. 1999. "Gender Inequality, Income, and Growth: Are Good Times Good for Women?" Gender and Development Working Paper Series 1. Washington, DC, United States: World Bank.

Duryea, S. et al. 2007. "The Educational Gender Gap in Latin America and the Caribbean." Research Department Working Paper 600. Washington, DC, United States: Inter-American Development Bank.

Flabbi, L., and M. Tejada. 2012. "Gender Gaps in Education and Labor Market Outcomes in the United States: The Impact of Employers' Prejudice." Working Paper IDB-WP-357. Washington, DC, United States: Inter-American Development Bank.

Fryer, R., and S. Levitt. 2009. “An Empirical Analysis of the Gender Gap in Mathematics.” NBER Working Paper15430. Cambridge, United States: National Bureau of Economic Research.

Gammie, E. et al. 2003. “Gender Differences in Accounting Education: An Undergraduate Exploration.” *Accounting Education* 12(2): 177–196.

Gaviria, A. 2010. “Cambio Social en Colombia durante la Segunda Mitad del Siglo XX.” Documento CEDE 2010-30. Bogota, Colombia: Universidad de los Andes, Centro de Estudios sobre Desarrollo Económico (CEDE).

Gaviria, A., and J. Barrientos. 2001. “Determinantes de la Calidad de la Educación en Colombia.” Archivos de Economía Documento 159. Bogota, Colombia: Departamento Nacional de Planeación, Dirección de Estudios Económicos.

Gaviria, A., and S. Raphael. 2001. “School-Based Peer Effects and Juvenile Behavior.” *Review of Economics and Statistics* 83(2): 257-268.

González de San Román, A., and S. De la Rica Goricelaya. 2012. “Gender Gaps in PISA Test Scores: The Impact of Social Norms and the Mother’s Transmission of Role Attitudes.” IZA Discussion Paper 6338. Bonn, Germany: Institute for the Study of Labor/IZA.

Hanushek, E., and L. Woessman. 2011a. “The Economics of International Differences in Educational Achievement.” In: E.A. Hanushek, S.J. Machin and L. Woessmann, editors. Handbook of the Economics of Education. Volume 3. Amsterdam, The Netherlands: Elsevier.

----. 2011b. “Sample Selectivity and the Validity of International Student Achievement Tests in Economic Research.” *Economics Letters* 110(2): 79-82.

Heckman, J. 1979. “Sample Selection Bias as a Specification Error.” *Econometrica* 47(1): 153-161.

Klasen, S., and F. Lamanna. 2008. “The Impact of Gender Inequality in Education and Employment on Economic Growth in Developing Countries: Updates and Extensions.” Ibero-America Institute for Economic Research Discussion Paper 175. Goettingen, Germany: Ibero-America Institute for Economic Research.

Lee, D. 2002. “Trimming for Bounds on Treatment Effects with Missing Outcomes.” NBER Technical Working Paper 277. Cambridge, United States: National Bureau of Economic Research.

Lee, D. 2009. “Training, Wages, and Sample Selection: Estimating Sharp Bounds on Treatment Effects.” *Review of Economic Studies* 76(3): 1071-1102.

Lewis, M., and M. Lockheed. 2008. “Social Exclusion and the Gender Gap in Education.” Policy Research Working Paper 4562. Washington, DC, United States: World Bank.

Lochner, L., and E. Moretti. 2004. “The Effect of Education on Crime: Evidence from Prison Inmates, Arrests, and Self-Reports.” *American Economic Review* 94(1): 155-189.

Magnoli, A. 2000. “Bridging the Gender Gap in Developing Regions.” INDES Working Paper I-16. Washington, DC, United States: Inter-American Development Bank.

McCaffrey, D. et al. 2008. “Marijuana and High School Dropout: The Influence of Unobservables.” NBER Working Paper 14102. Cambridge, United States: National Bureau of Economic Research.

Murnane, R. 2013. “U.S. High School Graduation Rates: Patterns and Explanations.” *Journal of Economic Literature* 51(2): 370-422.

Ñopo, H. 2012. “Gender Differences in Education in Latin America and the Caribbean: Girls Outpacing Boys.” In: H. Ñopo, editor. *New Century, Old Disparities*. Latin American Development Forum Series. Washington, DC, United States: World Bank.

Rodríguez, C., and F. Sánchez. 2012. “Armed Conflict Exposure, Human Capital Investments and Child Labor: Evidence from Colombia.” *Defence and Peace Economics* 23(2): 161-184.

Spencer, S., C. Steel and D. Quinn. 1999. “Stereotype Threat and Women’s Math Performance.” *Journal of Experimental Social Psychology* 35: 4-28.