The Effect of Converting Single-sex Schools to Coeducational: Quasi-experimental Evidence from Colombia[1]

Gloria L. Bernal[*a,c], Kristof De Witte [b,c]

*Corresponding author: E-mail: gbernal@javeriana.edu.co, Tel: + (571) 3208329 ext 5189.
[a] Department of Economics, Pontificia Universidad Javeriana.
[b] Leuven Economics of Education Research, Faculty of Economics and Business, KU Leuven, Naamsestraat 69, 3000, Leuven, Belgium.
[c] UNU-MERIT, Maastricht University, Boschstraat 24, 6211 AX Maastricht, The Netherlands.

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Abstract

There has long been a debate about the effect of coeducational settings on pupils' academic achievement in schools. Exploiting quasi-experimental evidence from Colombia, this paper examines the effects of the conversion of single-sex to coeducational schools on students' performance. Using a time varying difference-in-differences strategy, we exploit the conversion of 95 male-only and 184 female-only schools to coeducational schools in a period of 20 years. The results suggest that males attending former male-only (ex-male) schools decreased their performance. In contrast, females attending former female-only (ex-female) schools increased achievement. Moreover, female students attending ex-male schools outperform females in coeducational, ex-female and current female-only schools. Our findings support the hypothesis that a masculine schooling environment (i.e. on average, characterized as more competitive, and with a stronger math focus) may be beneficial for females' performance, although this is to the expense of males' achievement.

Keywords: Single-sex schools; Coeducational schools; Academic performance; Gender composition of students

JEL-Classification: I2, J1, H5, J24, I21

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1. Introduction

The debate surrounding the conversion of single-sex schools into coeducational institutions, or vice versa, has garnered significant attention and extensive discussions within academic circles and the wider public, however, without consensus (Title IX of the federal Education Amendments, 2006; Department for Education and Skills UK, 2007). Theoretical arguments state that both male and female students perform better in a single sex-school academic environment; for example, because of the adaptation to different learning mechanisms, or the development of competitive-related skills (Booth and Nolen, 2012; Schneeweis and Zweimuller, 2012). In contrast, other theories favor coeducation as a mechanism to improve performance of both genders, e.g. due to undesirable behavior such as sex-segregation and gender stereotypes (Halpern et al. 2011; Hilliard et al., and Liben, 2010). However, there has been little causal evidence on the effects of mix-gender composition on achievement. In this paper, we exploit a rich longitudinal dataset and the unique quasi-experimental case of Colombia to examine the extent to which the conversion from single-sex schools to coeducational schools affects the academic achievement of male and female students.

Empirical studies have stressed the benefits of single-sex schools over coeducational schools, when looking at the impact on academic performance. However, a number of these studies suffer from self-selection bias (see the meta-analysis by Pahlke et al., 2014). That is, single-sex schools and their students might self-select in these schools such that they differ in unobservable characteristics from coeducational schools and the students attending them. Therefore, the estimates obtained when comparing single-sex to coeducational schools cannot be interpreted as causal effects. Nevertheless, two studies used a causal framework to investigate the impact of converting single-sex schools to coeducational on academic achievement, however, they suffer from low power. Lee and Park (2017), and Dustmann and Kwak (2018) exploited the conversion of a few (7 males-only) private, single-sex schools to coed, and the random assignment of middle-school graduates to different high schools in Seoul, South Korea. Both investigations indicate that the conversion leads to worse academic outcomes for boys.[2]

Using a similar research question and methodology as Lee et al. (2018) and Dustmann et al. (2018), we contribute to the literature on the conversion of single-sex schools to coeducational in three aspects. First, we exploit a large-scale natural experiment, where numerous single-sex schools (95 male-only and 184 female-only) converted to coeducational facilities, during the 1990s and 2000s in Colombia. Second, we exploit the unique significant variation in the share of opposite sex students -from 1% up to 70%- among former single-sex schools and across cohorts within the same school, thus allowing to teased out the gender peer effect from the possible endogenous responses of teachers and parents right after the change. Third, given that the causal evidence of single-sex schools versus coeducational in general, and the conversion of single-sex schools to coeducational in particular, has been almost exclusively examined for high income countries (e.g. South Korea, England, or the USA), this paper contributes to the literature in analyzing the conversion of single-sex to coeducational system in the context of a developing nation characterized by low performance and high gender academic gap.[3] Colombian academic conditions are fundamentally different from other developed nations such as South Korea.[4] Fourth, we contribute to the extensive literature that claims that nurture over nature is a decisive element of academic success regardless of the students' gender (Guiso et al., 2008). Unobservable learning dynamics and school environments, such as those pursued in masculine and in feminine environments, are possible determinants of academic success

[2] Dustmann et al. (2018) studied in addition 4 female-only schools and find a negative effect on girls' performance in ex-female-only schools.

[3] While South Korea consistently occupies a top 10 position in international rankings of math (and occasionally reading) assessments, Colombia consistently ranks in the bottom 10, and has amongst the largest gender gap in math (and amongst the lowest gender advantage in reading) across PISA-participating countries (OECD, 2018). In Colombia, boys outperformed girls in mathematics by 20 score points, which is 4 times larger than the average gender gap in mathematics across OECD countries. In addition, the advantage for girls in reading is 3 times lower than the OECD average. Moreover, while girls slightly outperformed boys in science overall, in Colombia boys outperformed girls in science by 12 score points.

[4] According to Smyth (2010) the societal context within which coeducational and single-sex education take place can influence the processes at play and it is usually neglected by researchers.

(Van De Gaer et al., 2004). Finally, the present study contributes to the literature that analyzes the interactions between male and female students in school environments (e.g. Welch et al., 2014), and to the scarce literature of gender peer effects on performance in developing countries.

Two main reasons triggered the schools to change their gender composition status: (1) the explicit recommendation in the Colombian National Education Plan (1996-2005) to switch single-sex schools to coeducational; and (2) the worldwide idiosyncratic trend considering coeducational schools favorable for children development (UNICEF, 1993). Selection into coeducational regimen was not mandatory in Colombia, but highly recommended. As long as selection is based on time-invariant school characteristics (observed and unobserved) selection shall not affect the causal interpretation of the difference-in-differences (DiD) with fixed effects estimates. Moreover, we are considering students in high school, for whom cost of switching school is high and unlikely. Altogether,[5] this setting allows for a natural experiment consideration. Using the 2001data from compulsory high school exit examinations along with a time varying DiD methodology and school fixed effects capturing observed and unobserved heterogeneity at school level, we aim to answer the following question: Does this conversion of single-sex schools to coeducational affect academic performance of incumbent students? Moreover, we answer the question: Does this conversion has differential effects on the performance of incoming opposite-sex students in converting schools? i.e. females in ex-male schools and males in ex-female schools.

Our results suggest that, when females join an ex-male school, the decrease in the performance of males is proportional to the percentage of females that newly enroll in the school. This decrease in performance is already quite pronounced at even a 10% share, where males see a decrease in their academic performance of 0.1 standard deviations. In contrast, when males join an ex-female school, the increase in the performance of females is proportional to the percentage of males entering to the school. Conditional on observed characteristics, females in ex-male schools score the highest among other types of schools (i.e. mixed, ex-female or female-only schools). In contrast, males in ex-female schools perform worse than ex-male and male-only schools, and yet better than in coeducational schools. Our findings support the hypothesis that a masculine schooling environment, which has typically been characterized by more competitive, and with a stronger math focus, may be beneficial for females' performance, but this might be at the expense of males' achievement. Furthermore, the hypothesis that boys may lose focus on their studies and/or experience disruptive behavior, as shown in the South Korean studies, is also a possible explanation to the reduction in boys' performance.

The remaining of the paper is structured as follows: Section 2 and 3 provides a review of the literature and a description of the Colombian educational system, respectively. The dataset and the difference-in-differences model framework is described in Section 4. Section 5 presents the results, and various robustness checks; and Section 6 discusses the results and concludes.

2. Literature review

In the late 19th and early 20th centuries, coeducation became more widely accepted in different nations such as the USA, China, UK, and the Soviet Union countries. In fact, under the arguments of gender inclusion, equal education opportunity and diversity many nations required their public schools to be coeducational by mandate. By the early 21st century, coeducational education became the rule with most of the countries in the world having lower than two percent single-sex schools (Wiseman, 2008).[6] However, there is still an opened debate over the

[5] Students´ residence (86% of the municipalities did not have another single-sex school to transfer) and high cost of single-sex private schools prevent students transferring to another single-sex school. Even in the case that moving from the converting school occurs, our estimates will be bias downwards as parents will transfer those students that would be negatively affected by the presence of the opposite-sex in their classes.

