School Allocation Policy and the Reverse Gender Gap in Academic Achievement: Evidence from a Quasi-experiment in Hong Kong

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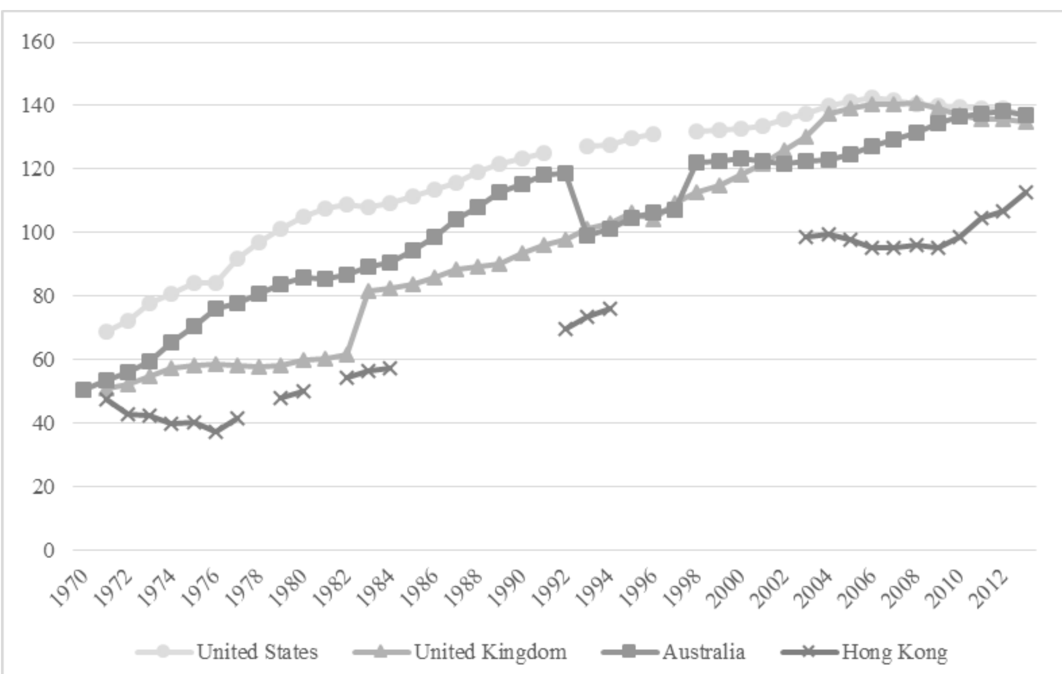
Abstract

This paper examines the impact of school allocation policy on gender disparity in academic achievement in Hong Kong, using a major policy shift in 2002 as a quasi-experiment. Based on two waves of data from TIMSS (Trends in International Mathematics and Science Study) in 2003 and 2007 and the difference-in-differences (DID) method, we present strong evidence that the policy change towards equal opportunity has actually led to an enlarged gender gap in academic achievement in favor of girls. The reverse gender gap is largely due to the fact that girls are increasingly more likely to secure enrollment in better-quality secondary schools than boys. Our results suggest the importance of equal opportunity for women in capitalizing their potential better learning behaviors and social skills in socioeconomic attainment.

Introduction

The late 20th century has witnessed a new trend in gender educational disparity across all industrial countries: men have increasingly lagged behind women in educational outcomes. In terms of educational attainment, women have been showing a clear advantage in college enrollment in developed countries as early as 1970s (see Figure 1). hile many scholars presume that boys tend to outperform girls in mathematics and science but fare worse in literacy subjects (Ardila et al. 2011), various recent international and regional assessments have shown otherwise—girls not only possess an advantage in language, they are also catching up with boys in mathematics and science (Hyde et al. 2008; Lindberg 2010; Ma 2007). As summarized by DiPrete and Buchmann (2013) in their book, *The Rise of Women: The Growing Gender Gap in Education and What It Means for American Schools*, "women have made substantial gains in all realms of education and now generally outperform men on several key educational benchmarks."

Figure 1. Ratio of Female to Male Tertiary Education Enrollment in Selected OECD Countries, 1970-2013



Data source: United Nations Educational, Scientific, and Cultural Organization (UNESCO) Institute for Statistics

The reversal of gender disparity in education has received intense attention from education researchers and policymakers. Why have women overtaken men, rather than simply caught up and reached parity with them (Goldin, Katz and Kuziemko 2006)? While developmental psychologists often point to the gender differences in biological or developmental traits that make girls more adept at learning in general, economists and sociologists tend to highlight either girls' superior behavioral and social skills which are conducive to learning outcomes (DiPrete and Jennings 2012), or boys' poor non-cognitive skills (Cornwell et al. 2013) and their masculine gender norms that deter them from engaging fully in study and achieving good performance (Jha and Kelleher 2006; Kimmel 2009; Lavy 2008; Legewie and DiPrete 2012; Luschei and Chudgar 2011; Page and Jha 2009).

However, these interdisciplinary, micro-perspective inquiries are silent on why the reverse gender gap is observed only in recent decades and mostly in industrialized societies. In fact, all the gender-based biological and psychological traits conducive to learnings outcomes have existed for a long time, and so has the socialization process of gender identity to a large extent; and these differences certainly are not unique to developed countries. Women have historically lagged behind men in education, because educational opportunities—especially quality ones—have been unevenly distributed to men. Hence, the emergence of a reverse gender gap in academic performance at societal levels may be the result of structural changes in educational opportunities that have afforded girls an equal footing with boys in classroom learnings. These structural changes may have occurred in particular historical periods and in particular contexts. Women's learning potential can only be fully realized when the constraints of gender norms (such as family resources allocation) are relaxed and access to education—especially quality education—are made equally available to them (Wu, Ye and He 2014).

"Equal opportunity", nevertheless, is a subtle concept not easily measurable on empirical grounds. While the temporal trend in gender disparities in education in favor of women has often been linked to the enforcement of equal opportunities and the prohibition of gender discrimination, few studies have evaluated the consequences of "equal opportunity" shortly before and after the law was enacted and the policy implemented.

In this paper, we take advantage of the reform of the school allocation system in a developed society—the Hong Kong Special Administrative Region—to conduct a quasi-experiment on equal opportunity and gauge its impact on the gender gaps in learnings. Ever since 1978, the Secondary School Places Allocation (SSPA) system in Hong Kong had adopted a gender-based policy, in which boys and girls in co-educational primary schools were admitted separately with similar quotas for the purpose of maintaining a balanced sex ratio in schools (EOC 1999). Since girls performed relatively well in certain assessments in primary school, they had had to achieve much higher scores than boys to be admitted to a secondary school of comparable quality. Such positive discrimination against girls in the SSPA system was challenged by parents with daughters. Starting from 2002, the system no longer made any distinction between male and female students in school admission. This shift in school allocation policy provides a rare and unique case to evaluate the importance of educational opportunities in promoting gender equality. We analyze the data from two waves of the Trends in International Mathematics and Science Study (TIMSS hereafter) with students who were admitted before and after the SSPA system reform, and employ the difference-in-differences (DID) approach to evaluate the effect of the shift in school allocation policy on the disparity in academic performance between girls and boys within the period concerned.