[6] Using Mathematics and Science Study (TIMSS), Wiseman (2008) identified that nations with more than 15% of the schools being single-sex included: Chile, Singapore, England, Israel, Hong Kong, Israel, New Zealand, Australia, South Korea, and Muslim nations.

benefits on non-cognitive and cognitive outcomes of keep students separated by gender (in some classes for instance).

The large theoretical and empirical literature in the area of educational psychology and economics observes mixed and inconclusive evidence on the effects of mixing boys and girls in the classroom on learning. On the one hand, some theoretical studies show that students perform relatively better in single-gender classes. This literature shows that the higher levels of performance could be explained by the following factors: teachers can easily focus on the needs and ways of learning of each sex (Sax, 2010; Lee, Marks and Byrd, 1994); the development of competitive-related skills (Booth and Nolen, 2012); and more concentration of students on academics rather than on appearance and popularity (Riordan et al., 2008). It is also argued that girls may perform better in girls' schools because they have more self-confidence, and there are fewer gender stereotypes (Eisenkopf et al., 2015; Shapka and Keating, 2003). On the other hand, some other theoretical studies argue that stereotypes are in fact strengthened in girls' schools (Bigler and Liben, 2007; Halpern et al., 2011) and that girls in female-only schools are less likely to pursue careers in science and technology (Oakes, 1990; Thompson, 2003).

In terms of academic achievement, the literature is not conclusive either. Single sex schools tend to show higher performance but this advantage is small or even disappear after properly control for individual factors such as socio-economic status, ethnicity or school factors as leadership and teacher expertise (Smithers et al., 2006; Pahlke et al., 2014). Empirical evidence using causal research designs tends to find positive effects of attending single sex schools over coeducational. Using random assignment of pupils to either single sex or mixed schools to assess performance, Park et al. (2013) find that attending a coeducational (versus single-sex) school lowers achievement and decreases the likeliness to apply to higher education for both boys and girls in Seoul, South Korea. Moreover, the benefits on achievement of a single-sex school over coeducational in the United States are also highlighted by Choi, Hyungsik and Geert (2014) and Briole (2021), whereas Jackson (2012) finds for Trinidad and Tobago that only the girls with a revealed preference for girls' schools before their assignment experienced benefit of single-sex schooling. In contrast to the other studies, and conditional in nearly random assignment, Doris, O'Neill and Sweetman (2013) do not find that single-sex schooling reduces the significant gender gap in performance favoring boys in Ireland. The mentioned studies compared mixed-always with single-sex-always schools, which relates to but is different to the present study. In the present paper, we compare the same school under two regimes of gender composition, which avoids large school heterogeneity in the comparison and allows for a better control of time-invariant unobservable characteristics of the school (such as school management, culture, believes, organization, teacher composition, etc.).

Lee et al. (2017) and Dustmann et al. (2018) are closely related to the present study. Both studies exploited school transitions from single-sex to coeducational schools in South Korea to identify the effects of single-sex schooling on academic achievement, using a difference-in-differences (DiD) approach with school fixed effects. Lee et al. (2017) focuses on the transition of seven boys-only schools, whereas Dustmann et al. (2018) analyzed these seven schools and another four female-only schools that were converted to a coeducational setting. Although the latter focuses more on comparing single-sex schooling to coeducational schooling, both studies compared cohorts in the same school that were exposed to either a single-sex or a coeducational environment at two different levels: within-high-school and within-class level. They find that the conversion of single-sex schools to coeducational leads to worse academic outcomes for boys (and girls in Dustmann's paper). While Lee et al. (2017) suggest that this negative effect disappeared after two years when the school transition was completed, Dustmann et al. (2018) conclude that the negative effects are more persistent.

3. Institutional background

Colombia performs significantly below the OECD average in international tests such as the PISA assessment, and the academic gender gap is among the largest in the world. Compared to all countries participating in the 2018 PISA assessment, males outperform females in math by the widest margin, but at the same time, girls outperform boys in reading by the lowest margin (OECD, 2018). Although policy discussions focus on ways to increase achievement

- including teaching each gender separately in mixed schools - there is limited research exploring the gender peer effect on academic achievement.

In Colombia, compulsory education starts when children are 5 years old and it lasts until children turn 15 years old (grade 9). In addition, students must study two more years to graduate from high school (grade 11). Two academic calendars are used simultaneously: one starts in February (A calendar) and one in August (B calendar). Most national schools, hosting approximately 95% of the students are in A calendar.[7] Up to the 1950´s, separate schooling for boys and girls was the rule. However, in 2019 only the minority of schools (about 4%) are single-sex schools, and those are often managed by a religious organization. Although conversion was implemented by many schools in the last six decades, tests scores to measure the consequences of this phenomenon are only available from year 2000 onwards.

Reasons for conversion of each particular school are unknown. However, two events likely trigger the school's decisions: (a) it was highly recommended (albeit not obligatory) by the government National Education Plan (1996-2005) to deliver coeducational rather than single-sex schooling arguing gender equalization, and (b) there were trend changes regarding idiosyncratic beliefs of parents and school administrators about mixing students in classes following worldwide trends (UNICEF, 1993). According to local media, parents who these days choose single-sex schools usually argue that single sex favors values, customs, discipline, non-discrimination and culture. These reasons are consisted with parents in other countries such as the USA (Heather, 2002).

Colombian parents have relative freedom to choose the school for their children compared to parents in other nations. In public schools, students are by default assigned based on their home location. However, there are no legal impediments for a student living in some district area to enroll a school in another district area (as it is the case in the USA or in South Korea). Although the dropout rate in secondary education is high (at roughly 4.09% annually, for the year 2019), a transfer from one school to another is a rather uncommon practice due to the high transactional costs of switching schools and the strict entrance limitations (e.g. in public schools it is difficult to find another available spot, and private high-quality schools do not often receive students from another school unless the student has outstanding credentials). Adding to this, in case students desired a relocation from one single-sex school to another one in the same municipality, in 86% of the cases there was no other school left to transfer to in 2001. While private schools have more autonomy (and on average have students with higher SES) than public schools, a similar number of private and public schools converted in our sample.

4. Data and Method

Data. We use administrative data of the national exit examination in Colombia, Saber 11°. The exam can be thought of as analogous to the SAT and ACT exams in the United States. It is administrated to all students who graduated from high schools in Colombia by the Colombian governmental agency in charge of measuring the quality of education: ICFES.[8] In 2014, the Saber 11° exam switched from evaluating eight subjects to five subjects. We examine math and reading sections not only because they are transversally evaluated in all versions, but also because they are high-stake subjects in which historically male and female respectively outperform the other sex. In its sampling strategy ICFES targets each subject to have a mean of approximately 50 and a standard deviation of about 10. We also examined the overall performance of the students' global score, as this score serves to enter to the university. The average of the student scores per school then makes up the school score, which is also the measure used for ranking schools. For each year, we standardized scores using z-score in the final sample and averaged students´ scores to the school level. In addition to test scores, Saber 11° also reports information on school characteristics and, since 2008, it also reports information on students' demographics such as socioeconomic (SES) strata. This strata measure is particularly unique in Colombia and lead the possibility to adequately know if the students belong to a low, middle- or high-income household.[9] Approximately 96% for senior high school students take the exam.

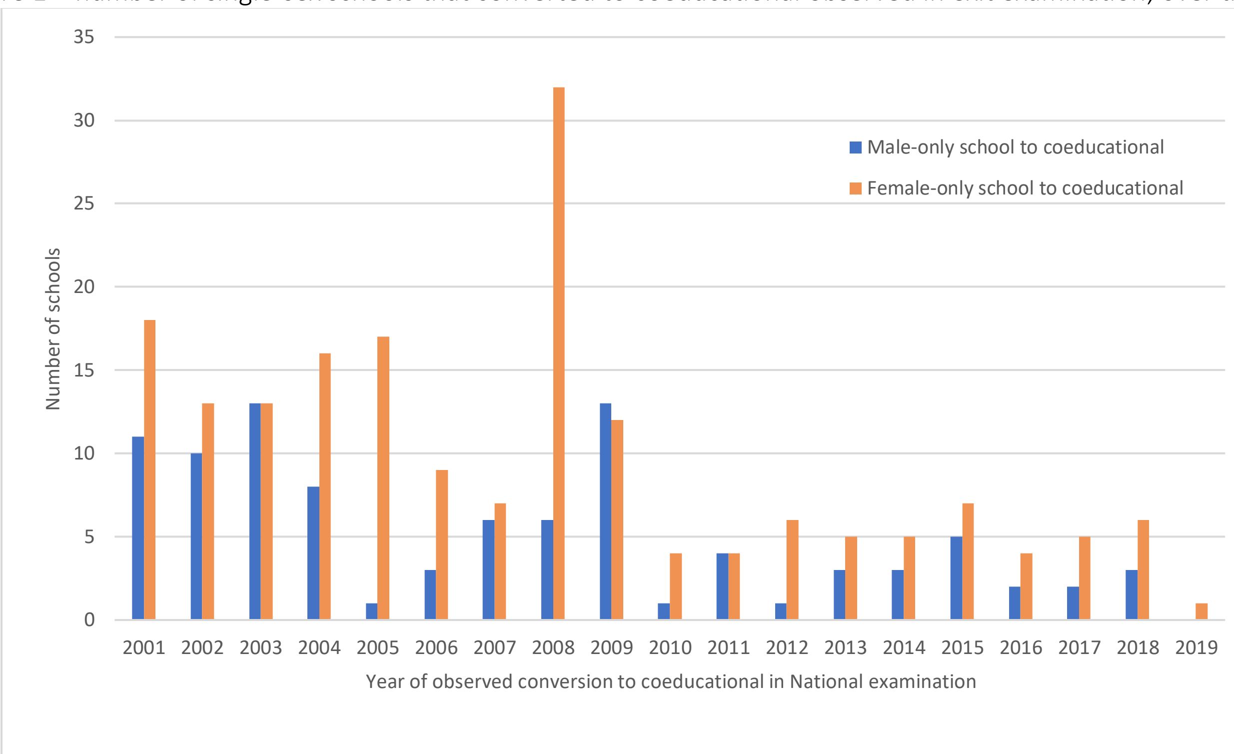
[7] Many B calendar are international schools in Colombia which align with international calendars.

[8] ICFES stands for "Instituto Colombiano para el Fomento de la Educación Superior".

[9] Low-SES are 1 or 2, middle-SES are 3 and 4, and high SES are 5 and 6. For more details see Bernal and Penney (2019).

The final sample consists of 4328 Colombian secondary schools (which include mixed schools, single sex schools and converting schools). In the period 2001-2019, we observed that 95 male-only and 184 female-only schools have converted to a mix their gender composition.[10] Years 2020 and onwards were not considered due to COVID-19 disruption in the educational system (i.e. virtual classes, wave of Saber 11 for enrollment higher education, etc.). Schools may have started their conversion to coeducational system in k-grade, which gives a time span from 1990 onwards. We excluded schools with fewer than 16 out of 20 possible registers in the study period. This leads to the inclusion of schools that graduate cohorts regularly during the study period. We also exclude schools with average cohorts' size of less than 30 students. This eligibility rule leads to an exclusion of mostly mixed rural schools, which usually differ in curriculum practices.[11] Figure 1 shows the number of converting schools observed at exit examination, by gender-type, during the period of analysis.[12]

Figure 1 – number of single-sex schools that converted to coeducational observed in exit examination, over time



Although there might be multiple reasons for a school to convert (see Section 3), our identification requires only that the decision to switch is based on time-invariant school characteristics (which we account for by school fixed effects) or time-trends (which we account for by year fixed effects). As long this mild assumption holds, the DiD estimates will identify the combined effects of a school's gender type and possible school-level changes that accompany the school-type conversion.

[10] This is approximately 6% of the total number of schools in the sample.
[11] Example of rural practice is the program "escuela nueva" in which students in different grades seat in the same room with one or two instructors. Each student follows a different guideline or book depending on the grade. Moreover, in inspection of rural schools, some of them did have single sex cohorts although they were mixed schools. This is because when graduating few students (one student in some cases), chances are that a particular small cohort has girls only or boys only.
[12] We observe that schools that adopted early the conversion were more likely to be public schools, in small cities, with low or no fees compared to those who adopt later the regimen. The nature and time invariant characteristics of schools are controlled under the school and school-trend fixed effects.

Table 1 – Summary statistics of the schools in the sample. Exit examination of senior cohorts 2000-2019.

Variables	Total (1)	Always male school (2)	ex-male schools pre (3)	ex-male schools post (4)	always female school (5)	ex-female schools pre (6)	ex-female schools post (7)
Males and females scores							
Math	-0.001	2.329	1.621	0.786	0.906	0.595	0.336
	(0.999)	(1430)	(1519)	(1444)	(0.966)	(1039)	(0.925)
Reading	-0.001	1.813	1.294	0.614	1.266	0.900	0.466
	(0.999)	(0.842)	(1.143)	(1.210)	(0.842)	(0.982)	(0.903)
Global	-0.001	2.187	1.533	0.716	1.152	0.788	0.404
	(0.999)	(1.136)	(1.345)	(1.336)	(0.940)	(1.037)	(0.904)
Gender specific scores		Males scores			Females scores		
Math		1.901	1.270	0.700	1.197	0.864	0.426
		(1240)	(1294)	(1356)	(1.009)	(1.097)	(0.960)
Reading		1.797	1.290	0.651	1.313	0.968	0.484
		(0.819)	(1.116)	(1.202)	(0.830)	(0.962)	(0.897)
Global		2.027	1.405	0.707	1.380	1.019	0.471
		(1101)	(1299)	(1318)	(0.987)	(1095)	(0.932)
School´s characteristics							
Cohort size	73.153	100.776	100.733	96.752	88.043	78224	84010
	(52848)	(61537)	(61911)	(58013)	(80535)	(49450)	(51993)
Shift modality (hours per day)							
Full day (8hrs)	0.246	0.714	0.487	0.368	0.441	0.351	0.260
	(0.431)	(0.452)	(0.500)	(0.483)	(0.497)	(0.477)	(0.439)
Morning (4-5hrs)	0.490	0.236	0.427	0.430	0.456	0.487	0.538
	(0.500)	(0.425)	(0.495)	(0.495)	(0.498)	(0.500)	(0.499)
Aternoon (4-5hrs)	0.066	0	0.009	0.002	0.005	0.006	0.003
	(0.248)	(0)	(0.096)	(0.043)	(0.072)	(0.077)	(0.059)
Night (3-4hrs)	0.016	0	0.013	0.029	0	0.004	0.012
	(0.127)	(0)	(0.115)	(0.167)	(0)	(0.063)	(0.111)
Weekend (6-8hrs week)	0.181	0.050	0.063	0.172	0.098	0.152	0.185
	(0.385)	(0.218)	(0.243)	(0.377)	(0.297)	(0.360)	(0.389)
Academic type	0.567	0.782	0.652	0.521	0.586	0.518	0.442
	(0.495)	(0.413)	(0.477)	(0.500)	(0.493)	(0.500)	(0.497)
Public school	0.749	0.202	0.283	0.599	0.427	0.498	0.742
	(0.434)	(0.402)	(0.451)	(0.490)	(0.495)	(0.500)	(0.438)
School fees >0	0.333	0.781	0.736	0.455	0.631	0.574	0.327
	(0.471)	(0.414)	(0.441)	(0.498)	(0.483)	(0.495)	(0.469)
SES avg. (lowest=1; highest=6)*	1.989	3.481	3.206	2.571	2.906	3074	2213
	(0.773)	(0.927)	(0.747)	(1028)	(0.894)	(0.831)	(0.769)
N	49150	259	217		2279	416	
Number of schools	4328	18	88		172	160	

Note: Standard deviation in parenthesis. *Socioeconomic Status, ses, is available only from 2008 onwards. Ses goes from 1 to 6, being 6 the richest. It was reported by students and averaged at school level.

The summary statistics of the sample schools are displayed in Table 1. Standardized math and reading scores by year are nearly zero for mixed schools (Column 1). By contrast, male-only and female-only schools significantly outperform mixed schools in math (reading) by 2.33 and 0.91 (1.81 and 1.27) SDs (Columns 2 and 4).

Notwithstanding these disparities, it is important to note that our DiD strategy effectively addresses and mitigates such variations. Similarly, converted schools outperformed coeducational schools before and after conversion. For ex-male schools, the average in math (reading) was 1.62 (1.29) SDs before the change and 0.79 (0.64) SDs after it (columns 3 and 4). For ex-male schools, the average in math (reading) was 0.60 (1.90) SDs before the change and 0.34 (0.47) SDs after it (columns 6 and 7). Similar pattern is displayed by global score, which is the overall performance of the students at the exit examination and the score considered by universities as criteria to enroll college. Taking into consideration score of incumbent males in ex-male schools there is a drop in math (reading) of 0.5 (0.64) SDs after the conversion. Similarly, the math (reading) score of incumbent females in ex-female schools also drop by 0.44 (0.48) SDs.

It is noticeable that, after conversion, the absolute achievement of students in ex-male and ex-female schools dropped roughly half in all subjects. Nevertheless, these losses cannot be interpreted as the causal effect of the transition from single-sex to coeducational system because of the possible influence of other observable and unobservable factors such as trends over time, school academic culture or idiosyncrasies or school particular trend. The empirical analysis will account for the mentioned elements.