In the following, we will first elaborate on why girls outperform boys in school from both micro-behavioral and macro-structural perspectives, and link the latter process to the changes in school allocation policy. We will then introduce Hong Kong's educational system and the rationale behind the SSPA system reform in 2002. After that we will describe the TIMSS data, variables, and the DID method, and give the empirical results from quantitative analyses. We conclude with a discussion on the implications of our findings for understanding the dynamics of gender inequality in academic performance and for formulating policy to promote gender equality.

Gender Disparity in Academic Performance: Micro- and Macro-Processes

In the modern educational system, the quality of schools and classes play important roles in determining students' academic performance (Coleman et al. 1966). The disparity in mean scores (measuring academic performance) between male and female students at the aggregate level could be derived from two sources. The first is within-school/class difference, resulting from male and female students competing in the same class room of the same school. The second is between-school/ class difference, arising from sorting male and female students into schools/classes of different quality. The two sources of variations can be linked respectively to the micro- and macro-processes of gender disparity formation. While the micro-process highlights the gender differences in social and behavioral skills in explaining their disparity in learning outcomes, the macro-process focuses on the structural constraints of access to opportunity, historically in favor of boys.

Why Are Boys Lagging Behind in School?

As mentioned at the beginning, the gender disparity in education has been reversed in favor of females. Why are boys now lagging behind in school? Scholars from various disciplinary backgrounds have attempted to explain the paradoxical disparity, mainly attributing it to gender differences in biological traits or developmental trajectory. Lynn (1999; 2000) argues that, because girls mature physically and intellectually earlier than boys, they tend to outpace their male classmates in learning. Pinker (2008) goes one step further to claim that, in contrast to males who have a wide range of biologically based foibles, making them prone to learning difficulties, attention disorders, and other related mental and behavioral problems, females seem to be "gifted" with many attributes that help them get ahead in school.

The explanation based on biological traits in developmental psychology is rather provocative. Economists and Sociologists, from a slightly different perspective, emphasize the importance of behavioral and social skills, as well as other social factors, in determining the learning outcomes. DiPrete and Jennings (2012), for example, revealed that girls have demonstrated superior behavioral and social skills as early as in their kindergarten years, which can explain the gender gap in academic outcomes in primary school to some extent. Cornwell et al. (2013) reported that teachers graded boys less favorably than they did girls in school, partly because of boys' poorer non-cognitive skills.

An even stronger version of the sociological account suggests that we should pay attention to the socialization process of gender norms. In this stream of literature, boys' lower achievement relative to girls is often linked to the masculine gender ideology that regards education as a "feminine" activity, creating an anti-school culture or mindset. As Sommers argued, in her book entitled *The War Against Boys: How Misguided Feminism is Harming Our Young Men* (Sommers 2001), current schools are failing boys, as they create an "inhospitable environment" that work against boys' natural propensities. Social/peer pressure thus prevents boys from working hard in school. While school learning is by no means a zero-sum game between boys and girls, scholars agree that the schooling process may have enhanced gender stereotyping which contributes to their disparity in education (Jha and Kelleher 2006; Kimmel 2009; Lavy 2008; Legewie and DiPrete 2012; Luschei and Chudgar 2011; Page and Jha 2009).

Nevertheless, the gender differentials in biological, psychological, or behavioral attributes, together with the gender stereotyping, cannot satisfactorily explain the recent trend in female dominance in education in the past decades across the industrialized world. To account for the reverse gender gap in academic performance and educational outcomes, the historical changes in educational opportunities available to both men and women at the macro level must be considered.

Women's Increasing Access to Educational Opportunities

The secularization of declining educational gender inequality has been widely observed over the past decades, with the gap even reversing in many countries. One explanation that many scholars have put forward is that, as more schooling opportunities become available (due to educational expansion), and families are less constrained by economic resources (thanks to economic development on the one hand and declining fertility on the other), parents can afford to invest equally in their sons' and daughters' education. As a result, girls would receive more educational opportunities (Wu, Ye and He 2014). More broadly, and as pointed out by Goldin, Katz and Kuziemko (2006) and DiPrete and Buchmann (2013), the rising female advantage in education is largely a response to women's changing status in society, increasing opportunity in labor markets, lowering barriers in the workplace, and expanding access to higher education, in the US and in other developed countries.

Such changes in educational opportunities in western societies also owed partly to social movements prompting governments to implement a series of educational reforms to achieve gender egalitarianism (Stone 1994). For instance, the civil rights movement and the women's rights movement back in the 1960s and 1970s led to certain "equal opportunity" legislations in education and employment in the US, notably *Title VII of the Civil Rights Act of 1964* and *Title IX of the Education Amendments of 1972* (DiPrete and Buchmann 2013). In the United Kingdom, the feminist movement in the late 1960s placed tremendous pressure on the Labor government to consider gender equality and related legislative and policy programs (Arnot, David and Weiner 1999). The government eventually passed the *Sex Discrimination Act* in 1975, which led directly to the establishment of the Equal Opportunities Commission (EOC).[1] In Australia, the *National Policy for the Education of Girls in Australian Schools*, instituted in 1987, was also heavily shaped by the feminist movement and placed much more emphasis on the "educational needs of girls." Indeed, "equitable resource allocation" is one of the four objectives of the policy (Yates 1993).

An important consequence of these gender-targeted education mandates is that they brought about a dramatic increase in women's access to education, especially desirable educational resources, as reflected in the gender distribution in schools of different quality. In other words, more girls are admitted into high-quality schools, where they could compete equally with boys. As good-quality schools can boost students' learning achievement, girls'

[1] In fact, Hong Kong, while still under British colonial rule, subsequently established the city's equivalent institution (EOC), which continued to exist after 1997 and played an active and decisive role in promoting the SSPA reform in Hong Kong, to be discussed in the following section.

slight advantage in their early years may be strengthened leading to greater advantages relative to boys in subsequent school transitions, which are often conditional upon their performance at previous levels of school. Because girls are given equal opportunities in competition, their superior non-cognitive skills have enabled them to blossom and their advantages to accumulate, resulting in the reversal of the gender gap in learning outcomes that we observe today.

Hence, it is the macro-level social changes that have fundamentally increased women's educational opportunities, making it possible for females to realize their potential traits of learning-oriented behaviors and for them to compete with their male counterparts in the classroom. This temporal trend in increasing educational opportunities available to women, nevertheless, is intertwined with another secular trend, namely, changing norms and ideology. Even without more opportunities and less resource constraints, parents may still treat their daughters and sons equally as society progresses, and girls may be raised with a belief that they can perform as well as boys in school.