Figure 2 - Example of the transition process for an ex-male school to coeducational school

observed conversion

	t-12	t-11	t-10	t-9	t-8	t-7	t-6	t-5	t-4	t-3	t-2	t-1	t	t+1	t+2	t+3	t+4	t+5
11°	Boys	Boys	Boys	Boys	Boys	Boys	Boys	Boys	Boys	Boys	Boys	Boys	B&G	B&G	B&G	B&G	B&G	B&G
10°	Boys	Boys	Boys	Boys	Boys	Boys	Boys	Boys	Boys	Boys	Boys	B&G	B&G	B&G	B&G	B&G	B&G	B&G
9°	Boys	Boys	Boys	Boys	Boys	Boys	Boys	Boys	Boys	Boys	B&G	B&G	B&G	B&G	B&G	B&G	B&G	B&G
8°	Boys	Boys	Boys	Boys	Boys	Boys	Boys	Boys	Boys	B&G	B&G	B&G	B&G	B&G	B&G	B&G	B&G	B&G
7°	Boys	Boys	Boys	Boys	Boys	Boys	Boys	Boys	B&G	B&G	B&G	B&G	B&G	B&G	B&G	B&G	B&G	B&G
6°	Boys	Boys	Boys	Boys	Boys	Boys	Boys	B&G	B&G	B&G	B&G	B&G	B&G	B&G	B&G	B&G	B&G	B&G
5°	Boys	Boys	Boys	Boys	Boys	Boys	B&G	B&G	B&G	B&G	B&G	B&G	B&G	B&G	B&G	B&G	B&G	B&G
4°	Boys	Boys	Boys	Boys	Boys	B&G	B&G	B&G	B&G	B&G	B&G	B&G	B&G	B&G	B&G	B&G	B&G	B&G
3°	Boys	Boys	Boys	Boys	B&G	B&G	B&G	B&G	B&G	B&G	B&G	B&G	B&G	B&G	B&G	B&G	B&G	B&G
2°	Boys	Boys	Boys	B&G	B&G	B&G	B&G	B&G	B&G	B&G	B&G	B&G	B&G	B&G	B&G	B&G	B&G	B&G
1°	Boys	Boys	B&G	B&G	B&G	B&G	B&G	B&G	B&G	B&G	B&G	B&G	B&G	B&G	B&G	B&G	B&G	B&G
K	Boys	B&G	B&G	B&G	B&G	B&G	B&G	B&G	B&G	B&G	B&G	B&G	B&G	B&G	B&G	B&G	B&G	B&G

observed outcome

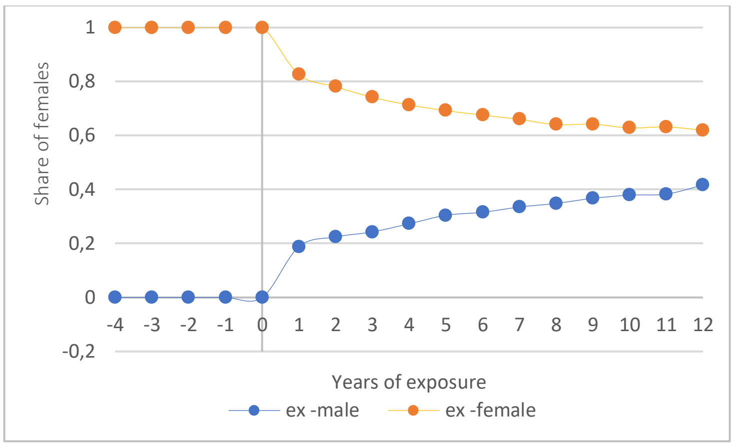
Note: Grades are represented in the right side. Score is observed in 11 grade. *t* is the cohort that we observe converting to coeducation; *t+1* is the subsequent cohort, whereas *t-1* is the previous to the change cohorts. Notice that this is an extreme case where school decided to converted in K grade. Other schools might decide to switch in different cohorts, or all school at once.

We observe the students' achievement in the high school exit examination. Nevertheless, the conversion and thus the exposure to a new regime may have started several years prior for most schools. Figure 2 shows an example of the transition process for an ex-male school to coeducational school. In this extreme case the transition started with kindergarten inflows (from boys only to allowing mixed classes to start), and it was done one cohort at the time for incoming classes only.[13] The observed outcome is at 11th grade. That is, we observe conversion to mix

[13] Unfortunately, there is no possible to identify from the dataset which schools star doing the conversion cohort by cohort from K grade.

gender composition in *t* period. However, this cohort could have been exposed to girl's presence in the school for a period as long as 11 years. The cohort in *t-1* did not have girl peers at class level, but they did at school level because the precedent cohort was gender mixed. That is, the *t-1* cohort experienced exposure to mix gender composition environment at school-level (although not class-level) for the last 10 out of 11 years of their compulsory education. The year of change to mixed regime at time *t* is labelled by 0. It should be noticed that the proportion of females has monotonically increase (decrease) along transition for ex-male (ex-female) schools (see Figure 3). Therefore, nonlinearities in peer effects are further tested. A similar transitional process in gender composition was experienced in ex-female' schools.

Figure 3: Share of females in ex-male and ex-female schools



Note: *t* is the year of conversion from single-sex to coeducational. The share of students from the other sex in ex-single sex schools fails monotonically.

Empirical model. Our goal is to determine the effect of school conversion from single sex to coeducational schools on students' academic performance. Moreover, we are interested in identifying the intensity effect (proportion of girls in the cohort) after the conversion. We use a difference-in-differences identification strategy with time varying implementation (following Bertrand, Duflo and Mullainathan, 2004) to compare schools' performance before and after the conversion from single-sex to mix. As treated schools later become the controls, this method controls better for differences across time (i.e. pre-trends and post-trend) compared to standard DiD method. We also include school fixed effects to control for time-invariant observed and unobserved school characteristics. The OLS model is formulated as follows:

$$y_{sgt} = cons + \beta_1 exmale * post_{st} + \beta_2 exfem * post_{st} + \delta X_{st} + \alpha_s + \gamma_t + \varepsilon_{st} + \emptyset_{st} \quad (1)$$

where y_{sgt} is the standardized test score of high school *s* in municipality *g*, who sat for the test in year *t*; *exmale*post* is a dummy indicating whether ex-male school *s* admitted females in year *t*; *exfemale*post* is a dummy indicating whether female school *s* admitted boys in year t. The year of change to coeducational regime at time *t* is labelled by 0. Moreover, $\alpha_s + \gamma_t$ are school and year fixed effects respectively, which controls for time invariant school characteristics and time trends. Moreover, $\emptyset_{st}$ represents school time-trends at school level dummies (such that every single school has a different slope depending on period), X_{st} represents time-variant controls (*cohort size, instruction time -some school extended their shift-, public or private school, school fee*) and ε_{st} is the error term. School and year fixed effects together with school time-trend allow to control for other changes in the schools and legislative framework. We cluster standard errors at the municipal level. The omitted comparison group includes students who are in the cohorts prior the conversion (t-1 or earlier). The coefficient β_1 is the effect on school performance of converting male schools to mixed, while β_2 will be the effect of converting female schools to mixed.

Due to the gender gap in math, ex-male schools could decrease performance after including girls merely because of girl's math test scores are lowering the average of the school *s* scores. To account for this composition effect, the dependent variable, y_{sgt}, is incumbent male´s scores when analyzing ex-male schools and incumbent female´s scores when analyzing ex-female schools. Analysis for males in ex-male schools and females in ex-female schools are run separately.

To measure the intensity to the treatment, we exploit the variation induced by the monotonic increase in the share of girls among converted schools. Therefore, we replaced the dummy time-treatment indicator for continuous variables indicating the proportion of girls of the school *s* at time *t*. Given that we include school fixed effects, differentials in gender composition induce different intensities of the treatment under the new coeducational regime.

Difference-in-Differences (DiD) assumptions. The DiD framework relies on several assumptions (Rubin, 1980) which also holds after including time varying implementation. First, the stable unit treatment value assumption (SUTVA): if conversion causes parents to change students from one school to another, selection occurs and SUTVA is not met. Due to data limitations, we do not observe if a particular student switches from one school to another. Nevertheless, methodologically, we mitigated possible selection effects by including school-time trends, which accounts for tendencies that a particular school experiences over time, including for instance, changes in class size or changing reputation of the schools. In practice, however, due to high transaction costs, parents are not likely to move to another schools, which mitigates the dissatisfaction of this assumption by 11th grade. In addition, if selective attrition occurred, students who are to be transferred are likely to be the ones who would perform worst in mixed schools' environments, which would biased estimates toward zero.

Second, the DiD framework is built on the assumption that the change in school gender composition should be unrelated to the performance outcome at baseline. As argued in Section 3, the motivations for conversion are mainly related to inclusion and not to improvements in performance. In fact, observed performance (public rankings) of schools show the majority of mixed schools perform worse than single-sex schools, and the transformed schools eventually performing even worse than before (Herrera, 2016). Therefore, improving performance is unlikely to be a reason to convert.

Third, the parallel trends assumption (PTA) is tested by examining the possibility of anticipation effects and phase-in effects. Leads and lags were included in the equation (1) following Autor (2003). The model can be formulated as follows:

$$y_{sgt} = \text{cons} + \sum_{t=-q}^{-1} \beta \quad * exmale_{st} + \sum_{t=0}^{m} \beta_{st} * exmale\_x_{st} + \sum_{t=-q}^{-1} \beta \quad * exfem_{st} \sum_{t=0}^{m} \beta_{gt} * ex\_fem_{st} + \delta X_{st} + \alpha_s + \gamma_t + \varepsilon_{st} + \emptyset_{st} \qquad (2)$$

In equation (2), notation of variables is the same as in equation (1). However, here *q* represents the number of leads or the anticipatory effects, while *m* denotes the number of lags or the post treatment effects. Lead coefficients close to zero indicate no anticipatory effects, fulfilling the PTA assumption. Lag coefficients measure the effects of the policy occurring *m* periods after adoption. Conversion is given by t=0.

5. Results

5.1 Effect of conversion from single-sex school to coeducational on performance

Our results indicate that converted female-only or male-only schools perform differently after converting to a coeducational regime. Table 2 displays the effects of the change on student performance. Using the composed score (i.e. taking the z-score of the school over time without observing the score of a particular gender), the performance of ex-male schools decreases significantly with 0.34 SDs in math and 0.14 SDs in reading, whereas the performance of ex-female schools increases by 0.19 SDs and 0.65 SDs respectively (Column 1 and 2). These significant changes can be due merely to the mixed gender composition of the new cohorts as in Colombia girls generally underperform boys in math (and boys do fairly similar to girls in reading). Therefore, the inflow of girls lowers the average scores of ex-male schools whereas the inflow of boys increases the average score of ex-female schools. The historic gender academic gap automatically decreases the performance of ex-male schools and increases the performance of ex-female schools after the conversion. This is not of particular importance for other countries such as South Korea, where girls scored similar to boys in math and significantly better in reading (OECD, 2018).[14] Although the composition effect is important to evaluate the overall performance of schools, henceforth, we will focus on the peer effect of conversion.

When exploring the achievement separately by gender the size of the estimated coefficients reduced significantly: the performance of boys in ex-male schools decreased by 0.12 SDs in math and in 0.10 SDs in reading (columns 3 and 4). This finding is in line with the findings from Dustman et al. (2018) and Lee et al. (2017) in terms of direction and magnitude. The results are also consistent with the academic advantage that male-only schools used to have over males in coeducational schools in the US (0.14 SDs in math) according to meta-analysis by Pahlke (2014). In contrast, we observe insignificant positive effect of 0.05 SDs in math and 0.004 SDs in reading for girls in ex-female schools (Columns 5 and 6). This finding does not fit the previous literature for the US as this suggested that female-only schools tend to perform better (0.14 SDs) than coeducational. However, nonlinear positive effects are visible when exploring marginal effects of the share of females. The results for the average effect are robust to the absent of different controls.[15]

[14] Absolute ranking supports our findings that ex-male schools do not benefit from conversion. In exploring the top 100 ranked schools over the last two decades, we found three of the ex-male schools and none of the ex-female schools sampled in this study.

[15] Results not shown but available under request.

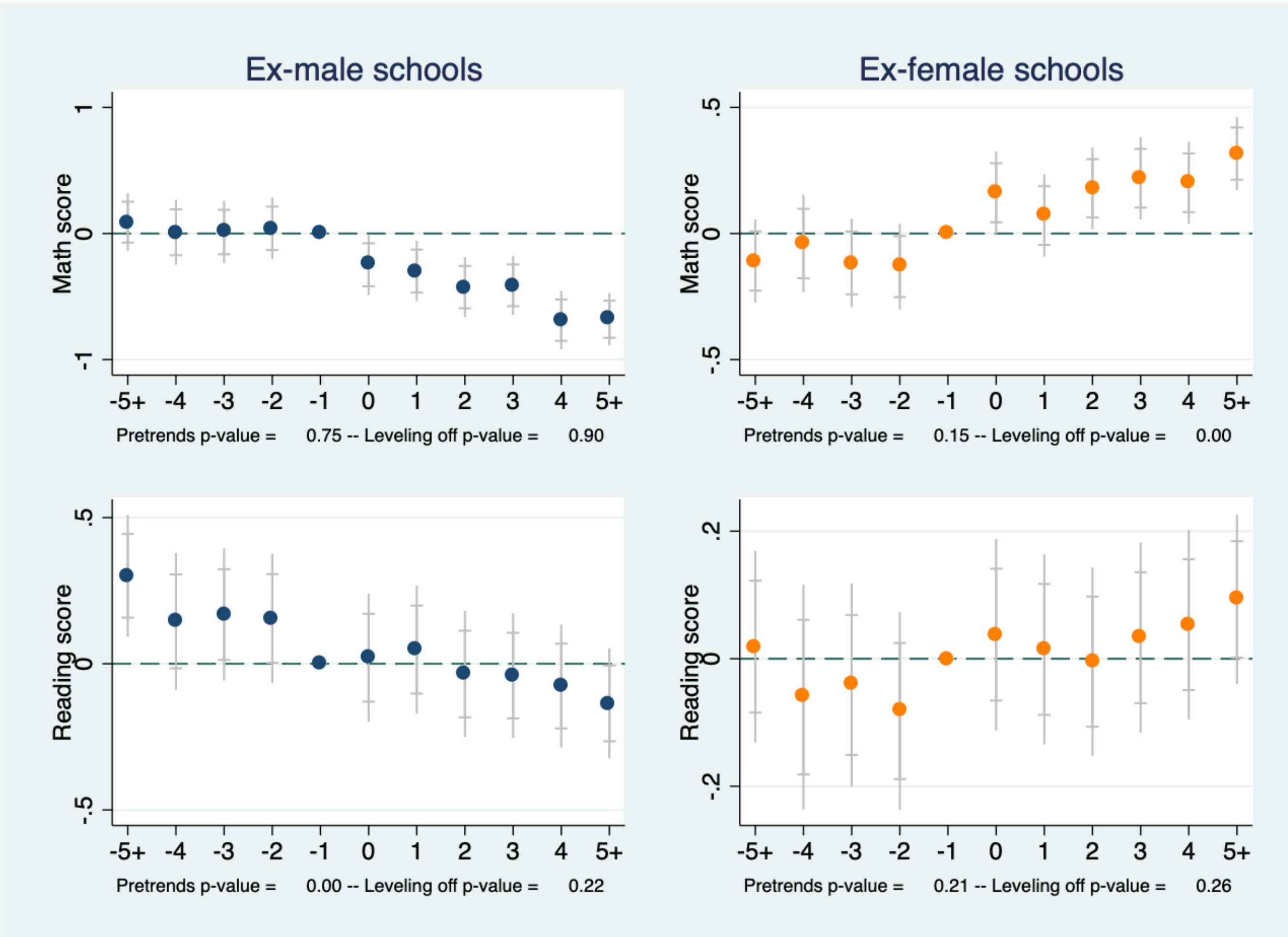
Table 2 - Effect on performance of single-sex schools converting to coeducational

	Composed score		Males´ score		Females´ score	
	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	math	reading	math	reading	math	reading
Ex_male*post conversion	-0.335***	-0.143***	-0.121**	-0.0970**		
	(0.0605)	(0.0429)	(0.0506)	(0.0422)		
Ex_female*post conversion	0.189***	0.0645**			0.0540	0.00405
	(0.0343)	(0.0272)			(0.0420)	(0.0293)
Constant	-0.129	0.0267	-0.0581	0.115	-0.300	-0.0671
	(0.142)	(0.0866)	(0.118)	(0.105)	(0.214)	(0.0993)
Observations	73.649	73.649	68.655	68.655	72.563	72.563
R-squared	0.014	0.020	0.009	0.012	0.006	0.011
Number of schools	4.328	4.328	4,110	4,110	4.297	4.297
School controls	yes	yes	yes	yes	yes	yes
School FE	yes	yes	yes	yes	yes	yes
Year FE	yes	yes	yes	yes	yes	yes
Cluster_Munipality	yes	yes	yes	yes	yes	yes
School time trend	yes	yes	yes	yes	yes	yes

Note: This table reports the estimates of equation 1. School control variables include: cohort size, meeting time (some school extended their shift), public or private school, school fee (categorical up to 2011 when several public schools became 0 cost), and years of exposure to the change. Variable ex_male school*post conversion (ex_female school*post) is a dummy indicating whether a male (female) school admitted females (males) in year. School fixed effects and year fixed effects are included. Robust standard errors clustered by municipality are in parentheses. Asterisks ***represent significance at 1% level, ** at 5% level, and * at 10% level.