As far as we know, there has not been any direct examination of how the enforcement of equal opportunities could afford girls advantages in learning outcomes and affect gender inequality. Moreover, seldom have we encountered a modern school system in which boys were openly favored over girls in school admission, and even more rarely do we observe the abolishment of such a gender-based quota system and have the opportunity to explicitly examine the consequences of equal opportunities for gender inequality. The reform of school allocation policy in Hong Kong in the late 1990s thus provides a most unique case for investigation.

Background: Reform in the School Allocation Policy in Hong Kong

Like many other developed countries or regions, Hong Kong has also witnessed girls playing catch up with or even overpassing boys in academic learning in recent decades. To prevent boys from lagging behind in subsequent educational transitions, a gender-based policy had been adopted in the Secondary School Places Allocation (SSPA) system in Hong Kong since 1978.

Under the SSPA system, students in primary schools in Hong Kong are evaluated and given placements in secondary schools based on their academic merit. Specifically, students take a series of internal assessments (IAs),[2] which are administered by their own primary schools. The results, duly standardized, would indicate each student's academic ranking within his or her school. To ensure that the level at which the IAs have been marked may be compared fairly, no matter which school a student attended, a historical body of data from the Academic Aptitude Tests (AATs) (which give the average performance of students from certain schools) are used to scale each school's IA scores. The IA scores, once scaled, represent each student's final SSPA score. Students are ranked according to their final SSPA score, which dictates their placement in secondary schools of (originally five but now three) different bands. Banding recognizes academic merit because all students in Band 1 would have priority over all students in Band 2 and so forth for a secondary school place and have much higher chances of entering better secondary schools (EOC 1999).

Girls would usually perform significantly better in the IAs, whereas boys enjoyed some advantages in the AATs. The AATs, however, did not affect the SSPA score directly, putting boys at a disadvantage. In light of this pattern, in 1978 the SSPA system introduced a gender factor into the scaling mechanism. First, boys and girls in co-educational primary schools had their results scaled separately, which in fact boosted the final SSPA scores of boys while reducing those of girls. Second, boys and girls were ranked separately in the banding process, so the band cutting scores would differ by gender, which basically downplayed girls' advantage in the SSPA scores. Third, a form of gender quota was employed for the purpose of maintaining a balanced mix of boys and girls in co-educational secondary schools (EOC 1999). The then Director of Education claimed that because boys experienced a late bloomer's effect in terms of academic development and this disparity in development between boys and girls was equalized at the time of graduation, the decision to run the secondary school allocation process separately for boys and girls was justified. Girls would have to achieve a much higher score than boys in order to be admitted to a school of comparable quality.

Such positive discrimination against girls in the SSPA system was challenged by parents who had daughters and the Equal Opportunities Commission filed a lawsuit against the Director of Education in 1998. The school allocation policy was subsequently declared

[2] There are three internal assessments (IAs) in primary school: the first in Year 5 and the second and third ones in Year 6 (EOC 1999).

discriminatory by the court, and revamped in 2002, so that it no longer made any distinction between boys and girls in school placement. The key elements of the policy reform are summarized in Table 1.

Table 1. Contents of the Hong Kong Secondary School Places Allocation (SSPA) System Reform

	1978-2001	2002-present
Scaling Mechanism	The scores were scaled for all primary students, on a gender basis, in their school assessments.	The scores are scaled for all primary students, regardless of their gender, in their school assessments.
Banding Mechanism	All students, on a gender basis, were banded into five academic merit bands.	All students, regardless of their gender, are banded into three academic merit bands.
Gender Quota	A form of gender quota was employed to ensure that a fixed ratio of boys and girls was admitted to individual co-educational secondary schools.	No gender quota is involved in admitting junior high students in co-educational schools.

Source: "Formal Investigation Report: Secondary School Places Allocation (SSPA) System", Equal Opportunities Commission (EOC), 1999.

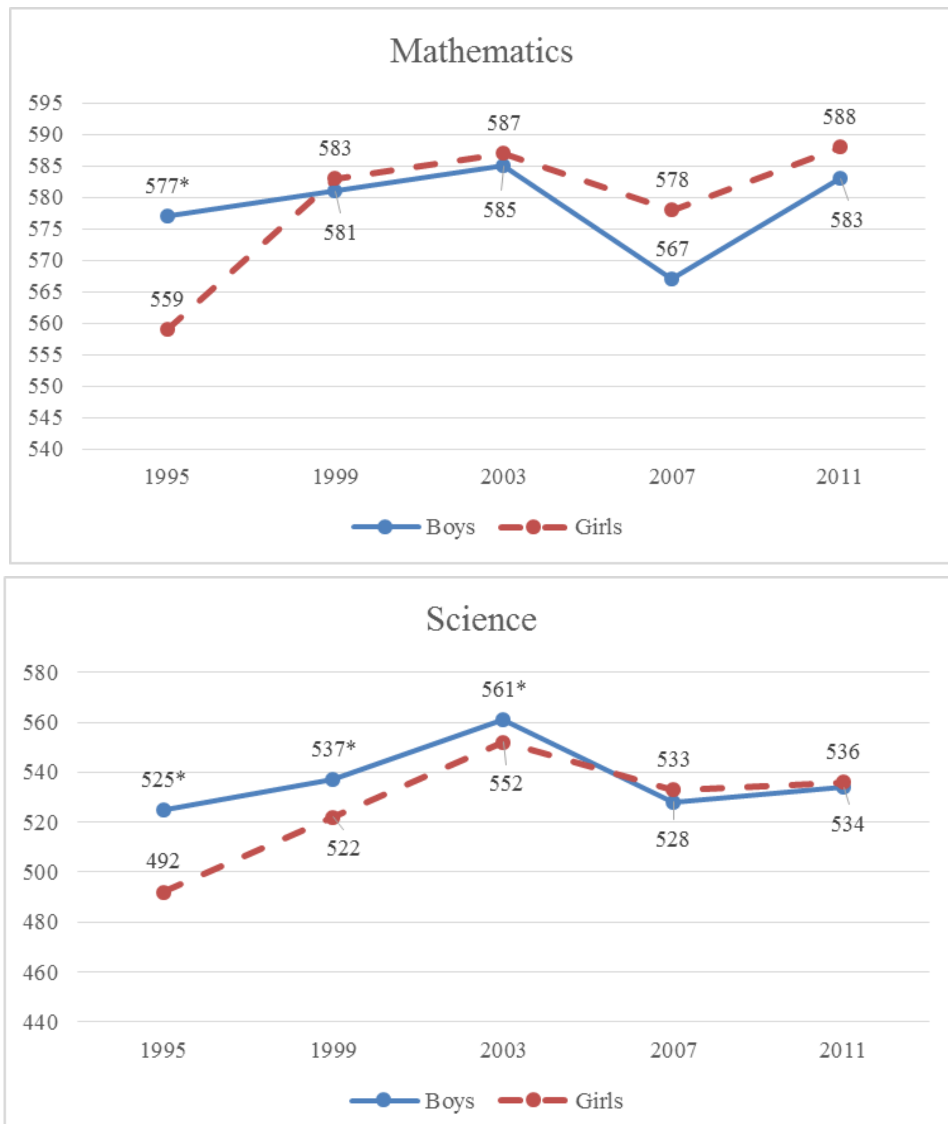
Parents and many educational researchers in Hong Kong are now worried that the new policy could push boys into more disadvantaged positions in the school system. The evidence gathered so far seems to justify their concern. Nevertheless, whether this changing gender disparity in academic achievement is a direct result of the policy reform, or simply an inevitable trend unrelated to the policy shift, needs to be assessed more rigorously. Because the policy shift was sudden and universal for almost all the secondary schools in Hong Kong, it provides the setting for a quasi-experiment to partial out other potential confounders, and to directly examine the impacts of education policy on the changing gender inequality in academic achievements. We do this by analyzing the data from TIMSS collected in Hong Kong in 2003 and 2007, respectively, with secondary school students enrolled before and after the policy was implemented.