Figure 4a and b presents the regression result described in equation 2, which tests the parallel trend assumption, and the impact of the conversion in the years before and after the change. Figure 4a shows the composed effect (i.e. dependent variable is the average score of females and males). We find no evidence of anticipatory behaviors during the pre-conversion period for either ex-male or ex-female schools, with the exception of *t-5* in the bottom left panel. The figures in the left show a sustainable drop in the math performance of the ex-male schools due to the transition to a coeducational school (when t=0), while drop in reading is noticeable but not significant. In contrast, the figures in the right show improvements in math performance of ex-female schools, with not significant effects in reading.

Figure 4a: Parallel trend assumption using composed scores (joint male and female scores)



Note: The event-study plot illustrates the cumulative effect of the conversion on the outcome. The dependent variable is given in the row label. Figures at the left hand side correspond to ex-male schools, whereas figures at the right hand side represent ex-female schools. Dots represent the estimate coefficient while lines are the intervals pointwise at 95% confidence. The event time is measured in the x axe.

Figure 4b: Parallel trend assumption using female´s scores or male´s scores

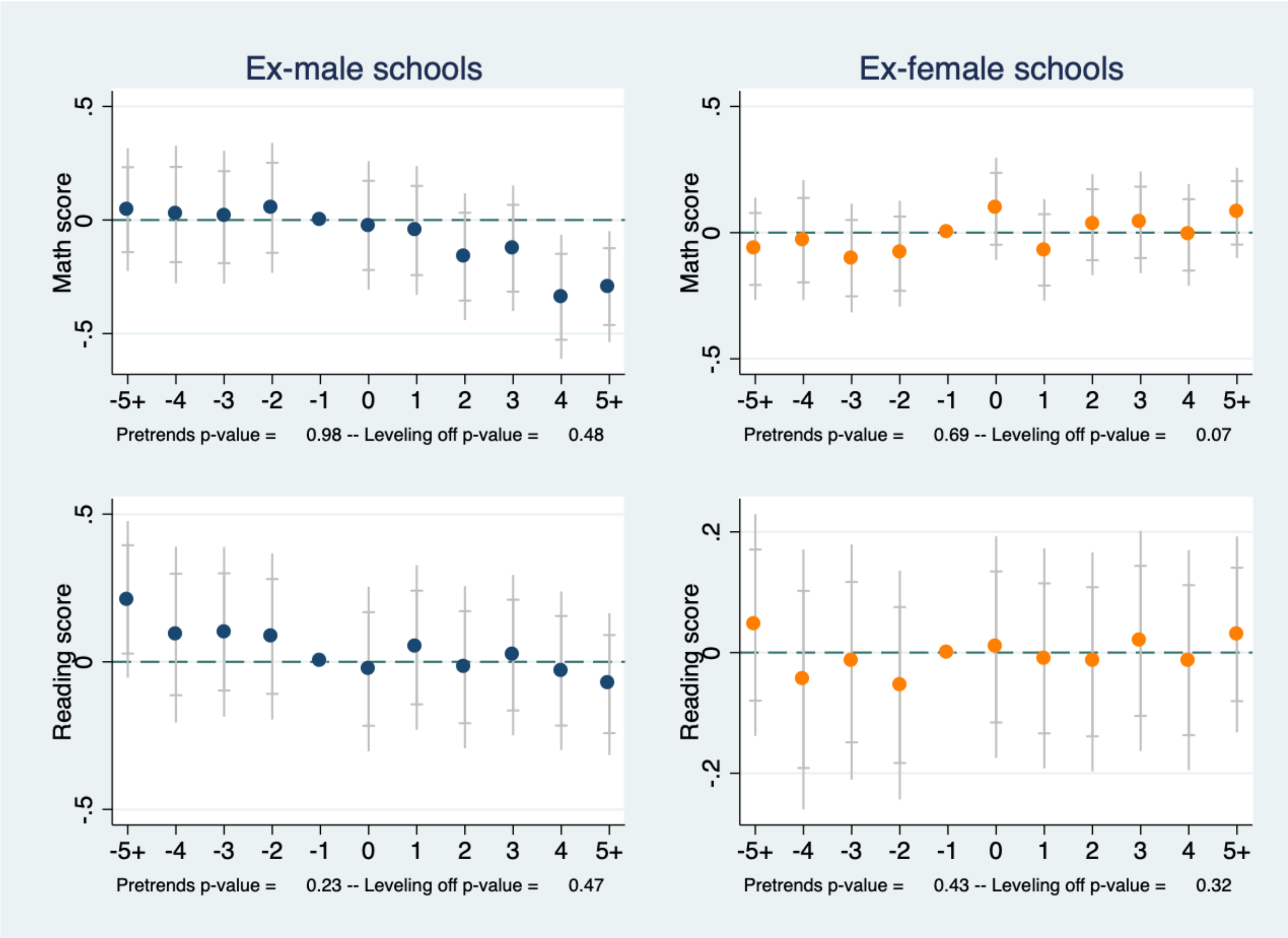
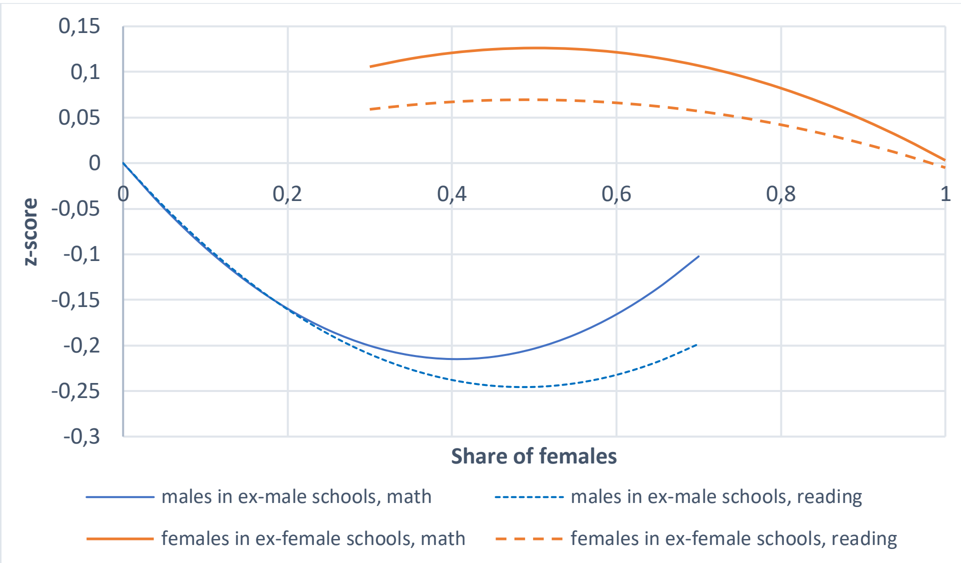


Figure 4b, left side, shows the test for parallel trend assumption when using the scores of incumbent males in ex-male schools as the dependent variable. Math performance decreases after the third year of transition whereas reading does not change in the scope of lags considered. The right side of Figure 4b, shows there is no effect on the math or reading scores of the incumbent females in ex-female schools. Parallel trend assumption (no previous effect) is fulfilled for all the cases.

5.2 Intensity Effect and Marginal effects

Given potential nonlinearities in the effect of classroom composition by gender, we exploit the monotonic increase of students from the other sex in the single sex schools. Figure 5 shows the marginal effect on performance of the proportion of girls on ex-male and ex-female schools. In marginal terms, our findings are partially in line with previous finding documented by Hoxby (2000), lavy and schlosser (2011), Schneeweis and Zweimuller (2012). As documented before, an increase in the proportion of girls decreases male test scores when the fraction is lower than 1/3, and this drop is followed by a marginal recovery in test scores when the share of females increases. However, our estimates show that this recover does not surpass the initial score losses (either in math or reading) as in previous literature.[16] By contrast, female students in ex-female schools experienced positive effects in math (not in reading) after the share of male students started to increase (read the Figure 5 from left to right for proportion of males). This marginal effect is hidden when only looking at average effect (Table 2).

Figure 5: Intensity effect, marginal changes in the share of students from the other sex in schools converted from single-sex to coeducational



Note: This Figure reports the estimates of Equation 1, but focusing in the intensity effect. We replaced the treatment dummy (when equals 1) for the share of female students in the converted schools allowing for marginal effect interpretation. While for ex-male schools interpretation should be read from left to right: marginal increments on female share on marginal changes on performance; for females the interpretation should be from left to right, as the share of girls was initially 1 and then t diminished. Notice that none of the converted schools has a share higher than 0.7 students from the incumbent sex. Regression includes school controls, years (and years ^2) of exposure controls, School fixed effects and year fixed effects are included. Robust standard errors clustered by municipality are in parentheses.