Data, Variables and Methods

Data

Trends in International Mathematics and Science Studies, aka TIMSS, is a comparative study designed in 1995 by the International Association for Evaluation of Educational Achievement (IEA). Its aim is to assess the quality of mathematics and science learning among the 4th and 8th graders across participating countries in a regular four-year cycle. To date, five waves of studies have been conducted in 1995, 1999, 2003, 2007, and 2011. Hong Kong has participated in all five waves. As shown in Figure 2, there is a clear trend from 1995 to 2011 that female 8th graders are catching up with and even overpassing boys in both mathematics and science subjects in Hong Kong, perhaps not incidentally, after the implementation of the new SSPA policy in 2002. Here we focus on analyzing the data on 4th and 8th graders in Hong Kong, 2003 and 2007, to assess the impact of the policy shift on the gender gap in performance in mathematics and science.

Figure 2. Trends in Average Academic Achievements, by Gender, 1995-2011



Data source: Trends in International Mathematics and Science Study (TIMSS), 1995-2011

Variables

The main dependent variable of our interest is the mathematics and science test scores. Because of its complex assessment designs, with each student responding only to the items in a single booklet and not the entire assessment, TIMSS relied primarily on item response theory (IRT) scaling methods to measure trends in students' mathematics and science achievement, and used a multiple imputation methodology to obtain proficiency scores for all students (Gonzalez, Galia and Li 2003). TIMSS estimated five plausible values for each individual student. In our analysis, every statistic of interest is calculated using each of the five plausible values, and then summarized by averaging the results in accordance with recommendations from Little and Rubin (Little and Rubin 1987).

As discussed before, we also aim to examine the impact of the policy shift on boys' and girls' placements in schools of different quality. School banding, to which the majority of students' prior achievement is intimately linked, is an ideal indicator of the school quality in Hong Kong. The banding information, unfortunately, is not released due to confidentiality concerns. A substitute variable, principals' perception of the school climate, is used to proxy for school quality. The index of principals' perception of school climate (PPSC) summarizes school principals' perception of their school's climate, including items such as teachers' job satisfaction, teachers' understanding of the school's curricular goals, teachers' degree of success in implementing the school's curriculum, teachers' expectations for student achievement, parental support for student achievement, parental involvement in school activities, students' regard for school property, and students' desire to do well in school. Principals rated each item on a five-point scale: very high = 1, high = 2, medium = 3; low = 4, and very low = 5. We then generate a three-point-scale composite index based on these factors to measure the school quality in general. A high index corresponds to an average rating equal to or less than 2. A medium index corresponds to an average rating greater than 2 but less than or equal to 3. A low index corresponds to an average rating of greater than 3. This index is a good indicator for school quality as it covers multiple dimensions of a school and is comparable across schools and across years. We also compute a school's average achievement (the sum of average mathematics achievement and average science achievement, divided by two) as an alternative proxy for school quality.

The key independent variables include gender, which is a dummy (male=1), period, also a dummy (year 2007=1), and whether or not the respondent is a 8^{th} grader (yes=1). We also control for a set of variables on individual characteristics, including age, immigrant status (natives, second-generation immigrants, first-generation immigrants),[3] number of books at home (0-10=1, 11-25=2, 26-100=3, 101-200=4, over 200=5), and whether the student has a study desk at home (yes=1). Table 2 presents the descriptive statistics of all variables, by grade and year. These numbers reflect the systematic differences between 4th and 8th graders, and also the temporal changes within a particular grade before and after the policy shift.

Table 2. Descriptive Statistics on Selected Variables, by Grade and Year

	8th Graders (Treatment Group)		4th Graders (Control Group)	
	Before (2003)	After (2007)	Before (2003)	After (2007)
Academic Achievements				
Mathematics score	586.9 (67.95)	568.7 (90.97)	575.1 (59.00)	606.2 (61.44)
Science score	556.7 (60.11)	527.9 (77.34)	542.9 (54.69)	555.3 (61.26)
School Quality				
Principals' perception of school climate (PPSC)				
High	12.69%	21.69%	30.75%	26.18%
Medium	68.04%	65.99%	63.34%	70.73%
Low	19.28%	12.32%	5.91%	3.091%
Average school achievement	571.3 (47.35)	548.4 (67.08)	557.9 (29.81)	580.1 (34.39)
Individual Characteristics				
Sex (boy=1)	48.99%	49.38%	52.81%	51.18%
Age	14.38 (0.889)	14.40 (0.813)	10.25 (0.690)	10.23 (0.594)
Immigrant status				
Natives	60.30%	59.36%	65.52%	70.80%
Second-generation immigrants	19.84%	22.44%	19.63%	15.54%
First-generation immigrants	19.87%	18.20%	14.84%	13.66%
No. of Books at home				
None or very few (0-10)	28.00%	27.06%	26.26%	18.19%
One shelf (11-25)	28.58%	31.25%	31.20%	24.25%
One bookcase (26-100)	26.84%	24.64%	27.31%	34.04%
Two bookcases (101-200)	8.353%	8.468%	9.037%	13.02%
Three or more bookcases (200-)	8.223%	8.583%	6.188%	10.50%
Study desk at home (yes=1)	74.23%	74.63%	68.73%	70.98%
Unweighted no. of cases	4,028	2,731	3,634	2,970

Notes: Standard deviations are in parentheses; data are weighted.

[3] Natives are students born in HK or who have at least one parent born in HK, second-generation immigrants are students born in HK but whose parents were both born outside HK, and first-generation immigrants are students born outside HK and whose parents were also born outside HK. Students with missing responses about birth places for themselves or their parents are excluded from the analysis.

Research Designs and Statistical Methods

The difference-in-differences (DID) method is designed to examine the difference in impact of an exogenous shock between the treatment group and the control group and has been used widely in policy evaluations. We employ this method to identify the causal effect of the shift in school allocation policy on gender disparities in academic performance.

As mentioned earlier, we analyze the TIMSS data on 4^{th} and 8^{th} graders in 2003 and 2007. Because the 8^{th} graders in the 2003 study were enrolled in secondary school in September, 2001, they were not affected by the policy change in 2002. The 8th graders in 2007, however, were presumably affected by the new allocation policy. The 4^{th} graders in primary school, on the other hand, were immune from the impact of the SSPA policy shift in both 2003 and 2007.

As a result, we have the academic achievements for two groups (4^{th} graders and 8^{th} graders) over two time periods (2003 and 2007): one group is exposed to a "treatment" (the policy change) in the second period but not in the first period, the other group is not exposed to the treatment at all ("control group"). This is an ideal setup for conducting a DID estimation, making the TIMSS data particularly suitable for directly assessing the net impact of the new SSPA policy on gender disparity in academic achievements in Hong Kong. Any difference between the treatment group and control group would reveal the varying effects of the policy shock on our outcome variables.

Here we presume that the 4^{th} graders and 8^{th} graders are comparable to each other, as long as their systematic differences remain invariant over time, because the TIMSS uses standardized tests to evaluate students' cognitive abilities and to scale their scores in mathematics and sciences. Moreover, thanks to the 12-year compulsory education in Hong Kong, the demographic characteristics of 4^{th} graders do not differ substantially from those of 8^{th} graders, though these characteristics may be taken into account in subsequent analyses.

Based on the funding source, Hong Kong's secondary schools can be broadly classified into four types: government-owned, government-aided, direct subsidized, and private/international. The SSPA policy shift is only applicable to government-owned/aided secondary schools, whereas schools under the direct subsidy scheme (DSS) can choose whether or not to participate in the allocation process. Private/international schools are not covered by the system. We restrict the analyses to those students from government-owned /aided schools, which make up over 80 percent of the schools in the sample.[4]

A basic model of DID can be specified as follows:

$$y = \beta_0 + \beta_1 Treatment + \beta_2 Year + \beta_3 Treatment * Year + u,$$

where y is either the mathematics or science test score, *Treatment* is a dummy variable for the 8th graders which captures possible differences between the treatment and control groups prior to the policy change; *Year* is a dummy variable for the time period exposed to policy shock, which captures aggregate factors that would cause changes in y even in the absence of a policy change. The coefficient of our interest is β_3, which indicates the policy impact on the treatment group relative to the control group. Given our central interest in the gender difference due to the policy change, we further let a male dummy interact with every term in the basic model. The estimation equation thus involves a slightly more complex specification:

$$y = \beta_0 + \beta_1 Treatment + \beta_2 Year + \beta_3 Treatment * Year + \delta_0 Male + \delta_1 Male * Treatment + \delta_2 Male * Year + \delta_3 Male * Treatment * Year + u,$$

The extended DID model above contains two parts: the first consists of the DID estimators for girls (the first four estimators), and the second part the gender disparities in DID estimators (the last four estimators). The coefficient of interest is now δ_3, which indicates the gender difference of policy impacts on the treatment group relative to the control group. The individual characteristic variables are also added into the equation to control for the fact that the population sampled may differ systematically between the two periods and between students of the two grades.

As TIMSS used a two-stage cluster sampling design rather than simple random sampling, the probability of being included in the sample is not fixed. Therefore, the sample weighting issue must be taken into account to ensure the representativeness of the sample (Rutkowski et al. 2010). In this study, following the strategy recommended by TIMSS, both the overall sampling weight and the replicate weights are used to calculate the point estimates and its standard errors.

[4] In a small number of government primary schools (not identifiable in the TIMSS data), students—like those in most DSS schools—can directly enter the alliance secondary schools without participating in the allocation system. The proportion of students not subject to SSPA, however, is presumably very small.

Results

Gender Disparities in Academic Achievements and School Placement

Table 3 presents simple comparisons of gender disparities in academic achievements and school quality between treatment and control groups, as well as between two time points. Boys' performance relative to that of girls is reported, with the *p* values for significance tests given in parentheses.

Table 3. Differences in Gender Disparities in Academic Achievements and School Entrance, by Grade and Year

			8^{th} Graders (Treatment Group)	4^{th} Graders (Control Group)	Difference
Academic Achievements	Mathematics score	Before (2003)	-1.638 (0.780)	0.726 (0.764)	-2.363 (0.724)
		After (2007)	-18.68 (0.006)	5.033 (0.067)	-23.71 (0.001)
		Difference	-17.04 (0.049)	4.307 (0.241)	
	Science score	Before (2003)	8.717 (0.047)	-1.582 (0.540)	10.30 (0.055)
		After (2007)	-11.55 (0.051)	3.473 (0.363)	-15.02 (0.016)
		Difference	-20.27 (0.006)	5.056 (0.289)	
School Entrance	High quality	Before (2003)	0.429 (0.278)	-0.021 (0.836)	0.451 (0.284)
		After (2007)	-0.480 (0.083)	0.046 (0.731)	-0.527 (0.096)
		Difference	-0.909 (0.059)	0.068 (0.729)	
	Average school achievement	Before (2003)	-8.548 (0.067)	-3.255 (0.027)	-5.293 (0.303)
		After (2007)	-29.07 (0.000)	-4.291 (0.008)	-24.78 (0.000)
		Difference	-20.52 (0.003)	-1.035 (0.659)	

Notes: p-values for significance tests are in parentheses; data are weighted.

As shown in Table 3, prior to the policy change, there were no systematic differences in gender gaps pertaining to academic achievement and school entry between the treatment and control groups. After the policy change, for the control group, as expected, we see no changes in outcome variables, whereas for the treatment group, there was a clear trend showing that boys are falling behind. In 2003, no significant gender disparities in academic achievement and school placement are observed, but in 2007 a gender gap in favor of girls can be seen clearly. Boys now score nearly 19 points lower in mathematics, and over 11 points lower in science; they are also less likely to enter schools of better quality and schools with higher average achievement.

However, there could be other factors unrelated to the school allocation policy change affecting girls' achievement relative to that of boys. To specifically assess the impact of the SSPA reform, we now turn to the DID analysis.

Effect of the School Allocation Policy on the Gender Achievement Gap

Table 4 reports the DID estimates of the impacts of the SSPA reform on the gender achievement gap in mathematics and science. Model 1 is the baseline model, in which we include the three key independent variables, treatment group (8th graders), gender, and year, all coded as dummies, and their interaction terms. Model 2 adds control variables such as age, immigrant status, number of books at home, and whether there is a study desk at home. The regressions are estimated using the ordinary least squares (OLS) method. As expected, for both mathematics and science performance, results show that the coefficients for the triple interaction terms are negative and statistically significant, suggesting the new policy did hinder boys' academic achievement relative to that of girls.