These results suggest the prevalence of the peer effects over the endogenous response of the teachers facing the change (such as changing attitudes or teaching techniques). As shown by Duflo et al. (2011) and Pop-Eleches and Urquiola (2013), teachers adjust attitudes and teaching techniques after gender mixed classes. This behavior would likely hold as soon as gender composition includes students from both sexes instead of one sex, and it will be absorbed by the school fixed effects. Therefore, small changes in marginal effect from variation on the proportion of female may be present (and if so, they should be linear if nor related to the gender composition). Instead, we observe a U-shape in marginal effects, which suggests that gender composition is driven by changes in performance. If teacher´s need to adjust her (new) teaching techniques due to indiscipline, these changes will be via gender composition and less likely to endogenous response to the change per-se.

5.3 Sub-analysis for females in ex-male schools and males in ex-female schools

Single-sex schools that convert to coeducational conserve several features (e.g. routines, academic culture, etc..) that can have differential impact on the academic achievement of the opposite-sex students, compared to other non-converted schools. Thus, we explore the performance of females in ex-male schools and males in ex-female schools. Using OLS, we explore the post conversion period of schools to analyze the performance of students, under

[16] Note that none of ex-male schools have a share of females no higher than 0.7, and ex-female schools is 0.43.

different gender type of the schools (coeducational, male-only, ex-male, female-only, and ex-female), conditional on the available observables as presented in Table 1.[17]

Table 3: Observational analysis of females in ex-male schools and males in ex-female school

	Male's scores						Female's scores					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
VARIABLES	math	math	math	reading	reading	reading	math	math	math	reading	reading	reading
School type (Ref: coed)												
Ex -male	0.985***	0.658***	0.400***	0.966***	0.626***	0.304***	0.695***	0.490***	0.375***	0.689***	0.448***	0.271***
	(0.0320)	(0.0293)	(0.0305)	(0.0285)	(0.0247)	(0.0244)	(0.0454)	(0.0409)	(0.0385)	(0.0381)	(0.0316)	(0.0306)
Female-only							1.304***	0.749***	0.153***	1.429***	0.801***	0.169***
							(0.0167)	(0.0209)	(0.0236)	(0.0139)	(0.0182)	(0.0219)
Ex -female	0.546***	0.375***	0.150***	0.601***	0.412***	0.170***	0.721***	0.441***	0.161***	0.808***	0.485***	0.171***
	(0.0246)	(0.0228)	(0.0214)	(0.0231)	(0.0209)	(0.0198)	(0.0179)	(0.0170)	(0.0179)	(0.0165)	(0.0155)	(0.0160)
Male-only	1.953***	1.358***	0.748***	1.852***	1.222***	0.562***						
	(0.0591)	(0.0620)	(0.0559)	(0.0391)	(0.0413)	(0.0427)						
Constant	-0.0522***	0.261***	-1.764***	-0.0545***	0.228***	-1.958***	-0.107***	0.254***	-1.505***	-0.116***	0.254***	-1.648***
	(0.00354)	(0.0255)	(0.0341)	(0.00359)	(0.0249)	(0.0317)	(0.00346)	(0.0273)	(0.0321)	(0.00350)	(0.0246)	(0.0305)
Observations	75,342	68,655	39,788	75,342	68,655	39,788	79,541	72,563	41,733	79,541	72,563	41,733
R-squared	0.053	0.271	0.493	0.051	0.304	0.548	0.102	0.318	0.538	0.122	0.402	0.602
Method	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
School controls	NO	YES	YES	NO	YES	YES	NO	YES	YES	NO	YES	YES
Female share	NO	YES	YES	NO	YES	YES	NO	YES	YES	NO	YES	YES
Year FE	NO	YES	YES	NO	YES	YES	NO	YES	YES	NO	YES	YES
Students SES*	NO	NO	YES	NO	NO	YES	NO	NO	YES	NO	NO	YES

Note: School control variables include: cohort size, meeting time (some school extended their shift), public or private school, school fee (categorical up to 2011 when several public schools became 0 cost), and years of exposure to the change. Variable ex_male school*post conversion (ex_female school*post) is a dummy indicating whether a male (female) school admitted females (males) in year. SES is only available from 2008 onwards. Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.

Table 3, in the preferred specification columns 3 and 6, show that males in male-only schools always outperform any other type of schools in both math and reading regardless the controls (always-coeducational schools is the reference group). The second-best type of schools in males' performance is ex-male schools followed by ex-female schools. Here, conditional on controls and SES (which is recognized as the main determinant of school´s performance along with pupil ability according to Smithers and Robinson, 2006), males in ex-female schools do fairly better than coeducational schools (0.15 and 0.17 SDs in math and reading), but do worse than those in ex-male schools (0.40 and 0.30 SDs) or male only (0.75 and 0.56 SDs). The significant advantage of male-only schools over coeducational is not explained by SES differences, but rather other characteristics of these schools (which do not allow for female peer effects) are determining their outstanding performance.

Moreover, Table 3 columns 7 and 10, show that females perform the highest in math and reading in female-only schools (1.30 and 1.43 SDs higher than females in coeducational schools). This is consistent with raw performance of female-only schools presented in other studies (Pahlke et al., 2014). However, conditional on school controls, columns 9 and 12, and particularly on SES, females perform the highest in ex-male schools: 0.38 and 0.27

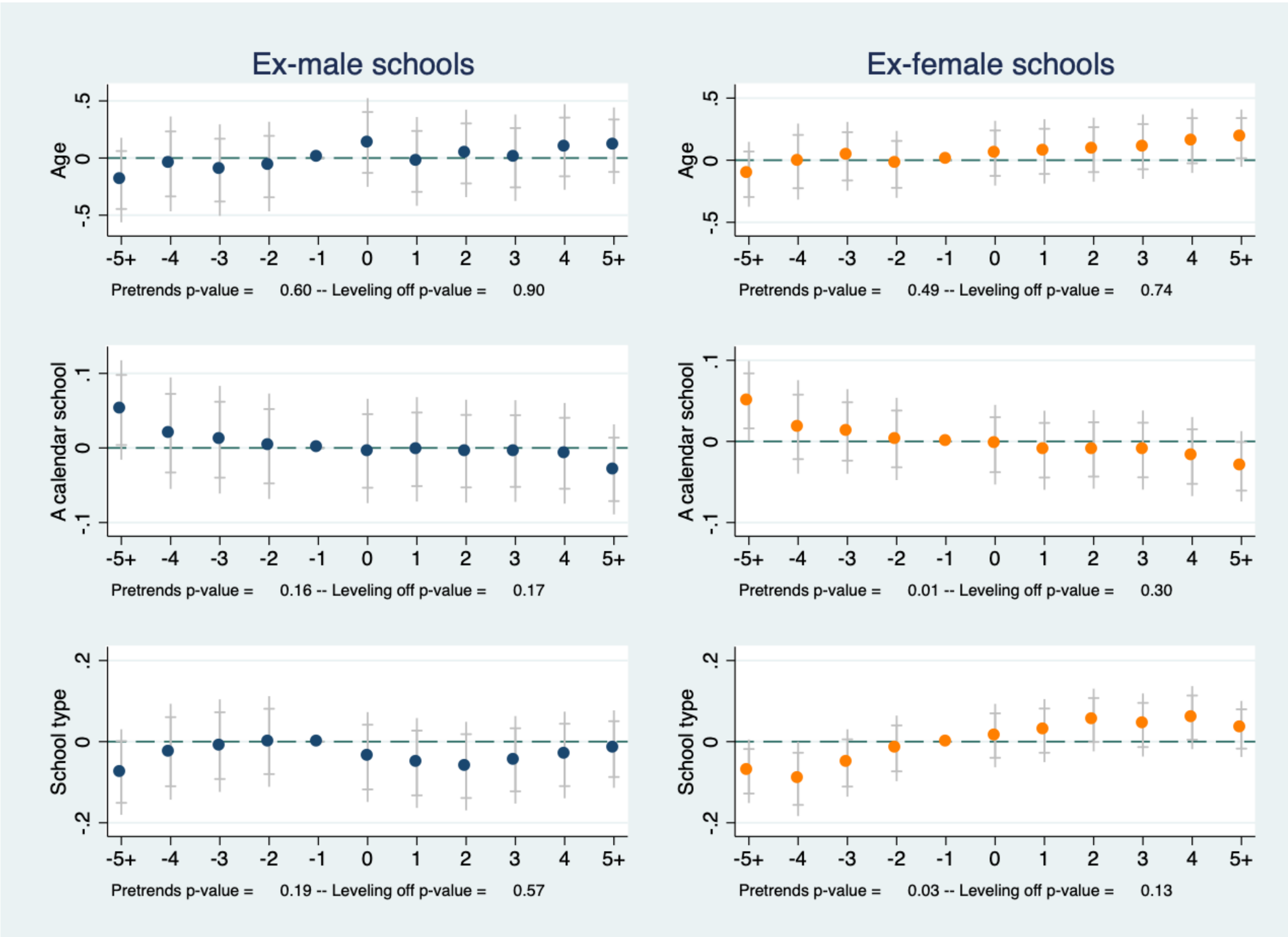
[17] Notice that DiD or fixed effects are no longer useful to analyze the subsequent periods after the conversion as the converted schools do not change their coeducational status, thus gender-type school is dropped from the estimation.