Based on the estimation from Model 2, we calculate the gender gaps in mathematics and science achievements for both the treatment group and control group in two time periods. Figure 3 plots the point estimates, together with a 90 percent confidence interval. It can be seen clearly that, while boys in the control group continue to enjoy a slight premium in these two traditionally male-dominated subjects, the gender gap is reversed for the treatment group after the policy shift. Other things being equal, for the treatment group in the ex-post period, boys score approximately 16 (2.777-4.131+4.192-18.19) points lower in mathematics and over 9 (-0.238+8.57+4.906-22.46) points lower in science than girls. These are nontrivial changes within a time window of only four years. Notably, the 8th graders in 2007 who have been affected by the SSPA reform are indeed the same cohort of 4th graders in 2003. Boys and girls in this cohort performed similarly in primary school, but ended up performing substantially differently in secondary school. This suggests that the new school allocation policy did enlarge the gender gap in academic achievements in favor of girls.

Table 4. DID Estimation Predicting the Effect of the SSPA Reform on Gender Achievement Gap

	Mathematics score		Science score	
	(1)	(2)	(1)	(2)
DID estimates				
Treatment	12.94**	49.38***	8.709*	39.94***
	(5.725)	(7.914)	(5.217)	(8.180)
Year	28.87***	25.23***	9.769**	6.661
	(5.496)	(5.377)	(4.958)	(4.839)
Treatment*Year	-38.57***	-36.59***	-28.62***	-27.00***
	(8.562)	(8.096)	(7.460)	(7.088)
Boy	0.726	2.277	-1.582	-0.238
	(2.406)	(2.361)	(2.561)	(2.511)
Boy*Treatment	-2.364	-4.131	10.300*	8.570*
	(6.668)	(6.065)	(5.276)	(4.816)
Boy*Year	4.307	4.192	5.056	4.906
	(3.637)	(3.422)	(4.668)	(4.583)
Boy*Treatment*Year	-21.35**	-18.19**	-25.32***	-22.46***
	(9.607)	(9.069)	(8.192)	(7.888)
Other Controls	No	Yes	No	Yes
Constant	574.7***	638.5***	543.7***	598.6***
	(3.792)	(18.446)	(3.575)	(19.169)
Unweighted no. of cases	13363		13363	
Average R-squared	0.038	0.092	0.032	0.084

Notes: Jackknife standard errors are in parentheses; * p < 0.1, ** p < 0.05, *** p < 0.01; data are weighted; other controls include students' age, immigrant status, number of books at home, and availability of a study desk at home.

Explaining Boys' Disadvantage in Academic Achievement

Why has the new SSPA system caused boys' drop-off in academic performance? A direct consequence of the SSPA reform is that girls are no longer admitted based on gender-based quotas but on academic merit, namely, performance in IAs. Because girls tend to do well in IAs, they are more likely to enter secondary schools of higher quality. Given the fact that the total number of slots has remained unchanged, boys are increasingly finding themselves in lower-quality secondary schools. According to local media reports[5], the sex ratio of students in many prestige schools has become very unbalanced, "making the co-educational schools look like girls' schools". The TIMSS data seem to lend support to this observation. Figure 4 shows the change in gender distribution of the treatment group (8th graders) in 2002 and 2007. Apparently, before the reform, boys enjoyed better chances of entering high-quality schools, whereas after the reform, girls far outnumbered boys in high-quality schools.

[5] News from *Wenweipo*: http://paper.wenweipo.com/2011/09/30/ED1109300004.htm.

Figure 3. Gender Disparities in Academic Achievements, with 90% Confidence Interval

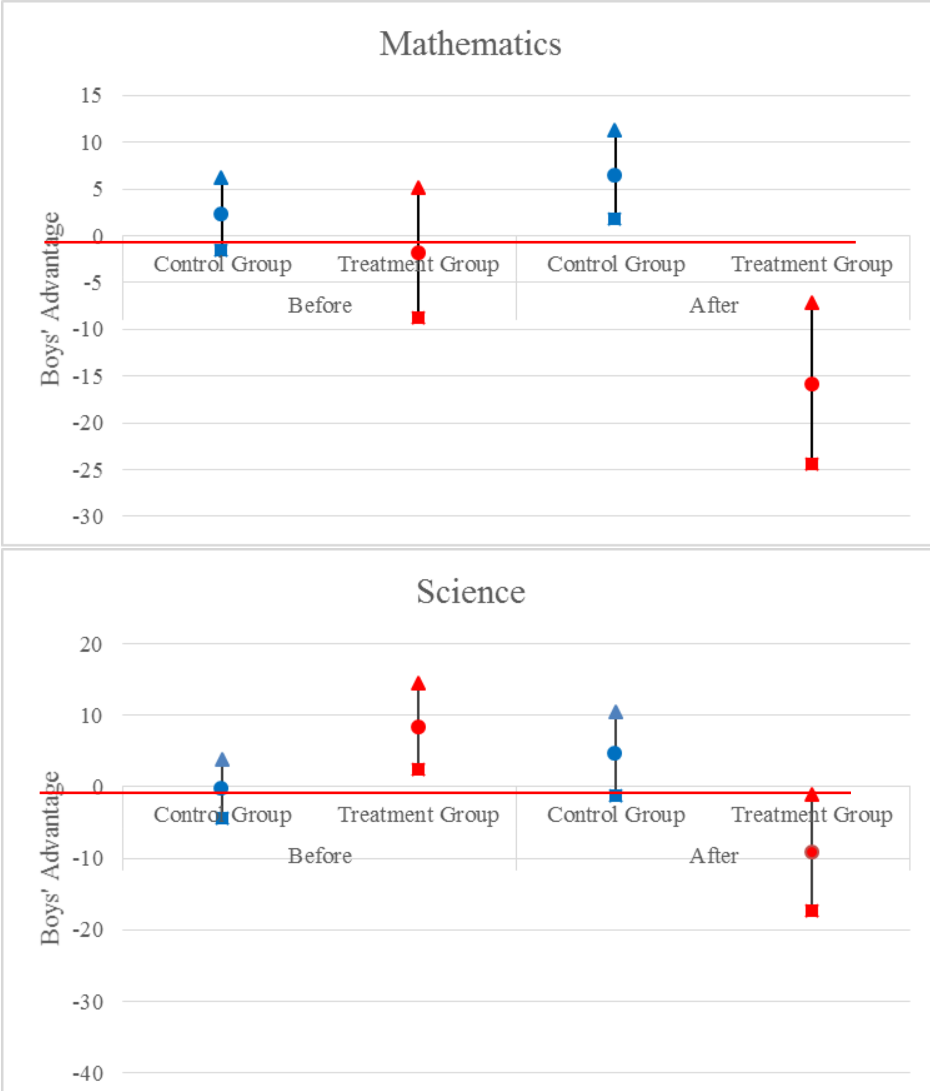
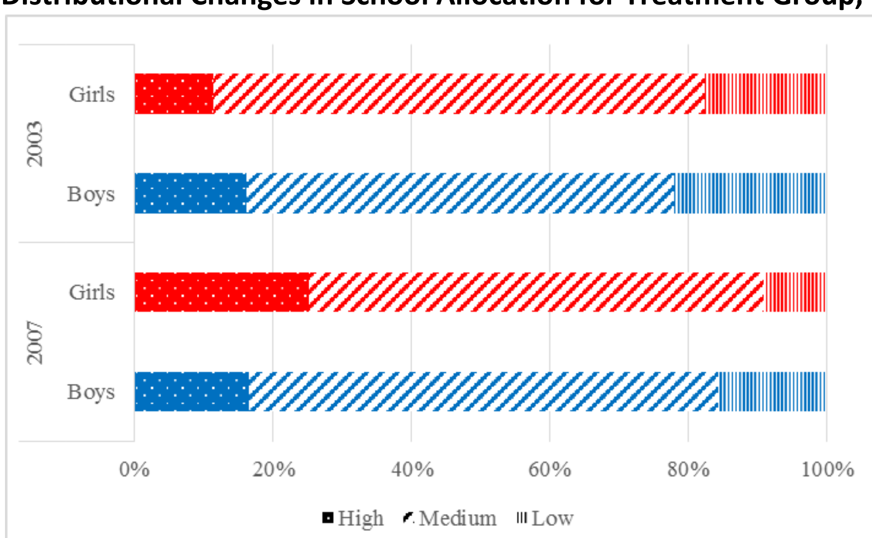


Figure 4. Distributional Changes in School Allocation for Treatment Group, by Gender



We also conduct a DID analysis to examine the impact of policy change on the gender disparity in school quality. The results are shown in Table 5. As mentioned before, we use both the principle's perception of the school climate and the average school achievement to measure school quality, which we analyze using multinomial logit models and conventional OLS regression models, respectively. Again, the significant coefficients for the triple interaction terms suggest that boys are more likely to enter lower quality schools than girls. The results from multinomial logit models show that, other things being equal, the odds of entering a medium (or low) quality school rather than a high quality school is 2.6 (or 3) times higher for boys than for girls. Similarly, results from OLS models indicate that boys in the treatment group tend to enter a school with a lower average achievement score after the SSPA reform.

Table 5. Multinomial Logistic/OLS Regression Models Predicting School Entrance

	MLogit (base: high quality)		OLS
	Medium quality	Low quality	Average school achievement
DID estimators			
Treatment	1.924	4.286*	42.09***
	(0.993)	(3.252)	(6.032)
Year	1.517	0.786	19.99***
	(0.536)	(0.565)	(4.997)
Treatment*Year	0.239**	0.277	-33.82***
	(0.144)	(0.260)	(6.853)
Boy	1.018	1.047	-2.521*
	(0.128)	(0.117)	(1.410)
Treatment*Boy	0.592	0.828	-5.996
	(0.229)	(0.322)	(4.536)
Year*Boy	0.918	0.843	-0.819
	(0.197)	(0.165)	(2.131)
Treatment*Year*Boy	2.577*	3.146**	-17.69**
	(1.335)	(1.632)	(6.700)
Other controls	Yes	Yes	Yes
Constant	0.665	0.055***	607.6***
	(0.403)	(0.047)	(13.396)
Unweighted no. of cases	13,363		13,363
R^2	-		0.143

Notes: Jackknife standard errors are in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$; data are weighted; coefficients for the multinomial logit models are odds ratios; other controls include students' age, immigrant status, number of books at home, and whether a study desk is available at home.

It is well-known that school plays an important role in learning and better schools tend to promote students' learning outcomes. Nonetheless, even with the same school quality, boys and girls may still perform differently. In other words, boys' underperformance at the aggregate level may be due to their lower chance of being placed in good schools, or to their poorer performance than that of girls within a school. For instance, Legewie and DiPrete (2012) found that, higher-quality schools "facilitate boys' commitment by promoting academic competition as an aspect of masculine identity", whereas lower-quality schools "implicitly encourage—or at least do not inhibit—development of a peer culture that constructs resistance to schools." Girls, on the other hand, were found to be not vulnerable to the influence of school quality. Therefore, they concluded that boys are more sensitive to school climate, and the size of the gender gap in educational performance varies by the quality of schools where they study.

Therefore, enrollment in lower-quality schools as a result of the policy change may be more detrimental to boys than to girls. To confirm this speculation, in Table 6, we present the results for 8th graders in 2007 on the changing gender achievement gap by school quality. Although lower school quality does substantially reduce students' academic achievement, the insignificant interaction terms between school quality and the gender dummy suggest that lower school quality does not harm boys any more (or less) than it does girls. Therefore, we fail to replicate the findings by Legewie and DiPrete (2012). We suspect that an unfavorable school climate and peer culture may harm not only boys but also girls by driving the latter's attention to activities like dressing and dating instead of academic learning. In fact, some studies have suggested that girls are more sensitive to peer pressure than boys (Guyer et al. 2009; Rose and Rudolph 2006). Hence, our analyses show that, at least in Hong Kong, the gender achievement gap favoring girls emerged mainly due to the unbalanced gender distribution among good-quality schools and among bad-quality schools.

Table 6. Different Gender Achievement Gap by School Quality, for 8th graders in 2007

	Mathematics score		Science score	
	(1)	(2)	(1)	(2)
Boy	-9.265	5.227	-4.584	7.093
	(5.668)	(10.417)	(5.142)	(9.024)
School quality (ref: high)				
Medium quality	-46.521***	-40.028***	-31.121***	-25.919**
	(12.404)	(12.946)	(9.953)	(10.569)
Low quality	-74.564***	-57.580***	-50.549***	-36.655**
	(22.030)	(20.923)	(17.855)	(16.864)
Interaction terms				
Medium quality*boy		-15.889		-12.744
		(13.592)		(11.158)
Low quality*boy		-32.550		-26.565
		(22.931)		(18.462)
Other controls	Yes	Yes	Yes	Yes
Constant	795.564***	791.635***	703.468***	700.352***
	(49.436)	(50.394)	(56.593)	(57.433)
Unweighted no. of cases	2731		2731	
Average R-squared	0.156	0.159	0.130	0.132

Notes: Jackknife standard errors are in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$; data are weighted; other controls include students' age, immigrant status, number of books at home, and whether a study desk is available at home.

Summary, Discussion, and Conclusions

Many countries have experienced a temporal decline in the gender gap in educational attainment, with females faring better in recent years. While many scholars adopting a micro-behavioral perspective tend to emphasize females' advantages in biological and developmental traits, or non-cognitive skills conducive to learning behaviors, they cannot explain why the gender gap is reversed at this particular moment of human history, as the gender-based differences in those attributes exist irrespective of historical context. We argue that the reverse gender gap in academic performance results from the macro-structural changes that allow girls to compete with boys on a level playing field. Only if women are given equal access to education can they truly realize their learning potential.

While such historical changes in opportunities were often prompted by feminist movements and legislative mandates, few empirical studies have examined explicitly the consequences of enforcing equal opportunities for gender inequality. We take advantage of the reform in secondary school place allocation in Hong Kong and TIMSS data on 4th graders and 8th graders in 2003 and 2007, and assess the impact of the policy shift on the gender gaps in test scores in mathematics and science before and after the reform.