SDs in math and reading relatively to the reference group of coed. This pattern different from that observed for males. In column 8, girls in ex-male schools perform better than those in ex-female and female-only schools and the difference is particularly high for math (0.38 versus 0.16 and 0.15 SDs). Alternative variables beyond SES, like school strong academic math culture or peer effects, might explain that females outperform other females in when study in an ex-male school. Interesting as well is that the coefficient of female-only schools falls dramatically after including SES controls (from 0.75 SDs to 0.153 SDs). This result indicate that SES might accounts for most of the success of females in female-only schools (also documented in Perry and McConney, 2010). The significant advantage of male-only schools over coeducational is not explained by SES differences, but rather other characteristics of these schools (which do not allow for female peer effects) are determining their outstanding performance.

6. Robustness checks

As a robustness test we perform the parallel trend assumption using time-varying school characteristics as a placebo test. Figure 6 displays the estimates for different variables not related to the change: average age, calendar and type of school. As displayed in all panels, there is no anticipatory behavior and neither there is changes after the time of the conversion in both ex-male and ex-female schools. These results support the hypothesis that transition to coeducational school and no their situation are driving the found effects.

Figure 6: Parallel trend assumption using control variables



Note: The event-study plot is meant to illustrate the cumulative effect of the conversion on the outcome. The dependent variable given in the row label. Figures in the left correspond to ex-male schools, whereas figures in the right represent ex-female schools. Dots represent the estimate coefficient while lines are the intervals pointwise at 95% confidence. The event time is measured in the x axe.

7. Discussion and conclusions

Exploiting a rich longitudinal dataset and the unique quasi-experimental case of Colombia, this paper studied the effect of converting of single-sex schools to coeducational on students' performance. Different from previous studies, our database accounted for a large set of converting schools (88 male-only and 160 female-only schools), and an extended variation in the proportion of opposite sex students. Time varying implementation over the period 2001-2019 allows us to control for time and school (un)observed heterogeneity. Moreover, this approach facilitates a rich variation in gender compositions, enabling the examination of the marginal impact arising from the influx of students of the opposite sex.

Our findings indicate that boys in male-only schools do not benefit from the change (in line with Dustmann et al., 2018; Lee et al., 2017; Park 2013). On the contrary, we find that girls in ex-female schools can benefit from the conversion. Our results partially confirm Hoxby (2000) findings: when boys outnumber girls (higher than 3:1), the performance of both marginally decreases, and this loss starts recovering when girls outnumber boys. Nevertheless, we do not find, as in previous literature, that the magnitude of the recovery does compensate the losses for the ex-male schools: male students are worst off in academic achievement terms after the conversion, even if females outnumber them. Moreover, for ex-female schools, it seems to be beneficial for girls´ math performance to increase up to half of boys in the class. In this research, the masculine or feminine environment of the schools (which remains at least partially after the change), as well as the context of a developing country, can play an important role. Contrary to mentioned literature that refers to developed countries, this research studied school gender composition in an environment where female highly underperform males in math (with the highest gender gap in math in PISA test), and gender stereotypes referring to females as less prompt for school are highly prevalent (Duryea et al., 2012). As far as we know, this is the first referent of causal evidence of converting single-sex schools into coeducational in a developing country.

Various mechanisms may explain why the inflow of girls decreases male performance. Our results support the hypothesis that boys may experience less competitiveness, disruptive behavior, or lose focus on their studies when girls are present in their academic environment (Nagengast et al., 2013). Other possible mechanisms include that teachers might change their teaching style in a way that does not favor boys when having girls in the same classroom (Briole, 2021). They may become less strict regarding math or reading subjects as they used to be before the conversion to avoid leaving behind girls joining the classes with average lower starting competence in these areas (Jackson, 2010). Teachers in ex-male schools might also have dedicated more attention to girls to the expense of less attention for boys after the conversion (Farrell, 2007). In contrast, positive spillover effects from peers are observed for incumbent females in ex-female schools. They experienced progress in math and not significant changes in reading. Boys could have boost girls´ interest in math as historically they have performed better than females in this area, particularly in developing country contexts.

Conditional on observables, including SES as the most relevant determinant on performance, we observed that male-only and ex-male schools outperform the other schools (female-only, ex-female and coeducational type). It is also worth noticing the outstanding achievement of females in ex-male schools over the other gender-type schools (i.e. female-only, ex-female and always-coeducational schools). This suggests that unobservable variables, such as the masculine environment idiosyncrasies or practices (on average, males´ schools tend to be more competitive, and with a stronger math focus; Gibb et al., 2008), might help boost the potential of the females. In contrast, feminine schooling environments for males (which are less competitive than others gender-type schools, and in some cases have more behavioral classes in the curriculum)[18] may not significantly boost males' academic achievement. It may be that the previous performance or cultural willingness of incoming male students in ex-female schools is not capable of producing peer pressure, or that the traditions of teaching methods less focused on average on math in the ex-female schools remain the same when the conversion occurs. Our findings support the hypothesis that a masculine schooling environment may be beneficial for females' performance, but this might be at the expense of males' achievement.

This study also contributes to the need for causal evidence of peer effects in Latin-American countries, where the educational system has had a significant presence of gender discrimination and gender stereotypes (Duryea et al., 2012), which prevents female students to achieve their potential. This paper adds to the literature indicating that nurture excels over nature (e.g. Guiso et al., 2008; Schiltz et al., 2019). In particular, it suggests that peer effects as well as certain academic practices can reshape the performance of students. Although our study does not speak for possible collateral benefits such as gains in soft skills that occur in the face of the coexistence of men and women in the classroom (Musiimenta et al., 2019), or potential downsides such as higher teenage pregnancy in mix gender environments (Cortés et al., 2019), it does inform policymakers on the vulnerability of male students facing changes in the gender composition of their schools' peers. It also suggests that, at least in the

[18] We randomly selected 5 male-only schools and 5 female-only schools for which curriculums were available in the website and compared them. Female schools included 8% more classes related to ethics and religion than male schools.

context of a developing country, a dose of competitiveness in the schools' environment is beneficial for girls, while boys need to be instructed to manage distraction in mixed-gender classes. Further research can test the incidence of peer effect on non-cognitive outcomes, and the effect of having single-sex classes in coeducational schools on several outcomes. It is also worth to explore the learning environments in single-sex-schools (especially in male-only schools), as compared to other schools type, they added the most to female students in terms of math.

In the aim to reach academic-gender equalization as driven educational policy, we suggest that policymakers need to pay special attention to the gender peer effects which are large and significant (particularly of females over males' performance). In coeducation environments, efforts need to be done in diminishing males' proclivity to distractions and females' proclivity to not exploit their academic potential, particularly in math. A dose of competitiveness environment accompanied to reduction of gender stereotypes in schools can be beneficial for girls to reduce the pronounced gender academic gap, which at present restricts their access to higher education, and particularly to STEM careers (Abadía and Bernal, 2017).

Moreover, assuming the benefits of single-sex education occur at the classroom level, implementing single-sex classes for some subjects within coeducational schools can be an alternative for preserving the advantages in both single-sex and coeducational environments. On the one hand, male-only schools tend to considerably strengthen males' academic performance, which can produce positive spillover effects towards females when mixed in some other classes.[19] Likewise, female-only classes are also associated with increases in self-esteem (Eisenkopf et al., 2015), which in a mixed gender environment can serve to improve the academic performance of girls. On the other hand, one important element of coeducational schools is that they allow for the development of a broader range of behaviors and attitudes within students (Wong, Shi, & Chen, 2018) and inclusion with children of the other gender. One consequence of reverting coeducational schools to single-sex schools is that the number of schools available for children decreases, which deprives parents of the scale economies of having opposite-sex siblings in the same school; this will particularly harm low-income parents who are highly sensitive to transport costs in education (cite Murnane and Willett, 2010).

[19] These spillover effects will be particularly beneficial when boys do not outnumber girls in a class, as previously shown.