Specifically, we utilized a quasi-experiment research design, in which 8th graders have been exposed to the policy change as the treatment group, whereas 4th graders (the control group) were unaffected, and compared the differences in gender achievement gaps between two time points. Results from DID analysis provided strong evidence for girls' enlarged advantages over boys in academic performance caused by the change from the gender-based allocation policy to a merit-based one. Before the reform, boys enjoyed a slight premium in test scores in both mathematics and science—two subjects that are traditionally male dominated. After the allocation policy change, they performed significantly worse than girls in both subjects, resulting in a reverse gender gap in academic achievement favoring the latter. Moreover, we showed that the reverse gender gap is largely due to the fact that girls are increasingly more likely to secure seats in better-quality secondary schools than boys, as girls have been outperforming boys in internal assessments in primary school, which serve as the sole basis of school allocation under the new system. As a result, more boys end up in lower-quality schools after the reform, even though we found no significant changes in the gender achievement gap within schools of the same quality level. Therefore, it is the change in gender distribution among "good schools" and among "bad schools"—resulting from the reform of school allocation policy—that has largely contributed to the reverse gender gap in academic performance at the aggregate level. In addition, we also examined factors that could undermine our conclusions, including the impacts of other educational reforms/policy changes, single-sex schools, and school transfers. Relevant analysis and evidences are shown in the Appendix. Overall, our conclusions stand robust despite all these potential confounders.

The feminist and human rights movements over the past few decades has afforded females unprecedented opportunities to progress on parity with males in the modern society. Equal access to education, especially quality education, represents one of the most treasured opportunities. As the society progresses and the economy develops, and perhaps also due to the fertility decline, the resource constraints on females' access to education seem to have relaxed to a large extent. With equalized opportunities, females can now compete with their male counterparts on the same footing and their superior biological, psychological, or other non-cognitive skills could render them successful in school. This academic success is accumulative as they progress through the school system, leading to the reverse gender gap in education in many developed countries.

As mentioned in the introduction, "equal opportunity" is a subtle concept not easily measurable on empirical grounds. The Hong Kong SSPA system reform offers us an interesting study setting in which the gender-based quota system was replaced by a merit-based assessment system so that boys and girls would have equal learning opportunities.

To be certain, women's improvement in education relative to men over time is associated with many other fundamental changes in the economy, society and culture in the industrialized world, such as the structural transformation of industries, the increasing returns to higher education, the changing social norms and expectations about women's roles and status, and greater legal protection for gender equality in the workplace (Autor 2010; DiPrete and Buchmann 2013; Goldin, Katz and Kuziemko 2006). These historical changes have given women more incentives and made it easier for them to seek better education. The causal impact of the change in school allocation policy that we have identified suggests the importance of equal educational opportunity in ensuring women receive better education.

Our analyses do not intend to address why girls outperform boys academically within the same learning environment; neither do we intend to judge whether the new system is better than the old one in promoting social justice. The gender-based quota admission system in Hong Kong was introduced before 2002 to protect boys who were lagging behind girls as a newly emerging phenomenon. While it may be justified to apply an affirmative-action-like policy to certain groups that are historically disadvantaged, whether males need such favorable treatment is a debatable question beyond the scope of this research, as males continue to dominate in most spheres in the modern society. The real paradox is that, after the reform in 2002, policies intended to achieve gender parity in access to opportunities have created new gender disparity in learning outcomes in favor of girls. Moreover, in 2009, the first cohort that was affected by the SSPA reform entered college. As can be seen from Figure 1, soon after that, and for the first time in Hong Kong's history, we started to observe women's advantage in college entrance. Findings in this paper call for new reforms of our education system to embrace and adapt to the essential gender diversities of students, and allow both boys and girls to prosper in schools. Whether the new advantages women have recently gained could compensate, to some extent, for the barriers they encounter in achieving socioeconomic parity with men remains an open question.

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Appendix: Robustness Check and Sensitivity Analysis

While the empirical results from DID methods has provided strong support indicating that the shift in school allocation policy has resulted in larger gender gaps in academic performance in Hong Kong, several potential problems could jeopardize our conclusions. First, the unbiasedness of the DID methodology rests on the important assumption of a "parallel trend", meaning that counterfactual gender achievement trends would be the same for 4th and 8th graders in the absence of the policy shift, so any change would be attributed to the treatment. Apart from the student population composition (which we have controlled for), other policies or events could also differentially affect the academic performance of 4th and 8th graders. However, as we are focusing on the gender difference in academic achievements, even if observable or unobservable factors exist that affect the 4th and 8th graders differently, unless we have good reason to believe these effects are different for boys and girls, the "parallel trend" assumption would not be violated. We have repeated our analyses based on other educational reforms/policy changes either in primary schools or secondary schools in Hong Kong close to the study period, but none seems to have an impact comparable to that of the SSPA reform on the gender achievement gap.

Second, under British rule for a century, Hong Kong's education system has been characterized by a considerably large proportion of single-sex secondary schools, which are mostly of relatively high quality. Therefore, an expansion of girls' schools or a reduction of boys' schools during the period of analysis could be a confounding factor that may explain girls' increasing advantages in academic achievements. In Table A1, we see the number of girls' schools and the percentage of students studying in girls' schools have actually decreased more rapidly than the number of boys' schools and the percentage of students studying in boys' schools. Moreover, when we use entering single-sex schools as the dependent variable and repeat the DID analysis, we find no significant change of the gender difference in the likelihood of entering single-sex schools from 2003 to 2007.

Table A1. Number of Single-Sex Schools and Percentage of Students Studying in Single-Sex Schools for the Treatment Group (8th Graders)

		Boys	Girls	Difference
	Before (2003)	9	14	-5
School	After (2007)	7	9	-2
	Difference	2	5	-3
	Before (2003)	18.77	25.51	-6.74
Student %	After (2007)	12.87	19.47	-6.6
	Difference	5.90	6.04	-0.14

Notes: these numbers are based on government-aided schools only.

Finally, school transfer could also be a source of bias, because the effect of school allocation could be contaminated by self-selection. For instance, boys are more likely to exhibit behavioral problems and thus be transferred to a less favorable school. In the survey of Program for International Student Assessment (PISA) in Hong Kong, 2009, participating schools were asked "how likely is it that a student in modal grade (9th grade in the Hong Kong case) for 15-year-olds would be transferred to another school because of the following reasons?", and the reasons included low/high academic achievement, behavioral problems, special learning needs, parents' or guardians' request, among others. Among nearly 120 sampled schools, less than 10 percent actually said that they would "very likely" transfer students for these reasons.[1] Therefore, we conclude that school transfer is possible but quite rare in Hong Kong, and our results stand robust.

[1] 12 schools cited low achievement, 1 school cited high achievement, 11 schools cited behavior problems, 2 schools cited special learning needs, 2 schools cited parents' or guardians' request, and 5 schools cited other reasons for transferring students to other schools.